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**A framework for Computing Education
that fosters the development of
creativity and critical thinking skills in
children**

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*“Educação não transforma o mundo.
Educação muda as pessoas.
Pessoas mudam o mundo.”
(Paulo Freire)*

Abstract

Research in Human–Computer Interaction has increasingly emphasized the importance of designing technologies and educational practices that are meaningful, inclusive, and sensitive to users’ contexts. In early childhood education, teaching computing presents additional challenges due to children’s cognitive, social, and expressive characteristics, as well as the limited availability of pedagogical frameworks that integrate participatory design, learning activities, and assessment strategies. Despite growing interest in co-design and participatory design with children, there is still a lack of consolidated approaches that support teachers in designing, applying, and evaluating computing education activities for preschool children. This doctoral thesis proposed and empirically evaluated a framework to support the teaching of computing in early childhood education, grounded in HCI principles and participatory design practices, with a particular focus on fostering creativity and critical thinking in children aged four and five. The research adopts a cumulative empirical approach, structured as a collection of articles. First, a systematic mapping study was conducted to investigate how co-design and participatory design have been applied with preschool children, identifying techniques, participant roles, contexts, and methodological challenges. Based on the identified gaps, pedagogical design principles for computing education in early childhood were derived from a thematic analysis of the literature. In parallel, an action research study was carried out involving early childhood education teachers and undergraduate students in pedagogy and computer science, who collaboratively designed and refined unplugged computing activity plans through a series of workshops. To support learning assessment, creativity, and critical thinking rubrics were translated and adapted to the early childhood context. The design principles, design activity plans, and rubrics for assessments were validated by experts through focus groups. Finally, the proposed framework was evaluated through a quasi-experimental study conducted in real classroom settings, comparing an experimental group and a control group, using qualitative triangulation of multiple data sources. The studies resulted in a set of co-designed activity plans and a validated set of pedagogical

design principles that together constitute the proposed framework. The classroom evaluation revealed qualitative improvements in the experimental group, particularly regarding children's engagement, expression of ideas, collaborative behaviors, and manifestations of creativity and critical thinking during computing-related activities. The adapted assessment rubrics proved feasible for capturing qualitative evidence of these skills in early childhood contexts. This thesis contributes to HCI and computing education by: (i) providing a systematic synthesis of participatory design research involving preschool children; (ii) proposing and documenting co-designed activity plans for early childhood computing education; (iii) formalizing pedagogical design principles grounded in theory and expert validation; and (iv) presenting an empirically evaluated framework that integrates participatory design, pedagogy, and assessment. These contributions advance HCI research on design with children and offer actionable guidance for educators and researchers seeking to design and evaluate computing education experiences in early childhood settings.

Keywords: Computing education. Early childhood education. Learning by design. 21st-century skills..

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List of Abbreviations

AI Artificial Intelligence

ACIEPE Curricular Activity for the Integration of Teaching, Research, and Extension

ACM *Association for Computing Machinery*

ASC Autism Spectrum Conditions

BNCC National Common Curriculum Base

CS Computer Science

CT Computational Thinking

CCI Child-Computer Interaction

CC2020 Computing Curricula 2020

PD Participatory Design

DBR Design-Based Research

FG Focus Group

HCI Human-Computer Interaction

IEEE Institute of Electrical and Electronics Engineers

IDEAS Interface Design Experience for the Autism Spectrum

P21 *Partnership for 21st Century Learning*

P21 ELF *21st Century Skills Early Learning Framework*

RQ Research Question

UFSCar Universidade Federal de São Carlos

ZPD Zone of Proximal Development

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Chapter 1

Introduction

Although young children are increasingly exposed to digital technologies and interact with a variety of digital tools from early ages (MARSH, 2005), there remains a lack of structured, evidence-based pedagogical frameworks that enable teachers to integrate computing concepts in developmentally appropriate, playful, and meaningful ways in early childhood education. Research indicates that, despite the growing interest in computational thinking and digital learning for young children, there is still no consensus on key components or pedagogical approaches, nor widely adopted frameworks that provide teachers with clear guidance for instruction and assessment in this domain (BERS; STRAWHACKER; SULLIVAN, 2022). As a result, many implementations take the form of isolated activities, tools, or digital resources, which may not foster sustained interaction among children or adequately consider the diverse developmental needs of early childhood populations (SOSA-ALONSO et al., 2025). This fragmentation underscores the need for more comprehensive, pedagogically grounded frameworks that support meaningful integration of computing concepts within early childhood curricula.

Although children are increasingly exposed to digital technologies, it is important to distinguish between the use of digital devices and the teaching of computing as a field of knowledge. The mere interaction with technological artifacts does not necessarily promote the understanding of computational concepts, such as algorithms, data organization, or problem-solving processes. In this sense, educational approaches that focus only on the instrumental use of technologies may reinforce passive consumption, rather than fostering active, critical, and creative engagement with computing.

In this context, this work aimed to develop a framework for teaching computer science and fostering creativity and critical thinking in 4- and 5-year-old children. One of the approaches presented is to develop principles and tools to help early childhood edu-

cation teachers introduce computational concepts in the classroom through co-designed collaborative activities.

This thesis, comprised of a collection of articles, reconstructs the path to the proposal and validation of a framework for teaching computing in early childhood education. In particular, this first chapter presents, in a synthetic way in section 1.1, the context, motivation, and problems addressed in this thesis. Section 1.2 specifies the objectives and research approach used, and Section 1.3 presents the articles that comprise this thesis.

1.1 Context, Motivation and Problem Statement

Computing has become an integral part of everyday life, influencing how people communicate, work, learn, and relate to the world. 21st-century children grow up immersed in environments permeated by digital technologies and interact with computing devices from a very young age. However, this early exposure does not necessarily imply an understanding of the principles that underpin these technologies, nor the development of a critical and creative relationship with them.

Even before literacy, children can use technological resources intuitively, but they often remain passive users, without understanding how technologies are created, modified, or used to solve significant problems in their daily contexts (PAIVA; COSTA, 2015; FISCHER et al., 2004). This scenario highlights the need for educational initiatives that promote computer literacy from early childhood education, aligned with the cognitive, social, and emotional characteristics of four- and five-year-old children.

In the Brazilian educational context, this need is reinforced by official educational policies and legislation. The National Common Curriculum Base (BNCC) recognizes the importance of including computing in Basic Education and, through the BNCC Supplement – Computing (BRASIL, 2021; BRASIL, 2022), establish that computing should be integrated into Basic Education from early childhood, not merely as the use of digital tools, but as a field of knowledge involving computational thinking, problem-solving, and the understanding of how technologies are created and operate. The document emphasizes that, from the earliest school years, children should have opportunities to explore notions related to the organization of information, sequences of actions, problem-solving, the responsible use of technology, and its impacts on the social world.

More recently, the Brazilian Digital Education Policy (Law No. 14.533/2023) (BRASIL, 2023) further strengthens this perspective by defining digital education as a fundamental right and by emphasizing the development of digital competencies that go beyond operational skills, including critical, ethical, and creative uses of technology. This legislation highlights the need to promote digital citizenship and a reflective relationship with technology from the early stages of education.

Internationally, similar movements can be observed, although with different levels of

consolidation and implementation. In the United Kingdom, computing became part of the national curriculum in 2014, introducing core concepts such as algorithms, logic, and data representation from the early years of schooling, with an emphasis on computational thinking as a foundational competence (ENGLAND, 2013). In the United States, the expansion of state-level computer science standards has influenced early computational learning initiatives, and research-based curricula such as Coding as Another Language (CAL) demonstrate efforts to integrate programming with broader developmental goals in early childhood (BERS, 2018; BERS; STRAWHACKER; SULLIVAN, 2022). However, international reports highlight that, across countries, early childhood computing initiatives often remain fragmented, with limited structured guidance for teachers and insufficient integration into cohesive pedagogical frameworks (BERS; STRAWHACKER; SULLIVAN, 2022), reinforcing the global relevance of developing validated and developmentally appropriate frameworks for this educational stage.

Beyond the development of computational knowledge, contemporary curricular documents and educational studies highlight the importance of promoting, from the earliest school years, skills considered essential for the holistic development of the individual, often referred to as 21st-century skills (SCOTT, 2017a). Among these skills, creativity and critical thinking play a central role because they directly enable exploration, formulation of questions, decision-making, problem-solving, and attribution of meaning to lived experiences.

In the context of computer science education, these skills broaden the child's role beyond simply performing tasks or using technology instrumentally, fostering their active participation in building solutions, reflecting on the impact of technology, and expressing ideas through different languages. Therefore, teaching computer science in early childhood education can contribute not only to digital literacy but also to the development of fundamental cognitive and socio-emotional skills.

Although the BNCC (BRASIL, 2022), the UK National Curriculum for Computing (ENGLAND, 2013), the K–12 Computer Science Framework (COMMITTEE et al., 2016), and international agendas such as OECD recommendations on computational thinking (BERS; STRAWHACKER; SULLIVAN, 2022) represent important steps toward legitimizing the inclusion of computing from the early years of schooling, teachers in early childhood education still face substantial challenges in translating these policy advances into classroom practice. In particular, there remains a lack of structured methodological guidance, developmentally appropriate materials, and pedagogical frameworks that meaningfully integrate computing concepts with the playful and exploratory nature of early childhood education.

Despite the advances represented by these policies, there is still a significant gap between what is proposed in official documents and what is effectively implemented in early childhood classrooms. While legislation establishes the importance of computing

education from an early age, it does not provide sufficient pedagogical guidance, tools, or validated frameworks to support teachers in translating these guidelines into practice. This gap is particularly critical in early childhood education, where teaching approaches must be developmentally appropriate, playful, and meaningful.

The literature presents initiatives to teach computing to young children; most of these proposals focus on isolated activities, specific tools, or the development of technical skills, with little attention to broader competencies, such as creativity and critical thinking. Furthermore, there is a gap in the systematic evaluation of integrated educational proposals, especially those involving collaborative and participatory processes in the context of early childhood education (MANCHES; PLOWMAN, 2017).

It is also observed that many educational proposals do not provide sufficient methodological support for early childhood education teachers to plan, adapt, and conduct computing activities in a contextually meaningful way. Studies indicate that teachers often lack pedagogical knowledge and structured guidance to integrate computational thinking and computer science concepts into early childhood practice (MASON; RICH, 2019; ZENG; YANG; BAUTISTA, 2023). The absence of clear pedagogical frameworks makes it difficult to translate computing concepts into developmentally appropriate activities and to align them with broader educational goals (CRITTEN; HAGON; UNLU, 2024). As a result, the lack of structured frameworks impedes the consolidation of pedagogical practices that integrate computing, child development, and 21st-century skills in a coherent and assessable manner.

This gap highlights the need for a structured framework that not only operationalizes computing education for children aged 4 and 5, but also grounds it in theoretically informed design principles and empirical validation.

1.2 Research Question

This thesis is guided by the following central Research Question (RQ):

RQ: How to support the teaching of computing concepts and foster the development of creativity and critical thinking in children aged 4 and 5 in early childhood education?

This RQ reflects the intersection between three domains: (i) computing education in early childhood, (ii) collaborative design processes involving young children, and (iii) the development and assessment of 21st-century skills.

1.3 Hypothesis

To operationalize this investigation, the study tests the following hypothesis:

If early childhood teachers implement a structured framework grounded in co-design principles, articulated through contextualized design activity plans, and supported by developmentally appropriate assessment rubrics, then children aged 4 and 5 will demonstrate evidence of creativity, critical thinking, and emergent computational understanding more than children who participate only in regular pedagogical activities.

This hypothesis establishes:

- ❑ **Independent variable:** Use of the proposed co-design-based framework.
- ❑ **Dependent variables:** Evidence of creativity, critical thinking, and emergent understanding of computational concepts.

The hypothesis was examined through a quasi-experimental design involving an experimental group and a control group in an authentic early childhood classroom context.

1.4 Thesis Statement

Based on the theoretical grounding, framework construction studies, and empirical evaluation, this thesis defends the following claim:

A co-design-based pedagogical framework, grounded in design principles, supported by structured activity plans and adapted assessment rubrics, provides computing education in early childhood, while fostering creativity and critical thinking in children aged 4 and 5.

More specifically, this work contributes to the field of Human-Computer Interaction (HCI) and Computing Education by:

1. Systematically mapping collaborative design practices with early childhood children and identifying methodological gaps;
2. Proposing empirically grounded design principles tailored to early childhood computing education;
3. Operationalizing these principles into actionable classroom activity design plans;
4. Adapting and validating assessment instruments for creativity and critical thinking in this age group;
5. Empirically evaluating the framework through a quasi-experimental study in a real-world educational setting.

In doing so, this thesis advances the understanding of how collaborative design methodologies can move beyond product-oriented outcomes and serve as structured pedagogical strategies for computing education in early childhood.

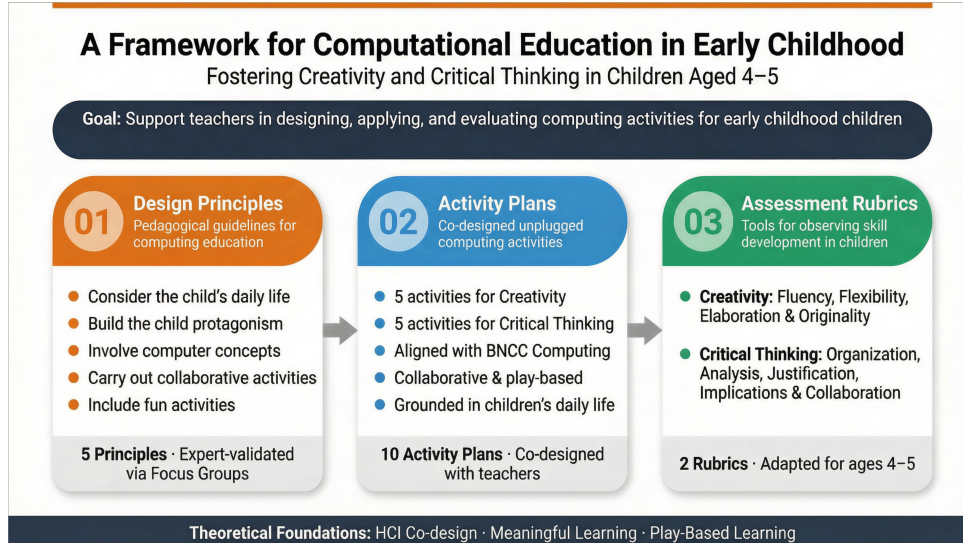


Figure 1 – The Framework.

1.5 Research Objective and Methodology

Driven by the motivation to seek solutions that support computer science education from early childhood, the overall objective of this thesis was to investigate how to teach computer science concepts and develop creativity and critical thinking skills in young children through co-design processes. In this regard, this work proposes a framework that supports computer science education by considering children's daily lives and collaborative activities. The term framework is defined by the Cambridge Dictionary as "1: A supporting structure around which something can be built; and 2: A system of rules, ideas, or beliefs that is used to plan or decide something." In this study, the term framework is used in its broadest sense: a structure composed of principles and tools for planning, decision-making, and executing design processes.

The framework proposed in this thesis is organized into 3 pillars: 1) Co-design principles that serve as a practical guide to ensure that 4 and 5-year-old children, in the final stage of Early Childhood Education, can actively participate in meaningful learning experiences that promote computational thinking, creativity, and collaboration; 2) Design activity plans that operationalize design principles in the context of the early childhood education classroom, structuring pedagogical proposals that combine play, problem-solving, storytelling, and the exploration of computer science concepts; and 3) Assessment rubrics for creativity and critical thinking that help the teacher observe the development of skills in children. Figure 1 summarizes the framework.

The research approach adopted included a systematic literature review (Chapter 2) to understand how early childhood education children are being included in collaborative design processes. However, to achieve the objective of this thesis, it was necessary to understand the different competencies required for creating materials for teaching comput-

ing in early childhood education. In this sense, the knowledge presented in the literature proved insufficient, and the strategy adopted considered the execution of two complementary studies.

The first complementary study was carried out between May and August 2023. We used two methods to propose design principles for computing education for 4- and 5-year-old children. Initially, a thematic analysis (BRAUN; CLARKE, 2006) of 13 articles focused on computing education was conducted. Based on the highlighted themes and codes, 5 principles were proposed. Finally, we held an Focus Group (FG) with professionals specializing in education, early childhood education, and computing areas to discuss the thematic analysis results and finalize the formalization of the principles. Two online meetings were held, each lasting 1 hour and 30 minutes. Results from these activities are reported in Chapter 4 of this thesis. Furthermore, the set of design principles is presented in Rodrigues e Neris (2025).

In addition, a second complementary study was conducted in parallel, within the context of a Curricular Activity for the Integration of Teaching, Research, and Extension (ACIEPE). This is an academic activity that combines teaching, research, and extension, involving professors and students. The participatory activities were conducted at the Teacher Training Center at UFSCar. The goal was to create educational tools that struck a balance between technical rigor and practical applicability. We conducted the research in two main stages, using Action Research (TORRANCE, 1966) and FG (MORGAN, 1996) methods. In the first stage, 15 collaborative workshops were held with early childhood education teachers and undergraduate students in pedagogy and computer science, resulting in 10 design activities. In the second stage, early childhood education and computing experts evaluated the design activities through an FG, providing feedback on clarity, applicability, and technical depth, thereby promoting the refinement of the proposals. Results from the activities carried out in this first study are reported in Chapter 3 of this thesis.

Furthermore, this thesis benefited from the translation and adaptation of the rubrics proposed by Shively, Stith e Rubenstein (2018), originally developed to assess creativity, critical thinking, and design processes. The adaptation involved translating the original material and adapting the descriptors to the context of early childhood education and the children's age range, while preserving the conceptual structure of the instrument and adjusting its language and indicators to the typical forms of expression of childhood. Details of how this adaptation was carried out can be found in Appendix A.

Finally, after the framework formalization, a quasi-experimental study was conducted from July to September 2025. Two early childhood education classes from a school in São Carlos participated in the study, divided into an experimental group and a control group. The experimental group received the intervention according to the proposed framework, while the control group maintained the school's regular pedagogical routine during the

same period, enabling a comparison between the two contexts. The evaluation results are described in Chapter 5.

Figure 2 shows the methodology flow adopted in this study, presenting the methods and execution times for each step. The complete framework, in Portuguese, can be found in Appendix F.

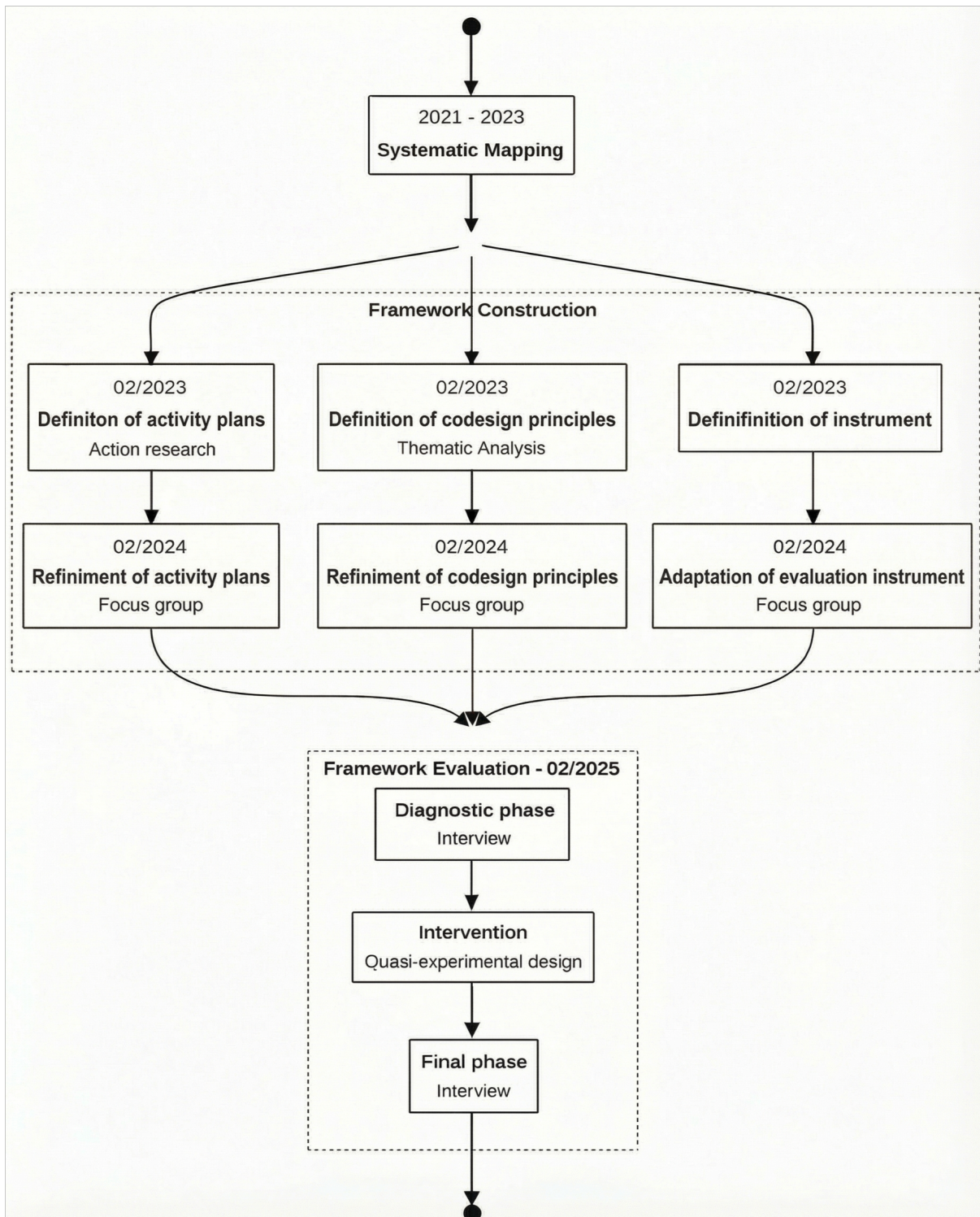


Figure 2 – Study methodology.

1.6 Thesis structure

This thesis comprises 6 chapters. Initially, Chapter 2 presents an article accepted for publication in the Journal of the Brazilian Computer Society. Later, Chapter 3 presents an article published at the Brazilian Symposium on Informatics in Education. Chapters 4 and 5 present articles submitted to journals. Finally, Chapter 6 concludes this work. In the following, we introduce the references and a summary of each article, highlighting its contributions:

[Chapter 2] RODRIGUES, S. M.; NERIS, V. P. A. Systematic Mapping of Co-Design and Participatory Design with Preschool Children: Techniques, Roles, and Methodological Challenges. Accepted to publication in Journal of the Brazilian Computer Society.

The systematic mapping carried out in this work revealed critical gaps in the literature, particularly the lack of standardized methodologies tailored to young children and the limited focus on learning outcomes in design-based approaches. Thus, this article identifies publication trends, research contexts, design techniques, participant roles, and methodological characteristics reported in empirical studies published between 2015 and 2025.

[Chapter 3] RODRIGUES, S. M.; NERIS, V. P. A. Design Principles for Computing Education in Early Childhood. In: XXXVI Simpósio Brasileiro de Informática na Educação, 2025, Curitiba. Anais do XXXVI Simpósio Brasileiro de Informática na Educação, 2025. p. 564-577.

Chapter 3 describes design principles derived from a thematic analysis of the literature and validated by experts in computing and education. In the context of this thesis, the design principles integrate the framework as a practical guide that helps the teacher to carry out co-design processes in classroom contexts.

[Chapter 4] RODRIGUES, S. M.; NERIS, V. P. A. Early childhood teachers and undergraduate students prototyping design activities to Computing Education. Submitted to a journal.

Chapter 4 presents the initial results of this study. The article outlines an action research conducted with undergraduate students in pedagogy and computer science, and early childhood education teachers. The objective was to create teaching materials for computing education that are accessible to early childhood education teachers. In the context of this thesis, the generated design activity plans are part of the framework as examples of how to apply computer science education through activities that consider children's daily lives.

[Chapter 5] RODRIGUES, S. M.; NERIS, V. P. A. Evaluating a Co-Design-Based Framework for Computing Education in Early Childhood: A Mixed Qualitative Triangulation Study with Preschool Children. Submitted to a journal.

Chapter 5 describes the final evaluation of the framework conducted in a real-world classroom setting at an early childhood education school in São Carlos, SP, Brazil. A semi-experimental study was conducted with an experimental and a control group. The experimental group participated in the intervention guided by the framework, while the control group maintained the school's regular pedagogical routine during the same period, allowing for comparison.

This thesis involved the use of computational tools to support different stages of its development, particularly in writing, revision, and visualization processes. Artificial intelligence-based tools, such as ChatGPT, were used to assist in refining the clarity, organization, and academic tone of the text, without generating original scientific content or influencing the research design and results. Grammarly was used to support grammatical revision and improve the quality of the English language. Additionally, the tool Manus.ia was employed in the creation of some illustrative images presented in this thesis, and Plotly was used to generate data visualizations, such as Sankey diagrams. All intellectual contributions, research decisions, and interpretations presented in this work are the sole responsibility of the author. The use of these tools was conducted in accordance with current academic integrity guidelines regarding Artificial Intelligence (AI)-assisted writing.

1.7 Another way to read this work

The composition of a thesis following the format of a collection of articles allows one to visualize the evolution of the work, as it shows preliminary results and highlights the sub-steps that led to them. If this is the intended reading order, it is recommended that the chapters be read in the sequence in which they were organized in this thesis.

However, if you wish to read this thesis following a more traditional format, Table 1 summarizes a possible structure considering the major areas of a scientific paper in computing.

Table 1 – Major areas of a scientific paper in computing and sections of this thesis

Areas of a scientific paper in computing	Content covered in this thesis	Sections
Summary of the literature review	Literature review on collaborative design with children aged 4 to 6 years.	2.5
Presentation of the theoretical framework	Computing education in early childhood	4.2.1 5.2.3
	Involvement of Teachers and Undergraduate Students in the Creation of Materials for Computing Education	4.2.2
	Design with children	4.2.3 5.2.2
	21st Century Skills	4.2.4
	CCI and early childhood development	5.2.1
	Assessing creativity and critical thinking in young children	5.2.4
Description of the framework construction studies	Creating design principles	3.3.1 3.3.2
	Creating design activity plans	4.4.1 4.4.2
	Adaptation of assessment rubrics	Appendix A
Formalization of results	Design Principles	3.4
	Design Activity Plans	4.5
	Assessment Rubrics	Appendix K Appendix L
Application and evaluation with end users	Framework assessment	5.4
Conclusion	Summary of contributions and critical analysis	6

Chapter 2

Systematic Mapping of Co-Design and Participatory Design with Preschool Children

Article title: Systematic Mapping of Co-Design and Participatory Design with Preschool Children: Techniques, Roles, and Methodological Challenges

Authors: Stefane Menezes Rodrigues; Vânia Paula de Almeida Neris

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Year: 2026

This chapter corresponds to the article “Systematic Mapping of Co-Design and Participatory Design with Preschool Children: Techniques, Roles, and Methodological Challenges” and represents the first stage of the methodological approach adopted in this doctoral research.

The purpose of this chapter is to establish a comprehensive overview of the scientific literature on co-design and participatory design involving preschool-aged children (4–6 years old). Through a systematic mapping study, this chapter identifies publication trends, research contexts, design techniques, participant roles, and methodological characteristics reported in empirical studies published between 2015 and 2025.

By synthesizing existing knowledge, this chapter highlights critical gaps in the literature, particularly the lack of standardized methodologies tailored to young children and the limited focus on learning outcomes within design-based approaches. These findings provide the theoretical and empirical foundation that justifies the need for the development of structured frameworks that integrate co-design, computing education, and early

childhood pedagogy. Consequently, this chapter directly informs the design decisions, principles, and empirical investigations presented in the subsequent chapters of the thesis.

2.1 Introduction

Computing has become an integral part of our lives, impacting everything from how we retrieve information to how we communicate. Children are no exception to this trend. No matter their surroundings, they are exposed to and influenced by the technology surrounding them. Digital natives are growing up in a world heavily shaped by computers and must navigate it fluently (MAJALI, 2020).

Even before they are literate, children learn to use most resources available through electronic devices randomly without having a specific objective (PAIVA; COSTA, 2015). Although children are surrounded by technology, children often remain passive users of technology (FISCHER; SCHARFF, 2000) and are unable to create, modify, or actively participate in technological solutions. Despite being surrounded by digital tools, they frequently lack an understanding of how these technologies are created or manipulated and are unaware of how they might leverage them to solve real-world problems.

For individuals to develop their skills and use technology effectively, they must understand and engage with the “digital world” just as they do with the physical one (ARETIO et al., 2019). This underscores the increasing importance of children learning about technology from a young age, with the support of adults (ROSE; HABGOOD; JAY, 2017).

Although current literature highlights the importance of involving children in the design process to improve their understanding and engagement with technology, very little has been done to map and study initiatives for younger children. Lehnert et al. (2022) study was a systematic review that provided an overview of how interaction design methods were carried out with children aged 0–18. While the work presents important contributions to the field, it summarizes that children of all ages participated, but the main focus was on those aged 7–13. To date, no studies have been found that address how collaborative design was carried out with preschool children.

While this growth in the literature has advanced some insights into young children introduced in the collaborative design process, little is known about the characteristics base inform this developing body of knowledge. For example, what ages of children are being included in collaborative design processes, and what roles? What are the techniques used in this process? And what are the other participants in the process? Considering these concerns, this systematic review of the literature is predicated on the need to better understand the characteristic knowledge base of the collaborative design with preschool children. The research question informing is: *How is the Co-design and PD process carried out with preschool-age children?*

We conducted a Systematic Mapping Study encompassing research published between 2015 and 2025. We searched several databases, including *Association for Computing Machinery* (ACM), Institute of Electrical and Electronics Engineers (IEEE), ScienceDirect, Scopus Elsevier, and Springer, using predefined inclusion and exclusion criteria to ensure the relevance and quality of the selected studies. The criteria focused on empirical studies involving children aged 4 to 6 in the design process using Participatory Design (PD) or Co-design methodologies. Our mapping synthesized 34 studies, from which we collected information such as year of publication, sources and databases, publication venues and locations, the temporal scope of the research, research approaches, and details about participants and researchers involved.

Our results reveal several key findings that contribute to the state of the art. We have observed an increase in publications over recent years, indicating a growing interest among researchers in involving preschool children in the design process. Seventeen different techniques were identified as being used in the studies, such as Comicboarding, Cooperative Inquiry, and Storytelling, although almost half of the PD studies (47.5%) did not clearly describe the methods used. Most studies included children in the roles of informants or users, while the role of design partners, considered the most inclusive, was adopted by only 8 of the 34 studies analyzed. In addition, a diversity of application contexts was found (schools, laboratories, homes), but in approximately 31% of the studies, this information was not reported.

These findings highlight the potential and the methodological and practical challenges of including young children in Co-design and PD processes. We have gained a clearer understanding of current practices and challenges in involving preschool-aged children in collaborative design, knowledge that was previously fragmented in the literature. Our study provides insights into effective techniques and highlights gaps where further research and methodological development are needed.

2.2 Background

The PD and Co-design approaches actively involve end-users in product, service, and technology development (HOWARD; SOMERVILLE, 2014; HUYBRECHTS; BENESCH; GEIB, 2017). These approaches have their roots in the tradition of participatory action research, which seeks to promote collaboration and co-creation between designers and stakeholders. Co-design and PD are collaborative approaches to design.

PD and Co-design approaches have been widely used as collaborative methodologies for creating technological and pedagogical solutions. PD stands out for its emphasis on democratic inclusion and user empowerment, particularly in contexts in which decisions directly impact participants. This approach is characterized by the application of methods such as collaborative workshops and participatory prototyping, which allow stakeholders

to actively contribute to all project phases (EHN, 2017). Co-design emerges as a more comprehensive evolution of this perspective, extending its application to various domains, such as education, health, and technological innovation. Focusing on collective creativity, Co-design uses playful and iterative tools to integrate the voices of multiple actors in the development of innovative solutions aligned with the specific needs of the groups involved (SANDERS; STAPPERS, 2008).

Despite sharing the goal of promoting active participation, PD and Co-design differ in their premises and applications. PD focuses on design process democratization, positioning users as co-decision makers (MULLER, 2003). On the other hand, Co-design emphasizes the construction of communities of practice by fostering a sense of belonging and collaboration among participants, who act as creative partners in the co-creation process (??). This approach facilitates the generation of innovative technological solutions and reinforces shared learning and the creation of collaborative networks. Thus, while PD has a more formal character and focuses on equality of power in decision-making, Co-design adopts a more exploratory and inclusive stance, allowing greater flexibility and creativity in academic and research projects.

In collaborative design studies with children, it is common to adopt the typology proposed by (DRUIN, 2002), which classifies children's roles into four main categories: users, testers, informants, and design partners. This classification has become a standard in the field because it provides a clear structure for analyzing the various levels of participation. However, contemporary authors have questioned its limits, especially when analyzing contexts in which participation does not fit into these categories. For example, Moraes, Falcão e Tedesco (2024) propose the recognition of intermediate roles, which arise from specific contextual conditions and challenge the deficiency of the traditional model. This discussion is particularly relevant to this work, which seeks to understand how children aged 4 to 6 were involved in Co-design and PD processes described in the scientific literature.

Co-design and PD with children, particularly when involving physical artifacts, expands the scope of their involvement beyond digital systems. Artifact-based design enables children to engage both tactilely and imaginatively, providing opportunities to integrate their lived experiences into the design. For instance, creating tangible tools or toys involves problem-solving and decision-making that align with their developmental stages and contextual knowledge.

Such approaches broaden the design landscape, allowing children's perspectives to inform diverse domains, including educational tools, play materials, and even urban spaces. Collaborative design processes are a valuable practice that benefits both children and the outcomes of the design process. Expanding this participation to include the creation of artifacts opens new avenues for engagement and innovation.

Including young children in these processes, however, presents challenges. It is nec-

essary to adapt methodologies, materials, and language to their capacity for attention, understanding, and symbolic expression, which may require additional time, resources, and careful planning (MECHELEN et al., 2017). Managing children’s expectations about implementing their ideas is also critical, ensuring they understand that not all contributions can be realized (KAPANEN et al., 2019). Furthermore, there is a substantial gap in the literature regarding the standardization of techniques and the systematization of how these methodologies have been implemented with this specific audience.

Although some methodologies, such as Cooperative Inquiry (DRUIN, 2002) and Comicboarding (HINIKER; SOBEL; LEE, 2017), are cited in studies with young children, it is still unclear how they are adapted to the preschool age group. Equally important, many studies focus on the products generated by children, neglecting procedural aspects such as the roles assumed by them, the contexts of application, and the forms of mediation adopted by adults. The absence of a consolidated view on these dimensions motivated the development of this systematic mapping, which seeks to synthesize evidence on how children aged 4 to 6 have been involved in Co-design and PD processes, identifying techniques, roles assigned to children, and the main methodological challenges faced.

2.3 Related Work

The inclusion of children in the technology design process is a recurring theme in Child-Computer Interaction (CCI). Alhatem et al. (2019) conducted a literature review on participatory design with children, focusing on children with visual impairments. The study highlights that PD can have a positive impact when including children with disabilities in the design process, allowing them to act as partners in technology development. Additionally, the work suggests that while there are different approaches and methods to engage participants during the design process, there is a lack of standardization in methodological choices and strategies for adapting methods to specific groups, such as children with visual impairments.

In the context of applied games, also known as serious games, Saiger, Deterding e Gega (2023) conducted a systematic review of children’s participation in game design, revealing that although PD and Co-design are widely used, there are still significant variations in how participation is implemented. Only half of the studies included children as true design partners. The authors suggest that the field would benefit from better documentation and justification for user involvement, as well as exploring factors that affect successful child participation, such as comprehension, cohesion, confidence, and accessibility.

Furthermore, the systematic review conducted by Ehsan et al. (2023) analyzed how engineering design was implemented with preschool children, highlighting the benefits of these activities in developing cognitive and technical skills. The authors suggest that while design practices provide valuable learning opportunities, there is still a lack of

standardization in the methods used to assess the impact of these activities, making it difficult to compare results across different studies.

Despite providing relevant contributions to the field of design with children, the studies by Alhatem et al. (2019), Saiger, Deterding e Gega (2023), Ehsan et al. (2023) present limitations that still leave important gaps in the understanding of practices with young children. The study by Alhatem et al. (2019), for example, reviews participatory approaches, but generically treats children, without segmenting them by age group or analyzing the specificities of the early childhood education audience. The review by Saiger, Deterding e Gega (2023), although broad, focuses on applied games and includes mostly older children, neglecting the methodological challenges of including children between the ages of 4 and 6 in design processes. In turn, Ehsan et al. (2023) discuss the presence of children in design engineering practices, but with an emphasis on STEM education and without detailing participatory techniques or school contexts.

None of these studies discusses in depth the roles effectively assigned to children, the duration of interventions, or the role of the teacher as a mediator, elements that this systematic mapping sought to make explicit. By addressing these aspects in greater detail, this work contributes to filling methodological gaps and offering more applicable subsidies to the field of Co-design and PD in early childhood education.

2.4 Materials and Methods

This Systematic Mapping Study aimed to provide a rigorous and repeatable process for identifying and documenting scientific studies investigating collaborative design with preschool children. Our primary goal in performing this study was to investigate how Co-design and PD methodologies are used to involve children aged 4 to 6 in designing technological solutions. The mapping was mainly based on the guidelines defined by Petersen et al. (2008), Petersen, Vakkalanka e Kuzniarz (2015). After identifying a set of relevant papers, we extracted the data needed to answer our research questions.

According to Petersen et al. (2008), Petersen, Vakkalanka e Kuzniarz (2015), a Systematic Mapping Study comprises five main steps: 1. Defining Research Questions, 2. Conducting the Search, 3. Screening of Studies, 4. Classification, and 5. Data Extraction.

In the *Defining Research Questions* step, we defined the research questions to guide our study, covering aspects such as the involvement of children in design processes and the methodologies employed. In the *Conducting the Search* step, we searched multiple digital databases to identify empirical studies involving preschool children (ages 4 to 6) in Co-design or PD processes. In the third step, *Screening of Studies*, we applied the inclusion and exclusion criteria to the retrieved studies. A total of 1217 studies were initially retrieved, with 34 studies ultimately selected for full analysis after applying the inclusion and exclusion criteria. In the fourth step, *Classification*, we categorized the

selected studies based on the role of children in the design process and the types of techniques used. Finally, in the fifth step, *Data Extraction*, we extracted relevant data from the selected papers according to the predefined criteria.

The study was conducted by the two authors of the article. The first author is a Ph.D. student and conducted all the steps of the study. The second author is a professor with a Ph.D. in Computer Science and actively participated in the creation of the research protocol and reviewed the remaining steps. All the steps are detailed in the next subsections.

2.4.1 Research Question

The high-level Research Question (RQ) of this study is: *How is the process of Co-design and PD carried out with preschool children?* Based on the main research question, we defined a set of two sub-questions and their motivations, summarized in Table 2. Each question covers a different facet of how the scientific literature has approached the design process, helping to outline a broad view of design with children and to structure our mapping results. Having such a comprehensive view is necessary to begin to look at design processes as a means of teaching computing concepts and providing environments that are more accessible and inclusive for such young children.

Table 2 – RQ and motivations.

Research Question	Motivation
RQ1: How are Co-design and PD methodologies used with preschool children?	This research aims to understand how Co-design and PD methodologies are applied in the context of preschool children. The characteristics extracted are design techniques, research participants, children’s ages, place of execution, and runtime.
RQ2: What is the role of children in the design process?	This research aims to understand the different ways in which children are integrated into the design process. In the context of Co-design and PD, it is essential to explore the roles played by children, whether they are informants, co-developers, or testers. The characteristics extracted are the design process steps.

2.4.1.1 Search Strategy

Two search strings were composed to identify all the possible articles that focused on collaborative design with preschool children (4 to 6 years). String 1 focused on children in the Co-design process, and String 2 focused on children in the PD process.

String 1: “(preschool OR “pre-school” OR kindergarten OR “early childhood”) AND (codesign OR co-design)”.

String 2: “(preschool OR “pre-school” OR kindergarten OR “early childhood”) AND (“participatory design”)”.

Five electronic academic database searches were performed in ACM, IEEE, ScienceDirect, Scopus Elsevier, and Springer. The searches were restricted to include research articles published between 2015 and June 2025. The Strings syntax was adapted to accommodate different database search peculiarities. Regarding the Springer search tool, a filter was performed at the time of the research, in which only studies included in the following categories were accepted: “Conference Paper” and “Article”. No other filters were applied to other databases or sources. Considering the two searches carried out, a total of 1217 studies were retrieved.

2.4.2 Inclusion and exclusion criteria

Articles were assessed against the inclusion and exclusion criteria presented in Table 3. For inclusion, articles had to be open-access. Articles that were not open-access were excluded. Articles not reporting on empirical research (e.g., theoretical works, systematic or scoping reviews), or articles not published in English, Portuguese, or Spanish were excluded.

Moreover, the definition of preschool varies from country to country, which is why only studies with children between the ages of 4 and 6 were considered. Some studies will present an age group different from that established. For example, studies investigating children aged 5-12 or 1-6 years will be presented. It should be noted that the first example concerns children aged 5-6 years, while the second example concerns children aged 4-6 years. For this mapping, to identify the characteristics of the knowledge base of collaborative design, the included articles had to use Co-design or PD with children aged between 4 and 6 years.

Table 3 – Inclusion and exclusion criteria

ID	Inclusion criteria	Exclusion criteria
1	The article focuses on children	The article focuses on children under 4 or over 6 years of age
2	The article is empirical research	The article is not open-access or paywalled
3	The article presents Co-design OR PD methods applied to children	The article was published before 2015
4		The article is not published in English, Portuguese, or Spanish

The study selection was conducted in two steps. In the first step, the titles and abstracts of each article were read. Then, the selection criteria were applied. When this preliminary reading was insufficient to obtain relevant information for research questions, the introduction and findings section of the study were read. In this study selection phase, 106 studies involving Co-design and 99 studies involving PD were accepted, totaling 205

articles selected for full reading. In the second step, full texts for the remaining articles were sought after the assessed relevancy of the full-text articles based on the inclusion and exclusion criteria. 205 full-text articles were assessed for inclusion; 171 were further excluded according to the exclusion criteria. In all, 34 articles were included in the review process.

Figure 3 details the results and the reasons for exclusion at each stage of the review process, including identification, screening, and classification.

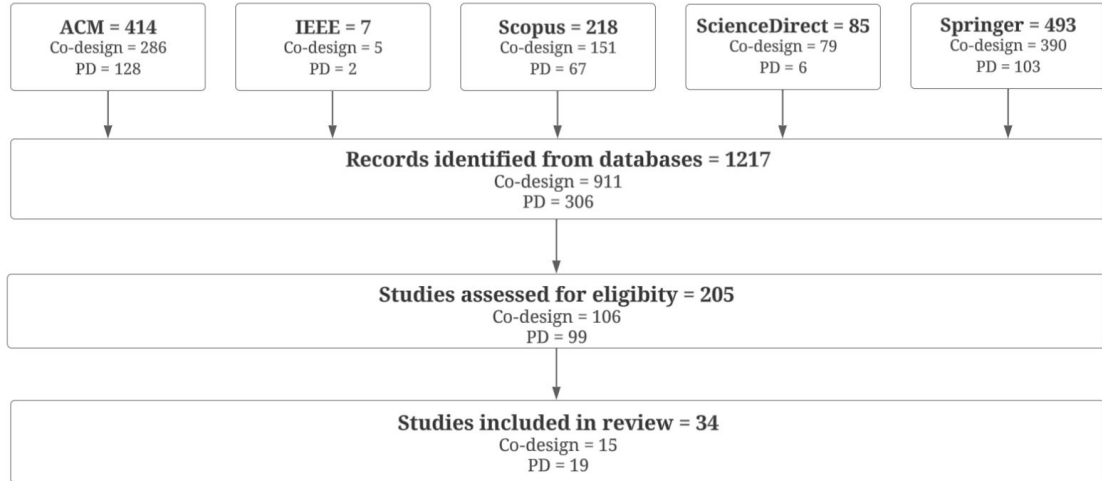


Figure 3 – Flow diagram of included studies.

2.4.3 Data extraction

The following information was extracted from each article: (a) authors; (b) year of publication; (c) title; and (d) the country in which the study was conducted. Additionally, a classification scheme was developed to analyze other aspects related to each research study. The classification scheme is described below, as the categories used to classify the data.

- ❑ **Children age:** age range of children participating in the study.
- ❑ **Design technique:** techniques used during the design process, such as Co-creation, Comicboarding, Cooperative Inquiry, and others.
- ❑ **Children role:** using Druin's framework (DRUIN, 2002), children were classified as users, informants, testers, or design partners.
- ❑ **Research Participants:** the participant was classified according to their involvement in the research, such as child, teacher, researcher, parents, teacher, etc. When several participants took part in the research, they were grouped as: (researcher and child), (researcher, parents and child), (researcher, teacher and child), etc.

- ❑ **Place of execution:** the setting in which the study was conducted (school, university, research laboratory, etc.).
- ❑ **Runtime:** duration of design sessions with children. The time was classified considering the number of meetings held or the duration, considering weeks and months.

Data was collected, analyzed, and categorized according to the classification scheme.

2.4.3.1 Threats to Validity

According to Petersen, Vakkalanka e Kuzniarz (2015), threats such as descriptive validity, theoretical validity, interpretive validity, and repeatability can impact the quality of a study. Each of these threats and the measures taken to mitigate them are detailed below.

Descriptive validity is achieved when observations are described accurately and objectively (PETERSEN; VAKKALANKA; KUZNIARZ, 2015). To reduce threats, a data extraction form was used to support data extraction.

Theoretical validity is determined by our ability to capture what we intended to capture (PETERSEN; VAKKALANKA; KUZNIARZ, 2015). One potential threat is having only one person conducting the study selection, which can cause important studies to be missed. In this study, the inclusion and exclusion criteria were conducted by the first author. However, whenever there was any doubt regarding the classification, the second author was consulted, and a joint decision was made. Another threat can occur in the data extraction and classification process. The first author conducted the classification process to minimize this threat, but the second author reviewed the categories created.

Interpretive validity is achieved when the conclusions drawn are reasonable given the data and therefore map to the validity of the conclusion (PETERSEN; VAKKALANKA; KUZNIARZ, 2015). A major threat in data interpretation is researcher bias, which was minimized by having a co-author review the study.

Repeatability requires a detailed account of the research process that is presented in this paper and follows existing guidelines (PETERSEN; VAKKALANKA; KUZNIARZ, 2015). In this research, we took steps to maximize repeatability, such as well-defined inclusion and exclusion criteria, a list of criteria used for exclusion, and the data extraction form.

A snowballing sampling process was not performed, nor was a manual search included, due to the number of studies found (29 in total). We believe that the total number of studies provides us with an overview of the literature. However, this may be a limitation of this study. Furthermore, the exclusion of articles with restricted access may have led to coverage bias.

Another limitation concerns the databases used. Even though the ACM, IEEE, Springer, ScienceDirect, and Scopus databases returned 1217 papers to filter and ana-

Table 4 – Combined details of articles included in this review.

Details	Number of Co-design articles	Number of PD articles
Year of publication		
2015		2 (10,5%)
2016		2 (10,5%)
2017	3 (20%)	5 (26,3%)
2018	2 (13,3%)	1 (5,2%)
2019	2 (13,3%)	1 (5,2%)
2020	3 (20%)	5 (26,3%)
2022	1 (6,6%)	1 (5,2%)
2023	1 (6,6%)	
2024	3 (20%)	2 (10,5%)
Country (of study)		
United States	6 (40%)	3 (15,7%)
China	1 (6,6%)	2 (10,5%)
Romania	1 (6,6%)	1 (5,2%)
Sweden	1 (6,6%)	1 (5,2%)
Denmark	1 (6,6%)	
Italy	2 (13,3%)	
Korea	1 (6,6%)	
Spain	1 (6,6%)	
United Kingdom	1 (6,6%)	
Australia		3 (15,7%)
Greece		3 (15,7%)
Finland		2 (10,5%)
Brazil		2 (10,5%)
Germany		1 (5,2%)
Costa Rica and Brazil		1 (5,2%)

lyze, which we considered a reasonable amount, we left important databases out of our protocol, such as the Brazilian Computer Society’s Digital Library (SOL). In particular, SOL presents technical limitations regarding its integration with systematic review tools and automated search procedures, which hindered its inclusion in our protocol. We recognize that this exclusion may limit the coverage of studies published in the Brazilian context. Therefore, we suggest that future systematic mappings consider strategies to include SOL in order to better encompass national research in this area.

2.5 Results

From the initial 1217 studies, 34 were selected according to the selection criteria, which represents 3.11% of the retrieved papers. The full list of selected papers, including title and author name, is present in the Appendix D and E.

The combined characteristics of the 34 articles included in this review are provided in this section. The characteristics were divided considering which methods were used in the study. Table 4 provides details of all articles included in this review.

In summary, Co-design studies were conducted in the United States (40%), Italy

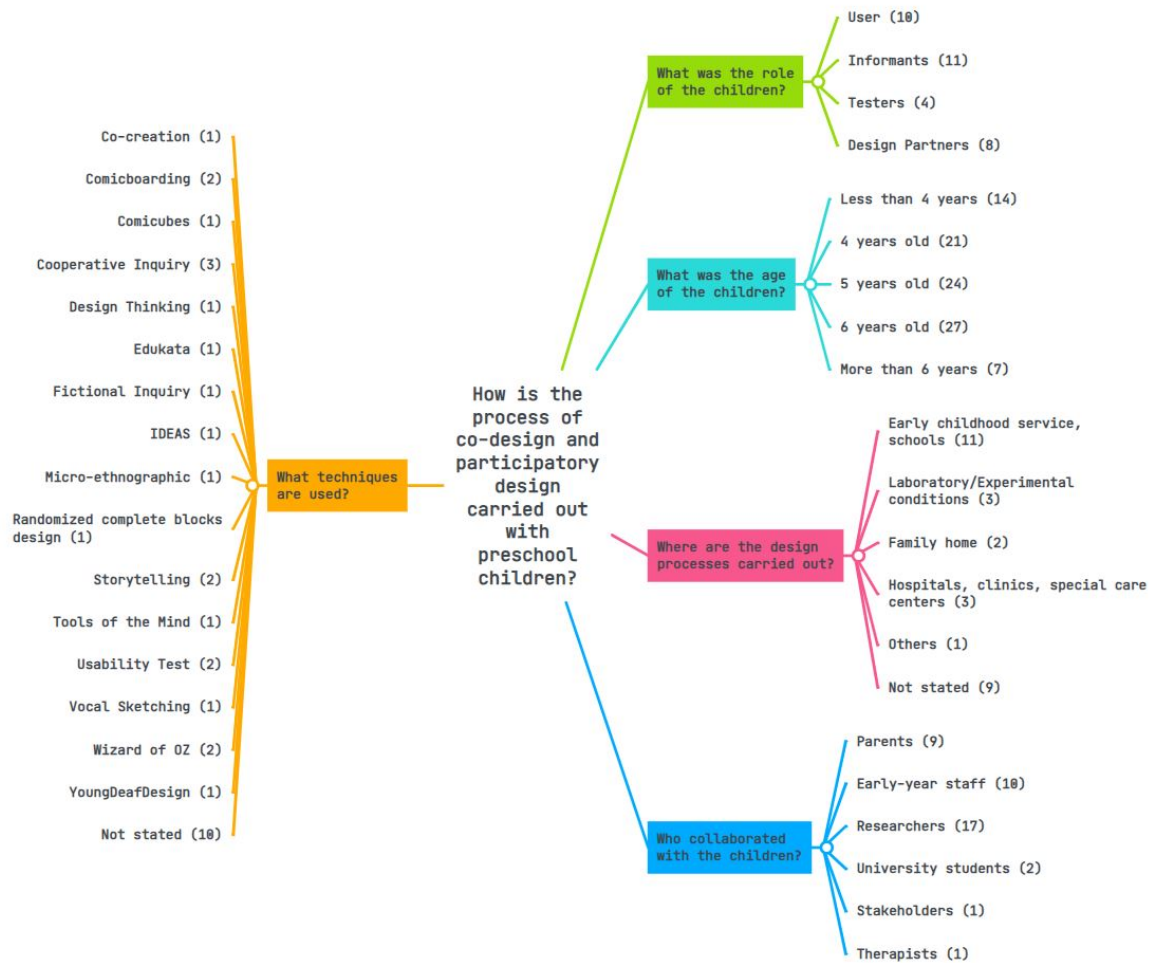


Figure 4 – Overview of Research Questions.

(13,3%), Denmark (6,6%), China (6,6%), Korea (6,6%), Romania (6,6%), Spain (6,6%), United Kingdom (6,6%), and Sweden (6,6%). PD studies were conducted in Australia (15,7%), Greece (15,7%), the United States (15,7%), China (10,5%), Finland (10,5%), Brazil (10,5%), Germany (5,2%), Romania (5,2%), and Sweden (5,2%). One PD study was conducted across Costa Rica and Brazil. It is possible to notice an increase in the number of studies over the years (in both methods), this growth decreases considerably during the COVID-19 pandemic between 2020 and 2021 and grows again in 2024. Therefore, the field of study relating collaborative design methodologies to preschool children still needs to be explored, regardless of the method used.

Figure 4 summarizes the results of the research question, presenting the main categories created for each extracted data item. The number in parentheses indicates the number of articles related to the respective category, without considering methods.

2.5.1 Answering the Research Questions

In the following, we answer each of the research questions.

Table 5 – Participants of articles included in this review.

Participant group	Number of Co-design articles	Number of PD articles
Children	12 (100%)	17 (100%)
Parents	7 (58,3%)	2 (11,8%)
Early-year staff	6 (50%)	4 (23,5%)
Researchers	4 (33,3%)	13 (70,5%)
University students	1 (8,3%)	1 (5,9%)
Stakeholders		1 (5,9%)
Therapists		1 (5,9%)

RQ1: How are Co-design and PD methodologies used with preschool children?

All the studies involved children (15 Co-design and 19 PD studies). However, as we can see in Table 5, other participants are involved in the research, such as parents (8 Co-design and 3 PD studies), early years staff (7 Co-design and 6 PD studies), university students (2 Co-design and 1 PD studies), stakeholders (1 Co-design and 1 PD study), and health professionals (1 Co-design). In several studies, the researchers actively participated in the design process (5 Co-design and 16 PD studies). In these cases, the researcher was responsible for conducting activities with the participants and was responsible for leading the design process. “Early childhood staff” includes early childhood education teachers, pedagogues, service directors, and possible actors who are part of early childhood education.

Among this wide variety of participants, we can see different groups working together, such as “children and parents”, “children, parents and Early-year staff”, and “children, therapists and researchers”, for example. Figure 5 presents all the different groups of participants identified in the studies. It is observed that PD is predominantly employed in interactions between children and researchers (10 studies), while Co-design is widely used in contexts involving children and multiple groups, such as parents, Early-year staff, and researchers. In addition, Co-design also stands out for the diversity of participating groups, including children, university students, and other stakeholders, reinforcing its collaborative and inclusive character. On the other hand, PD presents a more focused application, especially in contexts where researchers have a greater influence on the design process. These results suggest that Co-design is more frequently used in scenarios that require collective creativity and integration of multiple perspectives, while PD is better suited to processes with a more directive and hierarchical focus.

All studies involved children aged 4 to 6 years. However, several ages were mapped. Some studies include children under four years old or over 6. Examples in this area are studies that involve children between 4-11 years old in their design process (ID-1) or studies that include children from 2-6 years old (ID-15).

Specifically, 25 studies included 4-year-old children, 29 studies worked with 5-year-old children, and 22 with 6-year-old children. Some studies also incorporated children

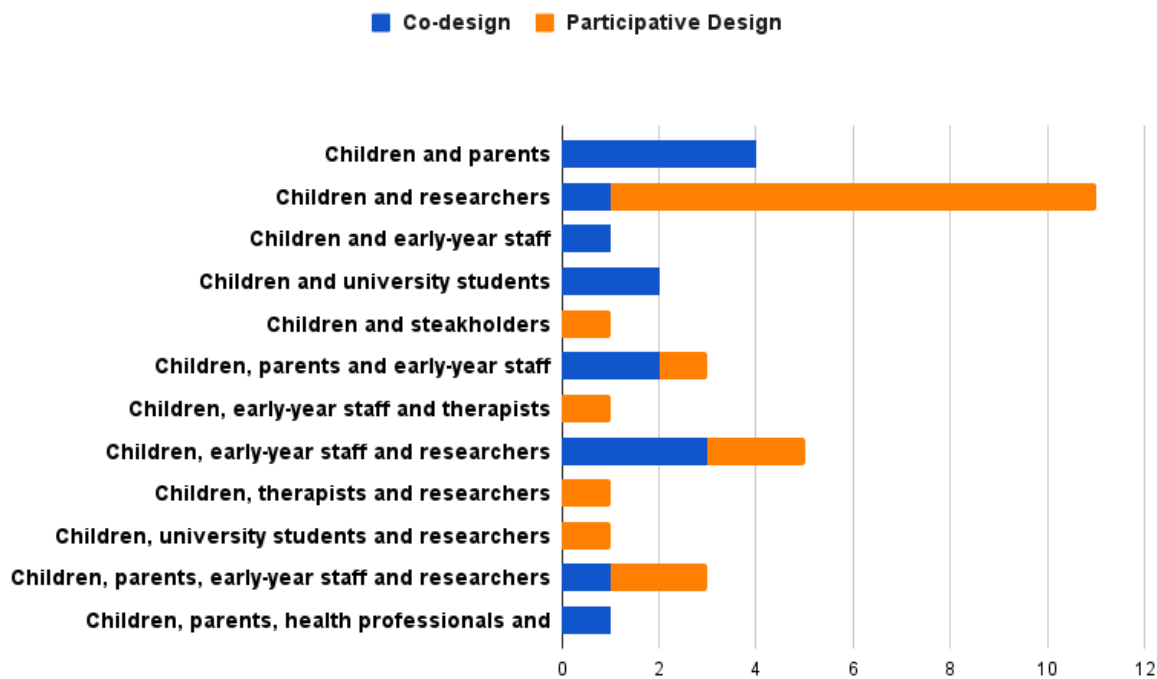


Figure 5 – Group of participants.

outside this age range; 17 studies included children under 4 years old, and 8 studies included children over 6 years old, indicating an age diversity in the processes analyzed.

Most studies involved children between 4 and 5 years old, while children under 4 or over 7 years old appeared less frequently. This age concentration may be related both to the literature in the area, which traditionally explores involvement in early childhood, and to practical factors, such as children's communication skills and expectations of inclusion in structured design processes. Older children, on the other hand, tend to be included in studies focused on formal computer or robotics education, which may explain their lower presence in this mapping focused on early childhood.

Table 6 presents the studies classified considering the age goal of the research. In this case, a study with 3 to 6-year-old children will be counted four times in the classification (less than 4, 4, 5, and 6 years), for example.

Table 6 – Children's age in articles included in this review.

Ages	Number of Co-design articles	Number of PD articles
Less than 4 years	9	8
4 years old	14	11
5 years old	13	16
6 years old	6	14
More than 6 years	2	6

The settings where design processes were conducted included a wide range of con-

texts. Data were predominantly collected from formal education settings such as early childhood services and schools (3 Co-design and 11 PD studies). These include, for example, primary schools, elementary schools, preschools, kindergartens, and daycare centers. Another location option that appeared was laboratories with experimental conditions, including university-based laboratories and workshops (2 Co-design and 2 PD studies). Furthermore, in Co-design studies, 2 (13,3%) studies captured data from families' homes during the pandemic, and 1 (6,6%) study from other public spaces such as museums. In PD studies, 3 (15,7%) studies captured data from hospitals and special care centers. Finally, a large number of studies did not state the setting of the study (7 Co-design and 3 PD studies). Table 7 shows this classification.

Table 7 – Classification of included articles according to the place of execution.

Setting (of study)	Number of Co-design articles	Number of PD articles
Early childhood service, schools	3 (20%)	11 (57,8%)
Laboratory/Experimental conditions	2 (13,3%)	2 (10,5%)
Family home (including through telephone/Skype/Zoom)	2 (13,3%)	
Others (e.g., public spaces including museums)	1 (6,6%)	
Hospitals, clinics, special care centers		3 (15,7%)
Not stated	7 (46,6%)	3 (15,7%)

In most studies, the activities took place in school contexts, which reveals a predominance of the use of Co-design and PD as a strategy to support teaching and learning processes. Projects carried out in schools tend to focus on the development of cognitive, motor, and social skills, while those carried out in laboratories or museums (ID-2, ID-4) sought to test technologies under development or expand children's creative expression. The prevalence of the school context may be associated with the ease of access to groups of children, the curricular integration with pedagogical activities, and the educational potential of the artifacts developed.

Without considering methods, studies had different durations, ranging from 1 session to 3 years. The classification mainly considered the number of meetings held. Studies classified as unique sections could include 30-minute to 3-hour meetings. Studies with durations in weeks, months, and years did not provide the number of meetings that were held in this period. Table 8 shows this classification.

The studies analyzed varied greatly in duration, ranging from one-off activities of 1 or 2 sessions (ID-1, ID-6, ID-15, ID-24, ID-26) to longitudinal projects with more than 25 sessions or that lasted for months or even years (ID-22, ID-27, ID-30, ID-33). Short-term studies were generally related to exploratory proposals, concept testing, or immediate feedback collection. Long-term studies were often associated with school contexts with ongoing weekly meetings and involved greater engagement of children in multiple stages

Table 8 – Design process duration in articles included in this review.

Ages	Number of Co-design articles	Number of PD articles
1 section	1	3
2 sections	2	
3 sections	1	1
4 sections	1	1
6 sections		1
10 sections		1
12 sections	1	
15 sections	1	1
2 weeks		1
3 weeks	1	
2 months		1
3 months	1	1
4 months	1	1
3 years		1
Not stated	4	7

of the design process. This difference appears to be related to the type of institution involved (e.g., school vs. research laboratory), the degree of maturity of the project, and the methodological proposal adopted. 4 Co-design studies and 7 PD studies did not state the process duration. There is no consensus or homogeneity about the duration of design processes carried out with preschool children.

To understand how these collaborative design processes were conducted, it is important to know what techniques are used in the process. We identified 17 distinct approaches. All the techniques reported in the 34 studies will be listed and described objectively. They were presented alphabetically and referenced with the study ID in which they were used.

- ❑ **Co-creation:** it's a collaborative development of new value (concepts, solutions, products, and services) together with experts and/or stakeholders (such as customers, suppliers, etc.). Co-creation is a form of collaborative innovation: ideas are shared and improved together, rather than kept to oneself (SANDERS; STAPPERS, 2008) (ID-1).
- ❑ **Comicboarding:** is a requirements elicitation technique that uses comics with partially completed content to scaffold children's storytelling and ideation. It leverages familiar narrative formats to reduce cognitive load and support expression of design ideas (MORAVEJI et al., 2007) (ID-3, ID-20).
- ❑ **Comicubes:** is a tangible physical object that allows for three-dimensional manipulation. The tool affords various forms of interaction, depending on its users' age and skills. Comicubes combine ideas associated with toys, games, and comic-style storytelling (HELJAKKA; IHAMÄKI, 2016) (ID-24).
- ❑ **Cooperative Inquiry:** also known as collaborative inquiry, is a participatory design approach that proposes involving children as partners in the design pro-

cess, working side by side with adults (researchers, designers, developers) during all phases of technological development (DRUIN, 1999) (ID-1, ID-20, ID-32).

- ❑ **Design Thinking:** is a methodology that imbues the full spectrum of innovation activities with a human-centered design ethos. It is a way of finding human needs and creating new solutions using the tools and mindsets of design practitioners (BROWN et al., 2008) (ID-14, ID-19).
- ❑ **Edukata Design Model:** includes several workshops with stakeholders that iteratively progress with reflection sessions. The activity aims to reach set goals and outputs. The PD sessions in Edukata enhance participants' understanding of the design context, challenges, and opportunities, guiding them to achieve concrete results (TOIKKANEN; KEUNE; LEINONEN, 2015) (ID-34).
- ❑ **Fictional Inquiry:** is a design method in which designers and users collaborate within a shared fictional world. By creating a fictional context and inviting participants to adopt roles within it, the method allows for exploration of design ideas and issues beyond the constraints of current reality (DINDLER; IVERSEN, 2007) (ID-3).
- ❑ **Interface Design Experience for the Autism Spectrum (IDEAS):** is a PD methodology developed specifically to support children with Autism Spectrum Conditions (ASC) within co-design activities. It includes strategies to scaffold participation, such as familiarization with people and spaces, consistent routines, and adapted communication methods (BENTON et al., 2012) (ID-16).
- ❑ **Micro-ethnographic Explorations:** the ethnographer, photographer, and videographer record particular images or events. In turn, it makes visible the social patterns, practices, and norms of their group (SMITH, 1978) (ID-27).
- ❑ **Randomized Complete Block Design:** is an experimental design in which experimental units are grouped into blocks, and treatments are randomly assigned within each block. Each treatment appears once in every block ("KUEHL, "2000") (ID-2).
- ❑ **Storytelling:** it consists of engaging in meaning-making and world-building, constructing identities and negotiating social roles through the act of telling stories (NICOLOPOULOU, 2013) (ID-13, ID-15).
- ❑ **Usability Test:** a technique used to evaluate a product by testing it on users, to identify usability problems, collecting qualitative and quantitative data, and determining the participant's satisfaction with the product (NIELSEN, 1994) (ID-17, ID-22).

- ❑ **Tools of the Mind:** an early childhood curriculum and teaching approach grounded in Vygotskian theory, emphasizing the development of cognitive and self-regulation skills through structured make-believe play, private speech, and scaffolding (BODROVA; LEONG, 2024) (ID-11).
- ❑ **Vocal Sketching:** is the act of using one’s voice to produce a representation or prototype of a sound-related design idea. This method aims to support ideation and communication during participatory design sessions focused on auditory features (FALKENBERG et al., 2020) (ID-4).
- ❑ **Wizard of OZ:** this is a process in which a user interacts with an interface without knowing that the responses are being generated by a human, not a computer (DAHLBÄCK; JÖNSSON; AHRENBORG, 1993) (ID-5, ID-12).
- ❑ **YoungDeafDesign Design Method:** is a method that consists of four phases to design with young deaf children: Sensitization, Design Sessions, Clustering and Analysis, and Final Concept Design. It emphasizes multimodal, visual, and embodied interactions to accommodate children’s communication preferences and to support inclusive design processes (BRINCK et al., 2022) (ID-33).
- ❑ **Not stated:** when the method used for the design process is not mentioned by the author (ID-6, ID-7, ID-8, ID-9, ID-10, ID-18, ID-21, ID-23, ID-25, ID-26, ID-28, ID-29, ID-30, ID-31).

Table 9 – Techniques used in articles included in this review.

Techniques	Number of Co-design articles	Number of PD articles
Co-creation	1	
Comicboarding	1	1
Comicubes		1
Cooperative Inquiry	1	2
Design Thinking	1	1
Edukata		1
Fictional Inquiry	1	
IDEAS		1
Micro-ethnographic exploration		1
Randomized complete blocks design	1	
Storytelling	2	
Tools of the Mind	1	
Usability Test		2
Vocal Sketching	1	
Wizard of OZ	2	
YoungDeafDesign		1
Not stated	5	9

Table 9 shows all mapped techniques divided by the number of occurrences in which method. Usability testing is not a design method but an interface evaluation method. However, in these cases, children participated as testers of ready-made solutions.

Several studies have not stated which techniques were used. In PD studies, this case represents 47,3% of all PD studies recovered. In Co-design studies, this represents 33,3%. Furthermore, we noticed that only Comicboarding and Cooperative Inquiry were used in both approaches.

Some techniques were used together. Examples in this area included studies where (a) Comicboarding and Fictional Inquiry were used in a workshop to generate ideas for implementing a system to help children plan how to spend their free time with media (ID-3); (b) Cooperative Inquiry and Co-creation were used to engage children in an inclusive letter-writing app design (ID-1); and (c) Cooperative Inquiry and Comicboarding were used to design a mobile game to help preschoolers learn Chinese characters (ID-20).

It is important to highlight that, among the techniques identified in this mapping, two were proposed in the studies analyzed: YoungDeafDesign (ID-33) and Vocal Sketching (ID-4). These approaches are not based on previously consolidated methods. Still, they are described as original creations developed specifically to meet the needs of certain groups of children in participatory design contexts (deaf children and young children involved in sound interaction design processes). The presence of original methods in the primary studies represents a significant contribution to the area, evidencing a movement of adaptation and methodological innovation aimed at inclusion and expanding forms of child participation.

Regarding the products developed, the highlights were paper prototypes (ID-2, ID-5, ID-6, ID-20, ID-25, ID-32), simple digital interfaces (ID-12, ID-19, ID-23), physical materials such as musical instruments (ID-4), 3D tactile materials (ID-15), 3D cubes, (ID-24), and multimodal materials such as texts, draws, videos, and audios (ID-7, ID-26, ID-27, ID-34). In some cases, the products were the result of single ideation sessions; in others, they were developed over several weeks of activities. These creations not only formed the final artifacts of the projects but also served as tools of expression for the children.

RQ2: What is the role of children in the design process?

Children's roles in the design process were categorized based on Druin's framework (DRUIN, 2002), which identifies children as users, testers, informants, or design partners. This can help to understand the children's role in the design process.

- **Users:** Children are considered the final recipients of the technology, with their involvement limited to interacting with completed designs. In this role, the focus is primarily on observing how children use the product to identify issues or opportunities for improvement. Usability testing and observational studies are commonly

employed methods at this stage, where children’s input is indirect and occurs after design.

- ❑ **Informants:** Children serve as valuable sources of insight during specific phases of the design process, such as ideation or prototype evaluation. Designers rely on interviews, observations, and discussions to understand children’s needs, behaviors, and preferences, which inform the design decisions. However, their involvement is periodic and situational rather than continuous.
- ❑ **Testers:** children engage with early or intermediate versions of the technology, providing direct feedback on functionality and user experience. This role represents an iterative approach, where children’s responses are utilized to refine the design incrementally. While children contribute actively through feedback, their influence on the conceptualization and decision-making aspects of design remains minimal.
- ❑ **Design Partners:** Children become integral contributors throughout the entire design process. As partners, they work alongside designers, participating in brainstorming sessions, decision-making, and the iterative refinement of ideas. This role embodies the principles of Co-design and PD, emphasizing shared ownership and mutual learning between children and adults. It also reflects a methodological shift, requiring designers to adapt processes to accommodate children’s active and meaningful participation.

The categorization of children’s roles was based on Druin (2002) taxonomy, as it is the most consolidated approach in the literature and allows comparison with previous studies. However, we recognize, as argued by Morais, Falcão e Tedesco (2024), that this classification may not capture all the nuances of children’s participation, especially in school contexts less structured for participatory practices. These authors propose the recognition of intermediate roles, which move between classic categories and reflect more situated forms of children’s involvement. Although we have maintained Druin’s classification in this study, we consider these contributions relevant.

Table 10 shows the children’s roles in the design process. In some Co-design studies, children had more than one role in the design. In the PD studies, children had a single role.

Table 10 – Children’s roles in articles included in this review.

Role	Number of Co-design articles	Number of PD articles
Users	5	5
Informants	8	4
Testers	3	3
Design Partners	4	7

In the Co-design studies, most children were included as users or informants. 5 studies included children as users (ID-2, ID-9, ID-10, ID-12, and ID-13) and 8 as informants (ID-1, ID-8, ID-10, ID-11, ID-12, ID-13, ID-14, ID-15). Only 4 studies included children as design partners (ID-3, ID-4, ID-6, ID-7), which represents a small number in this role, as children have significant input into all phases of design. In PD studies, 5 studies included children as users (ID-16, ID-17, ID-22, ID-28, ID-33), 4 as informants (ID-20, ID-27, ID-29, ID-32), and 7 as design partners (ID-21, ID-23, ID-24, ID-25, ID-26, ID-30, ID-34). Here we can see more studies including children in the role that most contributes to their learning. The role of testers was the least used, with 3 studies in each method (ID-1, ID-5, ID-8, ID-19, ID-20, ID-31).

In all PD studies, children had a single role during design. In contrast, in Co-design studies, we can observe children with more than one role, such as informants and users (ID-10, ID-11, ID-13) or informants and testers (ID-1, ID-8).

In the studies involving children as informants (ID-10, ID-27, ID-29, ID-32), children were consulted about preferences, themes, and visual elements, usually in the middle or final stages of the project. When they acted as users (ID-9, ID-16, ID-17, ID-22, ID-28), children participated in the activities only as end users, interacting with games, virtual agents, or interfaces that had already been developed. Their actions were observed for validation or usability evaluation purposes, without direct involvement in creative or conceptual decisions. While this type of participation is still valid in the context of child-centered design, it limits the opportunities for active listening and agency on the part of children in the design process.

The role of design partners appeared in smaller numbers, but with more expressive contributions. In ID-24, for example, children participated from the definition of the problem to the creation of physical and digital solutions, including the assembly of narrative cubes and the dramatization of situations. In the ID-3 study, children were involved in recurring co-investigation and design sessions, acting in all phases: ideation, development, and validation of prototypes. In these cases, they were able to directly influence decisions about the aesthetics, narrative, and functionality of the products created.

Furthermore, combined roles were found, such as “user and informant” (ID-11, ID-12, ID-13) or “informant and tester” (ID-1, ID-8), indicating that, in some cases, the child’s involvement was progressive or multifaceted. This variation shows that practice does not always fit neatly into classic models of participation, suggesting the need for more flexible and context-sensitive categories.

In some cases, children aged 4 and under had a little more difficulty being included in the design process. The authors point out that 4-year-old participants responded to the requests creatively, but with completely off-topic comments (ID-3), had difficulty creating paper prototypes that related to what was requested (ID-20), and in some cases, the children did not always present enough information in their designs (ID-4). Another

point raised would be the anxiety that caused the children to be unable to pay attention to the instructions (ID-31).

2.6 Discussion

This section critically analyzes the main findings of the mapping, focusing on the aspects that favored or limited the participation of children aged 4 to 6 in Co-design and PD processes. Based on the studies analyzed, good practices observed, difficulties faced, and recommendations that emerge from the practice with this specific audience are discussed.

A recurring and successful practice was the use of concrete materials and narrative techniques, especially for children aged 5 to 6. For example, studies that applied Comicboarding and the use of physical cubes reported that these resources facilitated the communication of ideas, even by children with little verbal fluency. Children are actively engaged when manipulating blocks, assembling stories with images, or drawing on interactive surfaces. Techniques such as Storytelling and Edukata were also associated with a greater ability of children to imagine and prototype solutions collaboratively, as observed in projects that resulted in prototypes of games, instruments, and multimodal narratives (texts, photos, audios, and videos).

These findings can be further understood through the lens of embodied cognition, which proposes that cognitive processes are grounded in bodily action and sensorimotor interaction with the environment (WILSON, 2002; THELEN, 2000). The effectiveness of techniques based on tangible manipulation, gesture, and physical exploration aligns with evidence indicating that young children often “think through doing,” with cognition tightly linked to action and movement. This perspective suggests that the success of tangible and narrative-based design activities is theoretically expected and reinforces the need for methods that integrate materiality and embodied interaction into early childhood design processes (GLENBERG, 2010; DOURISH, 2001).

Short, iterative, and well-organized sessions were more effective. Studies that held weekly meetings lasting between 30 and 60 minutes, allowing time for adaptation, reported greater comfort and involvement among children. The presence of adults with a facilitating attitude was also a differential. In school contexts where teachers were prepared to act as mediators of the process, greater fluidity in exchanges and greater autonomy among children in proposing and reviewing ideas were observed, as in projects that used the Cooperative Inquiry methodology.

From a Vygotskian perspective, this facilitator role can be interpreted as a form of scaffolding, temporary support strategies that help children accomplish tasks they would not be able to complete independently (VYGOTSKY, 1978; WOOD; BRUNER; ROSS, 1976). Such mediation, which may include modeling actions, reframing questions, or

co-constructing prototypes, aligns with the Zone of Proximal Development (ZPD), in which learning progresses through guided participation. This framing helps explain why sessions with well-prepared adults or teachers produced richer contributions and more sustained engagement, particularly among younger children whose executive function and self-regulation are still developing (CARLSON, 2016).

The mapping identified a variety of products created by children, from paper prototypes and digital interfaces to videos, illustrated stories, and physical games. Children participated in the creation of artifacts that reflected their ideas about technology, everyday life, and play. In one project, for example, they created a prototype for an AI voice agent that guided children through the toilet (HUH et al., 2022), and in another, they composed a Child Orchestra using co-designed musical instruments (CORE et al., 2017). These results show that, even at an early age, children can contribute significantly and materially to the design process when the context is favorable.

This collaborative artifact creation also resonates with socio-constructivist theories, which emphasize that knowledge is co-constructed through social interaction and shared meaning-making (ROGOFF, 2003). Many co-design activities in the studies, such as group prototyping, collaborative storytelling, or negotiated decision-making, functioned as social learning processes. Peer interaction, dialogue, and joint problem-solving, long recognized as cognitively valuable (FORMAN; CAZDEN, 2013), appear to play a central role in enabling children to articulate and refine design ideas. Thus, the social nature of many design sessions is not only methodologically relevant but theoretically significant.

One of the most notable challenges was the lack of a detailed methodological description. In 14 studies, the techniques used were not specified or were described in a generic way, which makes critical evaluation and replication of successful experiences difficult. Furthermore, few studies reported how the sessions were structured, how the adults were mediated, or how the children's ideas were documented. This methodological opacity represents a barrier to the consolidation of good practices in the area.

The categorization of children's roles revealed a predominance of passive participation. Most studies classified children as users or informants, with only 11 considering them as design partners. This tendency often reflects structural limitations, such as the organization of schools, teacher training, or the research model adopted. Even when children participated in creative sessions, they did not always influence design decisions. There was also an underrepresentation of children under 5 years old, which points to a possible age bias in the selection of participants.

Interpreting these patterns through theoretical perspectives helps clarify why they matter. Participation roles that restrict children to users or informants limit opportunities for scaffolding, embodied exploration, and social co-construction of meaning, mechanisms known to support early learning and development (VYGOTSKY, 1978; GLENBERG, 2010). Conversely, studies that engaged children as design partners tended to align more

closely with principles of socio-constructivism and guided participation, providing conditions for agency, creativity, and deeper involvement in the design process.

Based on the analysis of the 34 studies, some lessons for the practice of collaborative design with young children stand out: (I) Methods based on visual narrative and physical manipulation (e.g., Comicboarding, Storytelling, blocks) proved to be more effective for children aged 5–6; (II) The structure of the sessions (short, iterative, and continuous) favored engagement and reduced dispersion; (III) The role of the adult facilitator needs to be better described and valued, as it is central to ensuring children’s protagonism; (IV) Studies that allowed children to see their products take concrete form reported greater motivation and a sense of belonging to the process; and (V) There is a lack of systematic studies with children aged 3 and 4, which represents a relevant gap to be explored.

Integrating these insights with established theories suggests that approaches deliberately incorporating scaffolding (VYGOTSKY, 1978), embodied interaction (WILSON, 2002), and collaborative meaning-making (ROGOFF, 2003) may be particularly effective in supporting meaningful participation in early childhood design contexts. Future research can benefit from grounding methodological choices in these theoretical perspectives, enhancing both rigor and explanatory power.

2.7 Conclusion

This systematic mapping analyzed 34 studies involving children aged 4 to 6 in Co-design and PD processes. The most commonly used techniques included visual narratives, physical objects, and mediated sessions in school contexts. Most children were included as informants or users, and only a third of the studies considered the child as a design partner.

The results reveal good practices, such as the use of playful materials, structured sessions, and active mediation, but they also point to persistent challenges, such as the lack of methodological clarity, the predominance of passive participation, and the low inclusion of younger children. The scarcity of studies that detail the role of the teacher or the pedagogical impact of activities also limits the advancement of the field.

Studies such as Heljakka e Ihamäki (2017), Core et al. (2017), and Hiniker, Sobel e Lee (2017) have shown that techniques that combine visual expression, tangible prototyping, and continuity favor meaningful participation of young children. Such approaches should be explored further, especially with children aged 4 to 5, who are still underrepresented.

When interpreting these results through theoretical frameworks of development, such as socio-constructivism and Vygotsky’s theory of mediation, it becomes evident that children’s participation in design depends not only on techniques, but also on the creation of supportive contexts that enhance expression, collaboration, and embodied reasoning characteristic of this age group. This theoretical articulation allows us to understand why

narrative, embodied, and mediated approaches tend to generate richer design experiences that are more aligned with the ways in which young children construct knowledge about the world.

In addition to clarifying the prevalence of Druin’s traditional roles, our mapping revealed the emergence of several “intermediate” or hybrid participation roles that did not fit neatly into existing taxonomies. Across the studies, children often moved fluidly between informing, testing, and collaboratively shaping ideas within the same design process, assuming levels of agency that fluctuated according to task structure, adult mediation, and material affordances. These patterns resonate with the argument of (MORAIS; FALCÃO; TEDESCO, 2024) that children’s participation in early childhood settings is often situated, negotiated, and context-dependent rather than fixed within predefined categories. Recognizing these hybrid forms of participation, such as children who begin as informants but progressively co-create prototypes, or those who test solutions while simultaneously suggesting design modifications, strengthens the theoretical contribution of our work by emphasizing the need for more flexible, context-sensitive frameworks that capture the nuances of participation in early childhood Co-design and PD.

It is recommended that future research more systematically document the techniques used, the role of adults in the mediation process, and the concrete products developed by children. The creation of more robust methodological reporting protocols can contribute to the replication of good practices. In addition, it is necessary to advance in the construction of participation models that are more context-sensitive, which consider aspects such as children’s adaptation time, teacher training, and school culture. It is also important that studies include a greater diversity of age groups, especially children aged 3 and 4, and explore new participation roles, going beyond the traditional taxonomy of (DRUIN, 2002). The investigation of intermediary roles, as discussed by (MORAIS; FALCÃO; TEDESCO, 2024), can reveal important nuances in how children effectively contribute to design processes. Finally, we suggest that future research also examine the impacts of these participatory experiences on the development of creativity, critical thinking, and children’s protagonism, contributing to a more integrated dialogue between participatory design and pedagogical objectives of early childhood education.

Chapter 3

Design Principles for Computing Education in Early Childhood

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This chapter corresponds to the article “Design Principles for Computing Education in Early Childhood” and represents the third stage of the methodological trajectory of this doctoral thesis.

Building upon the results of the systematic mapping and the collaborative design of activity plans, this chapter aims to formalize pedagogical design principles that guide the integration of computing education into early childhood contexts. The principles were derived through a thematic analysis of scientific literature and validated through focus groups with experts in early childhood education and computer science.

The chapter proposes five design principles that emphasize children’s protagonism, collaboration, playfulness, meaningful learning grounded in daily life, and the intentional integration of computing concepts. These principles serve as a conceptual bridge between theory and practice and constitute a core component of the framework evaluated empirically in the subsequent chapter of the thesis.

3.1 Introduction

Nowadays, computing is everywhere, from seeking information and entertainment to communicating with other people, working, and studying. Children of the 21st century were born into a time when technology is an integral part of our way of life, and it is almost impossible to live without it. Paiva and Costa (2015) say that “children, even before they become literate, learn to use most of the resources available on electronic devices randomly without any specific objective”; they are passive consumers of technology. A user is considered passive when they cannot create, modify, or actively participate in a solution (FISCHER et al., 2004). Although children are surrounded by technology, they do not understand the issues related to the creation or manipulation of technological products, and cannot perceive the possibilities of future uses to solve real problems.

According to the National Common Curriculum Base (BNCC) (BRASIL, 2021), children must understand the digital world in the same way they understand the real world. It is necessary to understand aspects related to storage, processing, data transmission, ethical issues, and the social and economic impacts of technology. Children must understand the fundamental concepts of computing in a comprehensive way to understand the world around them (BRASIL, 2021). In the literature, there are studies involving children aged 4 and 5, and concepts of computational thinking, programming, creation of technological artifacts, or even fronts involving Design-Based Learning. However, challenges still exist, including teacher training, developing appropriate curricula, and evaluating the impact of computer science education on young children (SENTANCE; CSIZMADIA, 2017).

Despite technological and methodological advances, many educators still face challenges in effectively implementing these tools and approaches in the classroom. The lack of clear guidelines adapted to the educational context makes it difficult to adopt practices that integrate computing in a meaningful way into the early childhood education curriculum. These gaps highlight the need for research that proposes evidence-based pedagogical design principles, aiming to guide teachers in the application of computing activities that are aligned with local needs and realities.

This study aims to propose design principles for the integration of computing in early childhood education, using two complementary methodologies: Thematic Analysis and Focus Group (FG). The thematic analysis allows the identification of relevant patterns and categories from qualitative data collected in a scientific article (BRAUN; CLARKE, 2006). The FG composed of experts in early childhood education and computer science, serves to validate and refine the proposed principles, ensuring their applicability and relevance in the educational context (KRUEGER, 2014). Consequently, a collection of educational design principles was established to help teachers implement computing activities in early childhood education, fostering meaningful and contextualized learning. Additionally, the combined application of thematic analysis and FG signifies a methodological advancement in the field of educational research, providing a strong model for

the development and validation of evidence-based pedagogical guidelines.

The research question guiding this study is: “What pedagogical design principles can guide the effective integration of computing education into early childhood education?”. The investigation of this issue aims to contribute to the construction of a theoretical and practical framework that supports educators in adopting innovative and effective practices in teaching computing to children.

The remainder of this article is structured as follows: Section 2 presents the background and theoretical foundations. Section 3 details the methodology, including the Thematic Analysis and FG procedures. Section 4 introduces the design principles derived from the study. Section 5 discusses the implications of these principles in practice, and Section 6 concludes with final considerations and directions for future research.

3.2 Background

The involvement of young children in design processes has been widely studied. This type of participation acknowledges children as technology users and active collaborators in creating new solutions. While much of the research focuses on their role in designing systems, codesign with children extends beyond digital technologies and systems to encompass artifacts and physical materials. This broader perspective enables a more comprehensive examination of their creative contributions.

Children can assume different roles in design, including informants, testers, and design partners, with each role offering various levels of input and involvement (DRUIN, 2002; MORAIS; FALCÃO; TEDESCO, 2024). Including young children in these processes benefits the participants and the resulting designs. Children gain cognitive and social skills, such as problem-solving, critical thinking, and collaboration (MECHELEN et al., 2017). Additionally, being recognized as a contributor boosts their self-esteem and engagement, especially when their ideas are taken seriously and implemented (KAPANEN et al., 2019). The creative input of children often leads to innovative solutions that adults might overlook (MECHELEN et al., 2017).

Codesign with children, particularly when involving physical artifacts, expands the scope of their involvement beyond digital systems. Artifact-based design allows children to engage tactilely and imaginatively, offering opportunities to integrate their lived experiences into the design. Such approaches broaden the design landscape, allowing children’s perspectives to inform diverse domains, including educational tools, play materials, and even urban spaces.

Including young children in these processes presents challenges. Designers and researchers must adapt methods to accommodate children’s developmental needs, which may require additional time, resources, and careful planning (MECHELEN et al., 2017). Managing children’s expectations about implementing their ideas is also critical, ensur-

ing they understand that not all contributions can be realized (KAPANEN et al., 2019). However, this is a valuable practice that benefits both children and the design process outcomes. Expanding this participation to include the creation of artifacts opens new avenues for engagement and innovation. Addressing the inherent challenges thoughtfully ensures effective and meaningful collaboration, fostering skill development in children, and the significant design creation.

In the Brazilian context, this perspective is reinforced by Computing: Complement to the BNCC (BRASIL, 2022), which establishes learning objectives for the introduction of computing concepts from early childhood education. Furthermore, several authors have emphasized the role of digital technologies in transforming educational practices. Kenski (KENSKI, 2003) argues that technology reshapes the dynamics of teaching and learning by creating new times and spaces for interaction. Moran (MORAN, 2005) highlights that the integration of technologies in education requires methodological innovation, so that the tools are not used only as support, but as mediators of meaningful experiences. Valente (VALENTE, 1999b; VALENTE, 1999a; VALENTE, 2005) has long defended the idea that computing in education should go beyond technical instruction, focusing instead on problem-solving, creativity, and knowledge construction. These perspectives reinforce that, in addition to the international literature, the Brazilian field of research also recognizes computing education as a strategic element for children’s development.

3.3 Methodology

We used two methods to propose design principles focused on computing education for 4 and 5-year-old children. Initially, a thematic analysis with 13 articles focused on computing education was carried out. Based on the highlighted themes and codes, 5 principles were proposed. Finally, we held an FG with professionals specializing in education, early childhood education, and computing areas to discuss the thematic analysis results and finalize the formalization of the principles. Two online meetings were held, each lasting 1 hour and 30 minutes.

The combined use of thematic analysis and focus groups was chosen to ensure both theoretical rigor and practical validation. Thematic analysis allowed for a systematic identification of patterns in the literature, while FG provided an opportunity to refine these principles through expert discussion. This methodological triangulation strengthens the validity of the results, as it integrates evidence from scientific publications with professional expertise in early childhood education and computing.

3.3.1 Thematic analysis

To identify and structure design principles that guide early childhood education teachers in creating activities aimed at teaching computing to children aged 4 and 5, we carried

out a thematic analysis. This method is widely used in qualitative research to organize data into meaningful themes, allowing the construction of evidence-based knowledge (BRAUN; CLARKE, 2006).

3.3.1.1 Data Source and Data analysis

Two main sets of publications were analyzed: (I) scientific articles produced in the context of the research project “Discovering Computing”, an interdisciplinary group from the UFSCar composed of researchers from the areas of Education and Computer Science, and (II) complementary articles focused on teaching computing to children, selected based on the literature in the area. All articles analyzed in the thematic analysis can be viewed in the Appendix B.

The selection of these data sources was based on their relevance to the research objectives and their representativeness in the field. The first set was chosen to ensure alignment with the interdisciplinary scope of the project, while the complementary articles were identified through searches in recognized academic databases (such as Scopus, ACM, and IEEE) using keywords related to “computing education in early childhood” and “participatory design with children”. This ensured a broad and consistent coverage of the state of the art.

Content analysis followed the Braun and Clarke (2006) protocol and was conducted in five main stages. First, we familiarized ourselves with the material: each article was read in full to elicit initial understandings and highlight passages that mentioned methodologies, challenges, experiences, or teaching strategies. Then, in the coding phase, we assigned inductive codes to specific passages such as “meaningful learning”, “use of play in computer science teaching”, “collaboration in design”, and “child empowerment” capturing units of meaning that reflected core practices and concepts. In the theme generation stage, we grouped related codes to structure five broad themes: (1) activities based on children’s daily lives; (2) child protagonism; (3) collaborative processes; (4) intentional insertion of computing concepts; and (5) playful learning. Each grouping resulted from a joint analysis of the interrelationships between codes, ensuring that each theme reflected an aspect essential to the development of the principles.

We subsequently reviewed the themes to verify coherence and conceptual distinction, adjusting nomenclatures and eliminating overlaps. Finally, we defined and refined the five final themes together with the second author, validating their applicability to the context of early childhood education. This systematization provided the theoretical basis for formulating the design principles presented in this study.

3.3.1.2 Results

The thematic analysis allowed the identification of the 5 main themes that guide computing education for children in early childhood education. The 5 themes identified

were: (1) Consider the child's daily life, (2) The child must be the protagonist, (3) Adopt collaborative processes, (4) Involve computer knowledge, and (5) Include playfulness. A list is available with all the codes that were grouped in the Appendix C. Below, the identified themes are briefly explained, with their implications for the construction of design processes.

Consider the child's daily life: The analysis showed that computational concepts are favored in early childhood education when presented within the children's everyday context. This theme emerged from codes that indicated the importance of connecting computing to familiar activities and artifacts, such as the use of digital devices, remote controls, and electronic games. This approach is aligned with the Meaningful Learning Theory (AUSUBEL, 2003), which emphasizes the importance of the relationship between new knowledge and the child's previous experiences. By incorporating elements of everyday life into computer science teaching, teachers can facilitate the construction of meanings and make learning more intuitive.

The child must be the protagonist: Another recurring aspect was the need to ensure that children are active participants in design processes. This theme emerged from codes related to active participation, children as decision-makers, and authorship in the design processes. Research on children's participatory design reinforces that children's active participation in design processes improves their relationship with technology and contributes to cognitive and socio-emotional skills development (DRUIN, 2002).

Adopt collaborative processes: Collaboration emerged as a key element, indicating that learning occurs more effectively when children interact and share knowledge. This theme emerged from codes that highlighted the importance of group learning, communication of ideas, and collaborative solutions development. When engaged in collaborative play, children observe, imitate, or build on what they observe (SCOTT, 2017b).

Involve computer knowledge: The thematic analysis revealed the need to ensure that computational concepts are introduced in a structured and accessible manner. This theme emerged from codes that highlighted the importance of computational thinking and problem-solving in the early childhood context. According to Martins (2021), digital literacy and the introduction of computational concepts from the early school years are essential to prepare children for an increasingly technological world. In the early childhood education context, this involvement can occur through activities that explore computational concepts without the need for digital devices, such as challenges based on sequential logic and unplugged activities.

Include playfulness: The presence of play as a central learning tool was one of the most recurrent themes in the analysis of the articles. The literature emphasizes that play keeps children engaged, active in knowledge construction, and enables experimentation. This theme emerged from codes related to game use, creative exploration, and play-based learning. Children's learning occurs more effectively when mediated by play, as children

demonstrate what they are learning through experimentation and spontaneous interaction with the environment (SCOTT, 2017b).

These 5 themes were essential for the construction of the design principles. Each theme reflects challenges and opportunities for computing in early childhood education, providing support for formulating applicable guidelines by teachers. The next subsection presents a second stage of research based on these findings and discusses its applicability in computing education to early childhood education.

3.3.2 Focal Groups

After identifying the 5 main themes through thematic analysis, an FG with experts from early childhood education and computer science areas was conducted to validate and refine the formulated design principles. The objective was to critically evaluate the principles, verifying their relevance, conceptual coherence, and applicability in the context of teaching computing to children aged 4 and 5. The methodology adopted for the FG followed approaches recommended in the literature (KRUEGER, 2014; BRAUN; CLARKE, 2006), ensuring that the discussions were conducted in a structured and collaborative manner.

We developed a script with key questions and organized the discussion into two main stages. In the first stage, participants analyzed each principle individually, answering the following questions: (I) Is this principle relevant to computing education for this age group? and (II) Is this principle correct? In the second stage, participants evaluated the principles by answering the following questions: (I) Is there a need to exclude any formalized principles? (II) Is there a need to include any new principles? and (III) Do the principles present the minimum concepts necessary for early childhood education teachers to be able to carry out co-design processes with the objective of teaching computing to children aged 4 and 5? The answers to all questions were analyzed qualitatively, consolidating the main points raised by the experts.

3.3.2.1 Participants

The professionals were invited by convenience, considering their academic background and practical experience in early childhood education and computing. All participants are active in research groups and educational programs related to education or computing, ensuring a balance between expertise in pedagogy and computer science. This diversity of profiles enabled an interdisciplinary discussion, ensuring that the principles formulated were analyzed from both a pedagogical and technology design perspective.

Table 16 presents details on the participants, including gender, level of education, field of study, and time of experience. In the gender column, (F) represents the female and (M) represents the male. In the occupation column. This study obtained informed consent

Table 11 – Details about FG participants.

ID	Gender	Level of education	Field of Study	Experience Time	
				Computer Science	Education
P1	F	Master degree	Education	Between 1 year and 5 years	Between 6 and 10 years
P2	F	Postdoc	Education	Less than 1 year	More than 10 years
P3	F	Postdoc	Education	Between 1 year and 5 years	More than 10 years
P4	F	Postdoc	Computer Science	More than 10 years	Between 1 year and 5 years
P5	M	Master degree	Computer Science	More than 10 years	Less than 1 year

from all participants, who were informed about the objectives, procedures, and voluntary nature of their participation. All personal data were anonymized, and confidentiality was assured throughout the research process. The study was reviewed and approved by the Ethics Committee of Federal University of São Carlos, under protocol number 78975524.1.0000.5504.

3.3.2.2 Results

The FG results indicated a high degree of agreement on the principle’s relevance, but suggestions for refinement were made to improve clarity and ensure their applicability in the educational context. During the meetings, participants analyzed each principle critically, pointing out conceptual and practical aspects that could be improved. Discussions ranged from terminological adjustments to the need to emphasize the teacher’s role and the pedagogical intentionality of the proposed activities. Below, we present the main improvements based on the experts’ contributions.

Consider the child’s daily life: The relevance of this principle was widely recognized by the participants, who reinforced the need to relate computer science education to children’s daily experiences. P3 highlighted that young children do not yet have a fully structured theoretical mindset, and the learning should start from what they already know. She argued that “when we think about child development, this age group works in the empirical world, as theoretical thinking is still under construction. Therefore, starting from what the child already knows is essential to enable new learning”. P4 added that the principle formulation could emphasize the relationship between children, digital artifacts, and their social and natural environment. She suggested that children’s everyday lives should not be understood as just their daily routine but as a set of experiences and interactions that they go through. Furthermore, participants stressed the importance of ensuring that this principle is understood as a broad approach, connecting computational concepts to contexts that are meaningful to children. No modifications to the principle statement were necessary. However, an explanation expansion was recommended to reinforce the relationship between computational learning and the child’s previous experiences.

The child must be the protagonist: The term “protagonist” generated discussions among experts because it could be interpreted as a teacher’s role reduction in the teaching

and learning process. P3 highlighted that in early childhood education, children are often expected to act completely autonomously without structured guidance from the teacher. She argued that “the teacher will have to induce this protagonism. Children need role models, otherwise they cannot do it. This needs to be built progressively”. P5 agreed, emphasizing that children’s leadership development requires balancing autonomy and teacher mediation. He mentioned that, in some experiences with children, they expressed the desire to have an adult present for support, but without the adult making all the decisions. In light of these reflections, P4 suggested a reformulation of the principle title to emphasize the shared responsibility of adults in this process. She proposed using the term “stakeholders” which in computing refers to all those involved in a process. Thus, it was decided that the principle name would become “Stakeholders must build the child protagonism” ensuring that the teacher’s role is recognized as essential.

Adopt collaborative processes: The principle was revised to ensure greater specificity and clarity. Participants raised concerns about the generality of the “collaborative process”, which could be interpreted too broadly. P4 stressed that “what is expected is that children and adults engage in processes of joint creation. This needs to be clear so there are no misinterpretations of the term collaborative”. P2 suggested replacing “processes” with “activities” to make the principle more applicable to pedagogical practice. She argued that “the word ‘processes’ can be very broadly interpreted. ‘Collaborative activities’ provide better guidance to the teacher on what should be done in the classroom”. The name has been changed to “Carry out collaborative activities”.

Involve computer knowledge: Participants agreed that teaching computing in early childhood education should involve broader computing concepts, not be restricted to programming. P4 suggested including the document “Computing: Complement to the BNCC” reference, which deals with the learning objectives for teaching computing in Brazilian early childhood education. She mentioned that “this document can help justify the principle and bring teachers closer to the topic, showing that computing is already recognized as an important component in early childhood education”. P5 highlighted that “children already use computational concepts without realizing it. Our role is to make these concepts explicit and accessible”. During the discussions, the experts agreed that “knowledge” could be replaced by “concepts” to make the principle more precise.

Include playfulness: This principle has sparked debates about differentiating playful learning from games without pedagogical mediation. P3 raised concerns that “playful” could be interpreted as an invitation to play without a structured purpose. She pointed out that “playfulness must be present but with intentionality. The activity needs to be provoking, challenging, and engaging, not just a moment of free play”. P2 suggested reformulating the principle to emphasize the need for practical and thought-provoking activities, proposing that “instead of ‘Include playfulness,’ the principle could highlight hands-on, challenging, and thought-provoking activities”. P4 agreed, highlighting that

fun can be present within the context of structured learning. The name of the principle was changed to “Include Fun Activities”.

3.4 Design principles

This study proposes a set of educational design principles aimed at supporting early childhood educators in planning and implementing computing activities through co-design processes. These principles serve as a practical guide to ensure that children aged 4 and 5, in the final stage of Early Childhood Education, can actively participate in meaningful learning experiences that foster computational thinking, creativity, and collaboration. Table 29 summarizes the five principles identified, with concise descriptions that highlight their pedagogical focus.

Table 12 – Design principles for computing education in early childhood

Principle	Short description	Example of application
Consider the child’s daily life	Connect computing concepts with children’s everyday experiences to promote meaningful learning.	Organize a step-sequence game where children build a “recipe” (e.g., making a sandwich) to introduce algorithms.
Stakeholders must build the child protagonism	Encourage children’s active participation in co-design, with teachers mediating and guiding autonomy.	Children design a maze on the floor with tape/chalk while the teacher guides peers to “program” one another through it.
Involve computer concepts	Introduce fundamental computing concepts (e.g., sequences, patterns, algorithms) as defined by Computing: Complement to the BNCC (BRASIL, 2022).	Use rhythmic clapping games to represent loops, or sorting toys to teach classification and pattern recognition.
Carry out collaborative activities	Foster collaboration among children, teachers, and peers through structured joint tasks.	Groups create a collective story where choices follow logical “if/then” structures, simulating conditionals.
Include fun activities	Use playful and thought-provoking experiences to engage children while exploring computational ideas.	Organize a treasure hunt with logical clues that use conditionals to lead to the next step.

These principles represent a synthesis of insights from the literature and validation through expert focus groups, providing educators with clear and applicable guidelines to integrate computing into early childhood education. Importantly, they are not intended to be applied in isolation. Their combined use creates richer learning environments, balancing conceptual understanding, creativity, and collaboration. In the next section, we critically discuss the implications of applying these principles in practice, highlighting potential benefits, challenges, and conditions for successful implementation.

3.5 Discussion

The design principles proposed in this study provide a foundation for implementing computing education in early childhood. Rather than repeating their definitions, this section discusses their implications, potential challenges, and contributions to educational practice. The focus is on how they can support the development of computational skills, creativity, and collaboration in preschool education.

Consider the child’s daily life: Incorporating computing concepts into everyday experiences allows children to connect new ideas with familiar contexts. This strategy strengthens meaningful learning and aligns with the Computing: Complement to the BNCC (BRASIL, 2022). The challenge lies in preparing teachers to identify and translate these experiences into structured learning opportunities.

Stakeholders must build the child protagonism: Children’s active participation is fundamental, but it requires careful teacher mediation. Autonomy must be progressively constructed, with adults guiding interactions to ensure sustained shared thinking. The main implication is the need for teacher training focused on balancing guidance with opportunities for co-design.

Involve computer concepts: Introducing fundamental computing concepts (such as sequencing, pattern recognition, and problem-solving) helps children understand technology beyond programming. The Computing: Complement to the BNCC (BRASIL, 2022) reinforces this approach. However, a critical challenge is ensuring that teachers feel confident with these concepts, which demands continuous professional development.

Carry out collaborative activities: Collaboration fosters social, cognitive, and emotional skills while strengthening collective knowledge construction. Activities such as group problem-solving or storytelling with logical structures illustrate this principle. The implication is that schools must provide time and space for joint creation, which is not always prioritized in curricula focused on individual outcomes.

Include fun activities: Playful and thought-provoking tasks are essential to engage young learners. Activities like treasure hunts based on logical clues or simple algorithmic games exemplify how fun can be aligned with intentional pedagogical goals. The critical issue is avoiding the reduction of play to entertainment without clear educational mediation.

Overall, these principles highlight that computing education in early childhood should not be reduced to isolated technical skills. Instead, it must integrate children’s contexts, emphasize their role as active participants, and rely on structured teacher mediation. The main implication for practice is that teachers need both didactic strategies and institutional support to apply these principles effectively. Future research should explore how these principles perform in real classrooms and identify conditions that enable their successful implementation.

3.5.1 Limitations

This study has some limitations that must be acknowledged. First, the FG sample was small and selected by convenience, which may restrict the diversity of perspectives. Second, the proposed design principles were validated theoretically but have not yet been tested in classroom contexts with children and teachers. This represents not only a limitation but also an important avenue for future research. Conducting applied studies in real educational settings will make it possible to assess the pedagogical effectiveness and feasibility of the principles, generating empirical evidence to complement the theoretical foundation established here. Finally, the study focused on Brazilian educational guidelines, which may limit generalization to other educational systems. Future work should conduct pilot implementations and longitudinal studies to evaluate both short-term and long-term impacts of early computing education.

3.6 Conclusion

This study presented a set of design principles for teaching computing in early childhood education, derived from a thematic analysis of the literature and validated through a FG with experts in early childhood education and computer science. The principles offer practical guidance for educators seeking to introduce computing in a way that is both meaningful and contextually relevant.

By linking computing activities to familiar experiences, this work reinforces that children learn more effectively when concepts are introduced through materials and situations already present in their everyday lives. Valuing children as active participants proved essential, as it stimulates autonomy and supports their role as co-designers and problem solvers. Collaboration among children, teachers, and other stakeholders emerged as another cornerstone, strengthening social skills and collective knowledge construction. At the same time, deliberately integrating computing concepts such as logic, patterns, and sequences ensures that young learners develop a solid understanding that extends beyond mere programming. Ultimately, adopting playful strategies creates a dynamic and motivating environment that nurtures curiosity and experimentation.

The design principles laid out here provide a well-founded framework to support educators in cultivating computing education from the earliest school years. Continued collaboration among researchers and teachers will be crucial to developing increasingly inclusive, accessible, and effective computing education.

Chapter 4

Early childhood teachers and undergraduate students prototyping design activities to Computing Education

Article title: Early Childhood Teachers and Undergraduate Students Prototyping Design Activities to Computing Education

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This chapter presents the article “Early Childhood Teachers and Undergraduate Students Prototyping Design Activities to Computing Education” and corresponds to the second stage of the research methodology adopted in this thesis.

The chapter focuses on the collaborative construction of computing education design activities for early childhood education through an action research approach. It reports a series of workshops involving early childhood education teachers and undergraduate students from pedagogy and computer science programs, aiming to co-design unplugged, playful, and developmentally appropriate activities for children aged four and five.

This chapter contributes to the thesis by demonstrating how interdisciplinary collaboration supports the translation of abstract computing concepts into pedagogically meaningful practices. The resulting activity plans address topics such as algorithms, data representation, privacy, and electronic waste, connecting technical content to children’s

everyday experiences. The findings of this chapter directly inform the development of the design principles and the educational framework evaluated in later stages of the research.

4.1 Introduction

Computing education has been widely recognized as essential for the 21st century and is gaining significant attention in most early formal education curricula worldwide (MANCHES; PLOWMAN, 2017; SENTANCE; CSIZMADIA, 2017). Early exposure to computing education can benefit young children, including fostering creativity and enhancing critical thinking (GRETTER; YADAV, 2016). In an increasingly digital world, understanding computing fundamentals from an early age prepares children for the challenges of a technology-driven society. It can contribute to improved academic performance across other subjects (MAHAMA et al., 2019; CHANG et al., 2015).

However, integrating computing concepts into early childhood education remains a developing field (LIU; LUO; ISRAEL, 2023). Teaching computing to young children presents unique challenges (PLOWMAN; STEPHEN, 2005). These challenges include the need for age-appropriate pedagogical approaches and tools that can effectively introduce complex concepts in a way that makes them understandable and engaging for young learners (SENTANCE; CSIZMADIA, 2017).

This study aims to develop and evaluate design activities that introduce computing concepts to 4- and 5-year-old children in a playful and unplugged computing context. The goal is to create pedagogical tools that strike a balance between technical rigor and practical applicability. Additionally, the study seeks to empower teachers to feel confident in incorporating computing into their classrooms, ensuring that the activities are inclusive and relevant to real-world school contexts.

We conducted the research in two main stages, using Action Research (TORRANCE, 1966) and Focus Group (FG) (MORGAN, 1996) methods. In the first stage, 15 collaborative workshops were held with early childhood education teachers and undergraduate students in pedagogy and computer science, resulting in 10 design activities. In the second stage, early childhood education and computing experts evaluated the design activities through an FG, which provided feedback on clarity, applicability, and technical depth, promoting the refinement of the proposals.

This study presents a collaborative model for creating early childhood computing teaching materials. The design activities represent an innovative approach that combines technical rigor and pedagogical relevance, demonstrating that computational concepts can be taught meaningfully from the earliest school years. Furthermore, the findings underscore the importance of integrating teachers and specialists in the design process, ensuring that the proposals are viable, inclusive, and adaptable to educational realities.

4.2 Background

4.2.1 Computing education in early childhood

Computing refers to the broad field that encompasses the study and practice of computer systems, including the theory, abstraction, design, and implementation of software and hardware. Computing encompasses several disciplines, including computer science, computer engineering, information systems, and information technology. It is a field that focuses on how information is processed, stored, and transmitted. In addition, it also focuses on how computing technologies can be applied in different contexts (Association for Computing Machinery; IEEE Computer Society; Association for Information Systems, 2020). The Computing Curricula 2020 (CC2020) (Association for Computing Machinery; IEEE Computer Society; Association for Information Systems, 2020) organizes computing knowledge into six main categories:

- ❑ **Users and Organizations:** Related to social issues, professional practices, security, management, and leadership in computing applications.
- ❑ **Systems Modeling:** Involves analysis, design, and management of systems, including security and data issues.
- ❑ **Systems Architecture and Infrastructure:** Covers topics such as computer networks, embedded systems, emerging technologies, and distributed computing.
- ❑ **Software Development:** Related to the software development life cycle, quality, modeling, and design.
- ❑ **Software Fundamentals:** Includes basic concepts of programming, algorithms, programming languages, and computer systems.
- ❑ **Hardware:** Addresses the architecture, organization, and design of the physical components of computer systems.

These categories provide a comprehensive and internationally recognized framework for understanding computing knowledge and were used in this study to classify the technical concepts addressed in the proposed activities. However, in the Brazilian educational context, it is essential to complement international frameworks with national curricular guidelines. The Computing: Complement to the National Common Curriculum Base (BNCC) (BRASIL, 2022) introduces computing into basic education through three interconnected axes that guide teaching and learning from early childhood:

- ❑ **Computational Thinking:** focuses on the development of logical reasoning, problem decomposition, pattern recognition, abstraction, and algorithmic thinking. This

axis emphasizes the ability to structure solutions and understand processes step by step, which is fundamental for learning computing concepts.

- ❑ **Digital World:** addresses the understanding of how digital technologies function, including hardware, software, networks, and data processing. It aims to help learners understand the infrastructure that enables digital systems and how these systems operate in everyday contexts.
- ❑ **Digital Culture:** involves the critical, ethical, and responsible use of digital technologies. It includes aspects such as digital citizenship, data privacy, security, and the social impacts of technology in society.

Together, these three axes provide a pedagogical framework that connects technical knowledge with real-world applications and social awareness. While the CC2020 offers a detailed classification of computing as a scientific and technical field, the Computing: Complement to the BNCC contextualizes these concepts within educational practice, particularly in early childhood education.

In Brazil, it is important to distinguish between Computing Education and Digital Education, as these concepts, although complementary, address different educational objectives. Computing Education, as defined in Computing: Complement to the BNCC (BRASIL, 2022), focuses on the understanding of computational concepts such as algorithms, data representation, abstraction, and problem-solving. Its primary goal is to develop computational thinking as a structured way of reasoning about problems and solutions. In contrast, Digital Education, as outlined in Law nº 14.533/2023 (BRASIL, 2023), encompasses the critical, ethical, and responsible use of digital technologies. It includes aspects such as digital citizenship, media literacy, online safety, and the social implications of technology use.

This distinction is particularly relevant in early childhood education, where activities often integrate both dimensions. In this study, the proposed design activities are primarily aligned with Computing Education, while also incorporating elements of Digital Education, especially in topics such as data privacy, responsible technology use, and digital awareness.

Computing education is available across all levels, from primary to higher education. Introducing these concepts early can enhance diversity in the field by encouraging children from varied backgrounds to consider careers in technology. Early exposure allows children to build a strong foundation, equipping them to explore computing in greater depth as they progress (Association for Computing Machinery; IEEE Computer Society; Association for Information Systems, 2020). Fields, Giang e Kafai (2014) emphasize that active engagement in computational program implementation serves as a highly effective learning method. These core concepts form the basis for developing computational skills

and are recognized as essential elements in contemporary education. Wing (2006) highlights the importance of integrating computational ideas with other disciplines to cultivate fundamental cognitive abilities.

Initiatives have been dedicated to making learning programming and computational thinking accessible and fun for children. Projects such as Scratch (RESNICK et al., 2009) offer interactive platforms for children to create their own stories and games. However, computing education typically follows a passive approach, which may disinterest young children who prefer more active learning and reinforce the stereotype that computing is an isolating experience (YU, 2022).

Practical activities have proven effective in bringing computing concepts into children's daily lives. Bers, González-González e Armas-Torres (2019) highlights that programming robots and creating digital narratives teach computational skills and enhance digital literacy. Computing education for young children, which integrates computational concepts into daily activities, prepares them for the digital future and enhances their cognitive abilities. It is also expected to promote a meaningful understanding of computer science from the earliest years of life.

4.2.2 Involvement of Teachers and Undergraduate Students in the Creation of Materials for Computing Education

Teachers' and undergraduate students' active participation in creating teaching materials reflects an integrative approach that combines practical and pedagogical knowledge with technological and methodological innovations. With their direct experience in the classroom, early childhood teachers play an essential role in understanding children's educational needs and developing materials adapted to specific academic contexts. Their involvement is crucial to ensuring that teaching resources are relevant and effective in promoting meaningful learning (KAFAI; PROCTOR, 2022). This participation also promotes a greater commitment to using materials that they helped develop, as they are directly linked to educational practice.

Undergraduate students also play a vital role in this process, bringing innovative perspectives and up-to-date skills in technology and teaching methodologies. These students, primarily from the fields of education and computing, have the opportunity to apply their theoretical knowledge in practical situations, contributing to the creation of materials that meet both pedagogical and technological demands. Undergraduate students' participation in digital fabrication workshops enabled them to create manipulatives using 3D printers and laser cutters, allowing them to improve their technical skills and understand how these tools can positively impact children's learning (STIGBERG; STIGBERG; MAUGESTEN, 2024).

In addition, collaborative initiatives between teachers and undergraduate students

can popularize computing concepts through practical and playful activities. Exploring complex topics in accessible ways reinforces the importance of active methodologies for teaching computing in diverse contexts. It also connects technical learning to students' daily realities. From a theoretical perspective, this interaction between teachers and undergraduate students enables a collaborative approach to the production of pedagogical materials, promoting a balance between theoretical foundations and practical innovation. Studies highlight that such collaboration facilitates the creation of adaptable materials, enhances the technical and pedagogical participants' skills, and stimulates innovation in teaching (STIGBERG; STIGBERG; MAUGESTEN, 2024). However, ensuring well-defined roles in the collaborative process is essential to balance participation and maximize the impact of the materials produced (FINCH; MORENO; SHAPIRO, 2021).

Teachers' and undergraduate students' integration represents a promising strategy for computing education, aligning pedagogical foundations and technological advancements collaboratively. This theoretical approach underpins the creation of innovative materials and expands the possibilities for meaningful learning in basic education.

4.2.3 Design with children

The involvement of young children in design processes has been widely studied in the field of Human-Computer Interaction (HCI). This type of participation acknowledges children as technology users and active collaborators in creating new solutions. While much of the research focuses on their role in designing systems, codesign with children extends beyond digital technologies and systems to encompass artifacts and physical materials. This broader perspective enables a more comprehensive examination of their creative contributions.

Children can assume different roles in design, including informants, testers, and design partners, with each role offering various levels of input and involvement (DRUIN, 2002). Including young children in these processes benefits the participants and the resulting designs. Children gain cognitive and social skills, such as problem-solving, critical thinking, and collaboration (MECHELEN et al., 2017). Additionally, being recognized as a contributor boosts their self-esteem and engagement, especially when their ideas are taken seriously and implemented (KAPANEN et al., 2019). The creative input of children often leads to innovative solutions that adults might overlook (MECHELEN et al., 2017).

Participation in design processes enables children to develop a range of diverse skills and knowledge. Through these activities, children improve their communication and expression skills by articulating their ideas and opinions (KAPANEN et al., 2019). Working in teams teaches them the value of collaboration and how to interact effectively with others. Importantly, the process fosters creative and critical thinking, encouraging children to generate and evaluate new ideas to solve design problems (MECHELEN et al., 2017).

Codesign with children, particularly when involving physical artifacts, expands the scope of their involvement beyond digital systems. Artifact-based design enables children to engage both tactilely and imaginatively, providing opportunities to integrate their lived experiences into the design. For instance, creating tangible tools or toys involves problem-solving and decision-making that align with their developmental stages and contextual knowledge. Such approaches broaden the design landscape, allowing children's perspectives to inform diverse domains, including educational tools, play materials, and even urban spaces.

Including young children in these processes, however, is not without challenges. Designers and researchers must adapt methods to accommodate children's developmental needs, which may require additional time, resources, and careful planning (MECHELEN et al., 2017). Managing children's expectations about implementing their ideas is also critical, ensuring they understand that not all contributions can be realized (KAPANEN et al., 2019).

Including 4 and 5-year-olds in design processes is a valuable practice that benefits both children and the design process outcomes. Expanding this participation to include the creation of artifacts opens new avenues for engagement and innovation. Addressing the inherent challenges thoughtfully ensures effective and meaningful collaboration, fostering skill development in children, and the significant design creation.

Although children were not directly involved as participants in this study, the theoretical foundations of design with children play a central role in informing the development of the proposed activities. The design activities created in this research are intended to be applied by children aged 4 to 5, positioning them as active participants in design processes within educational contexts.

In this sense, the principles of design with children are not used as a methodological approach, but as a conceptual and pedagogical foundation to guide the structure of the activities. These principles support the creation of learning experiences in which children are encouraged to actively engage in problem-solving, ideation, and artifact creation, fostering creativity and critical thinking.

Thus, this study adopts a "design for children as designers" perspective, where the research focuses on designing activities that enable children to participate in design processes, even though they were not directly involved in the research phase.

4.2.4 21st Century Skills

Several models showcase 21st-century skills. The *Partnership for 21st Century Learning* (P21) advocates for integrating 21st-century skills (critical thinking, collaboration, communication, creativity, technological literacy, and social-emotional development) into learning experiences so that children develop the skills they need, not only in school but also in life.

The *21st Century Skills Early Learning Framework* (P21 ELF) (SCOTT, 2017a) was developed to include early learning by integrating 21st century skills into early childhood learning programs. This framework identifies early childhood as the years from infancy to early childhood education (ages 18 months to 6 years).

The P21 ELF covers 21st-century competencies, organized into three broad areas: learning and innovation skills, life and career skills, and information, media, and technology skills. Learning and innovation skills include creativity and innovation, critical thinking and problem-solving, communication, and collaboration. Life and career skills involve flexibility and adaptation, initiative and self-direction, social and cross-cultural skills, productivity, and leadership and responsibility. Finally, information, media, and technology skills refer to the ability to handle information and media literacy.

These skills are considered fundamental to preparing individuals for the challenges and dynamics of the contemporary world, promoting personal, academic, and professional development in an increasingly globalized, digital, and interconnected scenario.

4.2.4.1 Creativity and Innovation in Children

Creativity is becoming sensitive to problems, deficiencies, knowledge gaps, missing elements, and disharmonies (TORRANCE, 1966). It can manifest in innovative thinking that breaks with previously established norms (BAILIN, 2012). Through creativity, people can develop their potential, using their imagination to express themselves and make original and valuable life choices (LOVELESS, 2002).

Children can express their creative thoughts and feelings through many activities, including painting, writing, drawing, sculpting, theater, dance, movement, and scientific exploration. Part of creativity is learning to innovate. Innovation with young children is how they test their thinking and interact with the world. Children often start by imitating observed behaviors and innovate using new ideas or solutions if typical approaches don't work (SCOTT, 2017a).

In the computing education curriculum, creativity is often implicitly included, especially when the focus is on design and problem-solving. However, when it comes to teaching and learning, creativity needs to be more deliberate (BAILIN, 2012). In general, the use of digital technologies to develop creativity skills presents challenges in two areas: (1) in using technology to support creativity in traditional settings, such as schools; and (2) in developing resources to support innovation in new learning environments for creative activity and collaboration (LOVELESS, 2002).

To create environments conducive to creative development, several characteristics need to be explored. First, it is necessary to raise awareness of the different ways in which creativity relates to knowledge across the curriculum, and that rules and structures in other knowledge domains can be combined, explored, and transformed (BODEN, 2001).

It is necessary to provide an environment where children have the opportunity to explore and play with materials, information, and ideas, take risks, and make mistakes in a non-threatening space. The environment should provide opportunities for reflection, resourcefulness, and resilience (CRAFT, 2003; LUCAS; GREANY, 2000; DAVIES, 2003), providing a creative and flexible environment.

4.2.4.2 Critical Thinking and Problem-Solving in Children

Critical thinking includes analyzing argument skills, making inferences using inductive or deductive reasoning, judging, evaluating, making decisions, or solving problems (LAI, 2011; PAUL; ELDER, 2019). Prior knowledge is a necessary, but not sufficient, condition to allow critical thinking within a given subject.

Critical thinking involves cognitive skills and dispositions. These dispositions can be seen as mental attitudes or habits, and include openness and impartiality, curiosity, flexibility, a propensity to seek reason, a desire to be well-informed, and a willingness to consider different points of view (LAI, 2011).

Problem-solving involves the ability to generate and execute a solution to a problem. It occurs when a child uses trial and error to solve a problem until a successful solution is found. This includes imitation and observational learning, utilizing their problem-solving approaches, such as contrasting, grouping, classifying, and categorizing objects; using logic and reasoning to generate solutions to problems based on generally accepted rules; and planning and sequencing to develop and follow a multi-step plan to achieve a goal (SCOTT, 2017a).

Children can develop critical thinking from childhood. Critical thinking manifests in various ways, such as questioning information, analyzing complex situations, and making informed decisions. Children demonstrate critical thinking by evaluating the credibility of information sources, questioning the validity of statements, and considering different perspectives before concluding (HEYMAN; LEGARE, 2005).

The benefits of critical thinking for children are countless. It allows them to make informed decisions, solve problems effectively, evaluate information critically, and communicate their ideas. Critical thinking helps children develop conflict resolution skills, promotes creativity, and improves self-confidence (STERNBERG, 1986).

To develop critical thinking, children need to be involved in activities that challenge their cognitive skills and encourage them to think analytically and creatively. Puzzle games, debates, solving riddles, analyzing stories, and daily situations are some practical ways to apply critical thinking in authentic contexts, developing evaluation, decision-making, and problem-solving skills (ROCHE, 2014).

An environment for exploring and playing with materials, information, and ideas, taking risks, and making mistakes in a non-threatening space provides the opportunity for reflection, resourcefulness, and creativity (CRAFT, 2003; LUCAS; GREANY, 2000).

By providing opportunities for children to practice critical thinking through diverse and challenging activities, educators can help them develop essential skills that will be valuable throughout their lives (ROCHE, 2014). Preparing children to face the world's challenges more consciously and responsibly ensures a solid foundation for intellectual and emotional development.

4.3 Related Work

The creation of activities, tools, and curricula for computing education has been the focus of various recent initiatives and studies. These efforts aim to integrate computer science concepts and computational thinking into different disciplines and educational contexts, promoting meaningful and engaging learning for students.

A significant example of integrating computer science into non-related disciplines is the integrated Artificial Intelligence (AI) curriculum for K-12 classrooms (LIN; BRUMMELEN, 2021). This curriculum aims to introduce AI concepts and computational technology to students, even outside computer science or technology classrooms. Teachers involved in the codesign process sought to integrate AI into core subjects such as English, social studies, and literature. Through this approach, students explore data sets related to the subjects, reflect on real-world implications, and discuss AI ethics. This integration broadens students' access to technology knowledge and promotes the understanding and application of computational concepts across various fields of study.

Another relevant study describes the co-creation of computational modeling activities by a high school science teacher and a research team (SWANSON et al., 2023). The activities helped students understand the propagation of sound energy through waves and the relationship between the volume of a sound and energy. The results included student engagement with the model, teacher satisfaction with the outcomes, and the effectiveness of the implemented responsive teaching strategies. This study demonstrates that the co-creation of activities can be a practical approach to promoting meaningful learning and student engagement in science.

A third study addresses the logistical and conceptual challenges in creating a computer science curriculum in a public school district. Proctor, Bigman e Blikstein (2019) highlight the need to define the essential elements of computer science, promote inclusion through community education, and ensure equitable participation of diverse stakeholders. The study also addresses the difficulties, including those with no prior experience.

These studies illustrate different approaches and challenges in creating activities and curricula for computing education. Integrating computing concepts into various disciplines, co-creation activities with teachers and researchers, and constructing inclusive and equitable curricula have successfully promoted meaningful and engaging computing learning. The active participation of all stakeholders and the adaptation to the spe-

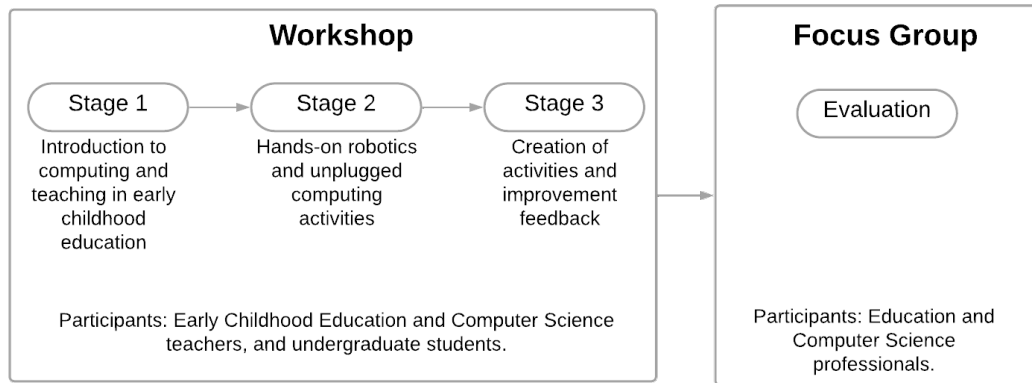


Figure 6 – Research methodology.

cific needs of each school community are crucial aspects for the success of these initiatives. Furthermore, including children in early childhood education is fundamental to developing computational skills and preparing them for future challenges in the digital age. Introducing younger children to computational education can develop skills such as problem-solving, logic, and creativity from an early age. Including computing activities in early childhood education can prepare children for deeper learning at later stages and contribute to building a solid foundation in computer science.

4.4 Method

This study adopts action research as the primary methodological approach, characterized by iterative cycles of planning, action, observation, and reflection conducted in collaboration with participants (TRIPP, 2005) to develop design activities for computing education to young children.

Action research is empirical research that involves the association between action and problem-solving, in which researchers and participants collaborate in a cooperative and participatory manner (THIOLENT, 1988). In this study, action research is framed as a collaborative and iterative process in which researchers and participants co-construct knowledge through cycles of intervention and reflection. The workshops served as the primary setting for these cycles, enabling continuous adaptation of the design activities based on participants' feedback and observed challenges. Considering the objective of design activities evaluation, an FG (MORGAN, 1996) was carried out with 5 participants. Two online meetings were held, each lasting 1 hour and 30 minutes. Figure 6 presents the research details.

4.4.1 Design activities Workshops

The action research process was structured into iterative cycles, each comprising planning, action, observation, and reflection phases.

- ❑ Cycle 1 (Workshops 1–5): Focused on understanding participants’ prior perceptions and challenges related to computing education in early childhood.
- ❑ Cycle 2 (Workshops 6–10): Involved hands-on experimentation with robotics and unplugged activities, allowing participants to explore practical approaches.
- ❑ Cycle 3 (Workshops 11–15): Focused on the co-creation and refinement of design activities, incorporating reflections from previous cycles.

Table 13 presents an overview of the content of each workshop.

The workshops were designed and conducted by an interdisciplinary team of researchers: a college professor specializing in computer science, a college professor specializing in computer architecture, a college professor specializing in early childhood education, a master’s degree in Education student with experience in early childhood education, and a Computer Science Ph.D. student.

Table 13 – Activities in the workshops.

Cycle	Meeting	Description
1	1	Welcome to the participants. Participants report experiences and perceptions about teaching computing to early childhood children.
	2	Inaugural class on the importance of teaching in early childhood education.
	3	Computing beyond computers, discuss the origin, history, mathematics, science, design, and engineering importance in the construction of the machine.
	4	An overview of teaching computer science to early childhood children.
	5	Computer science teaching in formal education curriculum.
2	6, 7, and 8	“Learning and experimenting with technology and sciences in the education of 4 and 5-year-old children: Robotics”: Practical activity
	9 and 10	“Computational Thinking and Unplugged Computing”: Practical activity
3	11 and 12	Creation of design activities to teach computing with a focus on creativity development: Co-creation
	13 and 14	Creation of design activities to teach computing with a focus on critical thinking development: Co-creation
	15	Socialization of the design activities created, and feedback from participants.

In the context of action research, the researcher assumed an active and multifaceted role throughout the study. The researcher acted as:

1. facilitator of the workshops, guiding discussions and supporting participants during activity design;

2. mediator, fostering dialogue between participants from different backgrounds (education and computing); and
3. reflective practitioner, analyzing data between cycles and adapting subsequent interventions accordingly.

This positioning aligns with the principles of action research, in which the researcher is directly involved in the intervention while critically reflecting on the process.

4.4.1.1 Participants

The research involves teachers and students, as it considers that teachers have a pedagogical practice that helps create educational materials. In contrast, undergraduate students have up-to-date knowledge in the education and computing areas. The teachers (4) and undergraduate students (7) worked together during the workshops.

All teachers had over five years of experience in early childhood or computing education. Participants also included undergraduate students. The students and teachers participated in class discussions at the end of each meeting. Table 14 presents details about the participants, including their gender, occupation, field of study, and experience time. For participants still in the undergraduate stage, the time experience (with the major) is related to the semester in which the participant was enrolled. In the gender column, (F) represents female and (M) represents male. In the occupation column, (T) represents the teacher and (S) represents the student.

Table 14 – Details about workshop participants.

Gender	Occupation	Field of Study	Experience Time
F	T	Early Childhood Education	More than 5 years
F	T	Early Childhood Education	More than 5 years
F	T	Early Childhood Education	More than 5 years
F	T	Telecommunications and Network Engineering	More than 5 years
F	S	Pedagogy	4th semester
F	S	Pedagogy	8th semester
F	S	Pedagogy	8th semester
F	S	Pedagogy	8th semester
M	S	Computer Science	8th semester
M	S	Computer Science	6th semester
M	S	Statistics	4th semester

This study obtained informed consent from all participants, teachers, and students. The study was reviewed and approved by the Ethics Committee of Federal University of São Carlos, under protocol number 78975524.1.0000.5504.

4.4.1.2 Design activities creation

In the third stage, workshops to create design activities were divided into four meetings. The first workshop (2 meetings) was focused on creating design activities to teach

computing and develop creativity. The second workshop (2 meetings) was focused on creating design activities to teach computing and develop critical thinking. The participants were advised to consider children's needs and propose activities that allow them to participate actively in the process.

The classification of activities proposed in this study provides a precise mapping between the topics covered and the areas of computational knowledge, ensuring academic relevance and practical applicability. Table 30 summarizes all design activities comprising details of title, abilities, and computing concept covered, categorization, and computing knowledge area to which the design activity fits. Finally, the table presents the design process proposed in the activity. The design activities present information such as theme, title, age group, duration, computing knowledge, activity objectives, activity development, materials needed to perform, and activity assessment. All design activities involve computing education, product design (play, stories, posters, games, etc.), and the development of creative or critical thinking. Five design activities aimed at improving creativity and five focused on enhancing critical thinking were created.

4.4.1.3 Data collection and data analysis

Data collection was structured into two main phases. In the first phase, 10 meetings were held, involving theoretical lessons, practical workshops, debates, and group dynamics. The researchers accompanied these activities with systematic observations, recording discussions, reflections, and group dynamics to ensure qualitative data collection. In the second phase, encompassing the last five meetings, participants produced artifacts such as lesson plans and design activities, which served as the primary data sources.

Data analysis employed a qualitative approach, focusing on the artifacts created by the participants. The evaluation considered several key criteria, including the incorporation of computing concepts into the products created, the accessibility of the artifacts for 4- and 5-year-old children, the connection with the everyday experiences and contexts of the children, and the promotion of skills such as creativity, critical thinking, and active participation. We evaluated in an FG among the researchers, leveraging reflections from group dynamics and direct analysis of the artifacts. This process enabled the identification of how the project objectives were embedded in the products created by the participants.

The combination of action research and qualitative analysis during the FG provided a comprehensive understanding of the pedagogical impact of the workshops. This approach will contribute to more inclusive and effective educational practices, training children to be active users of technology.

Table 15 – Developed Design Activities.

Title	Ability covered	Computing concept	Categorization by CC2020	Categorization by Computing: Complement to the BNCC	Design activity
Creating stories with Codes	Creativity	Binary numbering	Software Fundamentals	Computational Thinking and Digital World	Story creation
Sound Maze	Creativity	Input - Processing - Output of data	Systems Modeling	Computational Thinking	Creating a maze
I can be an amazing programmer!	Creativity	Algorithms and Programming Languages	Software Fundamentals	Computational Thinking	Creating algorithms with unplugged materials
Televising Ideas - Reporters in action	Creativity	Data Transmission	Systems Modeling	Computational Thinking and Digital World	Creation of a TV and remote control prototype using recyclable materials
Trail of the Internet Protectors	Creativity	Information Security	Systems Modeling	Digital Culture	Creating a board game and awareness posters
Virtual environment - Security beyond screens	Critical Thinking	Privacy and Data Security	Systems Modeling	Digital Culture	Creation of awareness flyers
Topological routine	Critical Thinking	Organizational strategies (Topological Graphs)	Software Fundamentals	Computational Thinking	Graph creation
Creating my computer	Critical Thinking	Hardware concepts (Monitor, CPU, keyboard, and mouse)	Hardware	Digital World	Prototyping electronic devices with recyclable materials
How do we deal with videos we watch online?	Critical Thinking	Abusive use of electronic devices	Users and Organizations	Digital Culture	Creating scripts for videos
Conscious Disposal	Critical Thinking	Electronic waste disposal	Users and Organizations	Digital Culture	Creation of a container for disposal of electronic waste

Table 16 – Details about FG participants.

ID	Gender	Level of education	Field of Study	Experience Time	
				Computer Science	Education
P1	F	Master degree	Education	Between 1 year and 5 years	Between 6 and 10 years
P2	F	Postdoc	Education	Less than 1 year	More than 10 years
P3	F	Postdoc	Education	Between 1 year and 5 years	More than 10 years
P4	F	Postdoc	Computer Science	More than 10 years	Between 1 year and 5 years
P5	M	Master degree	Computer Science	More than 10 years	Less than 1 year

4.4.2 Design Activities reviews

The FG method was chosen because it allows the collection of ideas, suggestions, and experiences through group interviews with several participants. The FG allows for qualitative data collection from the collaboration and discussion among the participants and the interaction with the researcher (MORGAN, 1996; TRAD, 2009; BARBOUR, 2009). The following equipment was used during the meetings: a notebook for holding online discussions and the Google Meet tool for recording audio and images.

All participants received and evaluated the design activities individually in advance. To guide the evaluation, we listed the following questions to be answered: (1) Does the design activity correctly present the computing concepts to be worked on? (2) Is the design activity developed consistently with the teaching and learning process used with children aged 4 and 5? (3) Do the proposed activities match the concepts worked on and the proposed duration? (4) Does the proposed activity involve the design process by the children? (5) Are creativity or critical thinking skills related to computing concepts? and (6) Does the design activity present an evaluation method consistent with the computing concept worked on? For each question, the participants answered “Yes”, “No”, or “Partially” and included a discursive response.

During the online meetings, individual assessments were discussed, and a collective response to each question was created, considering individual perspectives. The design activities were improved from these discussions.

4.4.2.1 Participants

The research involves 5 professionals with experience in computer and education. All participants had experience in early childhood or computing education. Table 16 presents details on the participants, including their gender, level of education, field of study, and the duration of their computer and educational experience. In the gender column, (F) represents the female and (M) represents the male. In the occupation column. This study obtained informed consent from all participants. The study was reviewed and approved by the Ethics Committee of Federal UFSCar, under protocol number 78975524.1.0000.5504.

4.4.2.2 Evaluation by Focus Group

The evaluations carried out by the participants in the meetings provided critical reflections on the activity plans, focusing on their clarity, technical depth, and applicability. The dialogue analysis showed agreement on several points and constructive disagreements that enriched the review process. The main results are highlighted below, along with the most debated issues.

One of the central points of the discussions was the perception that the computing concepts presented in the plans lacked greater technical depth, especially in the “Computer Knowledge” section. P4 argued that “the plans are shallow in computing content [...] and seem to speak to the teacher as if they were speaking to children”. This criticism led to the consensus that teachers, even without specific training in computing, need well-founded technical content that serves as a basis for developing activities in an informed and autonomous manner. In contrast, P2 suggested that keeping elements simpler could also be relevant for teachers who are less familiar with the topic, especially in early childhood education. To balance these perspectives, it was decided that the sections dedicated to technical knowledge would be further developed with classic references in the area. At the same time, guidelines for working with children would be presented in specific sections, such as “This in my world”.

Participants emphasized the importance of connecting computing concepts to children’s everyday lives. In the “Creating my computer” design activity on hardware, it was suggested that the associations be expanded to include familiar devices, such as tablets and cell phones. P5 reported that, even at more advanced levels of education, many students struggle to use basic computer tools due to the prevalence of interactions with mobile devices.

Another discussed point was the flexibility of activities and time management. P2 pointed out that “children’s routines are unpredictable” and suggested that the plans include guidelines for adaptation according to the class’s needs. This suggestion was well received and led to the decision to include examples of adjustable schedules, enabling teachers to adapt activities without compromising pedagogical objectives.

The issue of child abuse, addressed in the activity “Virtual environment - Security beyond screens” on data privacy, also generated discussions. P4 emphasized that “for children, the most tangible risk is not losing money, but having personal data or photos inappropriately used.” There was consensus that the topic should be included explicitly, aligning the concept of data privacy with the context of children and providing teachers with clear information to address the topic sensitively.

Assessment of activities was another widely discussed topic. In some design activities, assessment methods were considered unclear or insufficient. P2 suggested including concrete activities, such as reorganizing stories or identifying logical sequences, to check children’s understanding. This point generated a consensus that assessment criteria should

be more explicit, with practical examples aligned with pedagogical objectives.

The discussions held contributed significantly to the improvement of design activities. Among the most significant advances, we highlight the need to deepen technical knowledge in computing, improve content organization for diverse audiences (teachers and children), and enhance assessment methods. The inclusion of relevant social issues, such as child abuse, also reinforces the role of the activities as tools for raising awareness and ethical education. Table 17 summarizes all design activities and their respective changes based on the FG assessment.

Table 17 – Modifications made to each Design Activity.

Title	Computing Knowl- edge	Activity Objective	Duration time	Activity Develop- ment	Activity Assess- ment
Creating stories with Codes	X			X	X
Sound Maze	X	X	X		
I can be an amazing programmer!	X				X
Televising Ideas - Reporters in action	X				
Trail of the Internet Protectors	X				
Virtual environment - Security beyond screens	X			X	
Topological routine	X		X		X
Creating my computer	X	X	X	X	
How do we deal with videos we watch online?	X			X	
Conscious Disposal	X				

These changes demonstrate that early childhood computing education can be enriched by balancing technical rigor, practical applicability, and connection to children's daily lives. The collaborative review process ensured that the design activities met the teacher's needs and fostered meaningful and transformative computing education.

4.5 Findings

This research used two complementary methods (action research and Focus Group (FG)) to create and evaluate design activities for teaching computing in early childhood education, focusing on children aged 4 and 5. The findings underscore the importance of collaborative approaches in developing educational tools that strike a balance between technical rigor and pedagogical applicability.

We conducted action research through 15 workshops organized in three stages. In the first workshop (stage 1), some participants, mainly teachers, resisted teaching computing to 4- and 5-year-old children. Discussions focused on the difficulties of introducing computing into everyday classroom activities, particularly in large classes. Arguments such as the children's lack of maturity and the need for greater supervision were frequently raised, highlighting the challenges of this integration.

However, a noticeable change occurred in the practical workshops (stage 2), which involved experiences with robotics and unplugged computing activities. Most participants began to show interest in understanding how children carried out the practices, the difficulties they encountered, and the strategies to resolve them. In addition, teachers began to reflect on the connection between the proposed activities and those they had already carried out in the classroom, recognizing the skills developed in the process, such as creativity and critical thinking. This evolution in engagement reinforces the importance of including practical experiences to transform initial perceptions and broaden understanding of the potential of teaching computing in early childhood education.

In the final stage (stage 3), groups composed of participants from education and computing areas found it easier to translate technical concepts into pedagogical practices. On the other hand, groups formed only by educators faced challenges in defining the computational concepts to be worked on, requiring greater support from researchers. These results highlight the value of interdisciplinarity for developing technically sound and pedagogically appropriate teaching materials.

The FG, which were carried out to evaluate the activity plans, provided essential contributions regarding the clarity and technical depth of the proposals. Participants highlighted the need to improve the "Computer Knowledge" section, ensuring that teachers, even those without specific training in the area, have access to rigorous and relevant information. P5, from the computing area, suggested that the design activities offer a solid technical structure: "The teacher must have access to the computational content in a clear and well-founded manner". On the other hand, P2, from the early childhood education area, argued that the language should be accessible and connected to the school routine. The consensus was to divide the technical content into a specific section for teachers, with detailed explanations and a theoretical basis. At the same time, the practical guidelines would be presented in a simplified way in the sections dedicated to children. This organization made it possible to meet the needs of both audiences without compromising pedagogical quality.

The time needed to complete the activities was another widely discussed point. P2 highlighted that "children's routines are unpredictable; an activity that works well in one class may not work well in another". She suggested that plans include guidelines for adapting the time and strategies for reorganizing steps according to the children's interests and engagement. P5 argued, in turn, that more defined times are essential for teachers who

need structure to organize their classes and evaluate the progress of activities. He says, “The lack of a clear time estimate can make planning and executing activities difficult”. To address this disagreement, participants agreed to include suggested time frames for each step of the activities, accompanied by explanatory notes on the possibility of adapting the schedule. This approach was seen as a balance between providing structure and allowing flexibility, ensuring that teachers could tailor activities to the specific needs of their classes.

Action research and FG highlighted the collaborative process richness, especially in moments of divergence, such as discussions about the timing of activities and the technical approach. On these occasions, the researcher acted as a mediator, facilitating consensus that balanced the practical demands of teachers with the technical criteria of the computing area. Including practical experiences and interdisciplinary debates was essential to transform initial perceptions and align expectations.

The study findings demonstrate that action research enabled the creation of robust and adaptable teaching materials, while FG ensured the relevance and applicability of these materials. The evolution in participant engagement, especially among teachers, reinforces the potential of practical and interdisciplinary approaches to transform challenges into opportunities in computing education. The method combination enriched design activities.

4.5.1 Design activities

All design activities involve computing education (Appendix G), product design (including play, stories, posters, games, etc.), and the development of creative or critical thinking. Five design activities improving creativity, and five focusing on improving critical thinking were created.

The “Creating Stories with Codes” design activity aims to introduce the concept of binary numbering, the basis of computer operation, in a fun and accessible way for children. The proposal uses the creation of stories as a means to teach binary logic, where each action in the narrative is associated with a binary sequence (0 and 1). The activity seeks to develop skills such as logical thinking, sequential organization, and creativity, promoting the understanding of how computers process information efficiently. In addition, it encourages group work, cooperation, and collective validation, helping to build skills such as computational thinking and the expansion of interpersonal relationships. Through interactive materials, such as binary tables, illustrated cards, and prototyping tools, children experience computational logic in a practical and fun way, connecting technical learning to their daily reality. The activity introduces the language of computers and reinforces the importance of organization and clarity in communication, essential both for computing and for the social and cognitive development of children.

The “Sound Maze” design activity aims to teach children aged 4 to 5 the data processing concept, using a fun and practical approach. The proposal explores the three fundamental stages of computer operation – data input, processing, and output – through a game in which children create sound codes to guide blindfolded colleagues through a maze. Each sound represents an instruction (input), which is processed by the “robot” (blindfolded child), resulting in concrete actions (output). The activity promotes the development of skills such as logical thinking, cooperation, and creativity, in addition to introducing fundamental concepts of programming languages. Children learn practically how clear commands are essential on computers and in daily situations. In addition, the activity encourages review and adjustments of the codes created, reinforcing the idea that mistakes and iterations are part of learning. Using simple materials such as tape, small objects, and sound instruments, the activity connects computational processes to children’s real world, helping them understand how computers transform information into practical results. This learning builds computational thinking while fostering social and creative skills in a collaborative and interactive environment.

The “Televisioning Ideas - Reporters in Action” design activity aims to introduce wireless communication concepts, using the example of how TVs and remote controls work. The proposal seeks to educate children about wireless data transmission, using technologies like infrared and Wi-Fi, and connecting these concepts to their daily lives. Through practical demonstrations, such as creating commands for "human remote controls" and engaging in creative activities, like building TV prototypes, children experience the fundamental processes of data input, processing, and output in computing. In addition, the activity promotes creativity, collaboration, and logical thinking skills by involving students in creating their TV channels and presenting content to the school community. The design activity also encourages the exploration of wireless devices in the school environment, allowing children to understand the practical application of the technologies covered. Children are encouraged to reflect on the concepts learned, consolidating their understanding of how wireless communication technologies operate and their relevance in everyday life.

The “Trail of the Internet Protectors” design activity aims to teach fundamental security information concepts, addressing responsible and conscious practices when using the Internet. Through group discussions, storytelling, and interactive games, children learn to identify and avoid common dangers, such as suspicious links, messages from strangers, and sharing personal information. The proposal explores the three pillars of information security: confidentiality, integrity, and availability. During the activity, students create board games and educational posters, consolidating learning through collaborative and reflective practices. In the end, children are encouraged to reflect on the importance of protecting data and adopting safe behaviors in the digital environment, applying the concepts learned in their daily lives. The activity also seeks to raise awareness in the school

community about online security, promoting the integration between learning and digital citizenship.

The “Virtual Environment - Security Beyond Screens” design activity aims to teach fundamental concepts of privacy and data security to children aged 4 to 5, addressing the conscious and protected use of the digital environment. Through playful dynamics, such as creating safe virtual spaces, reading stories, and making educational posters, children learn to identify personal information that should be protected, recognize dangerous situations, such as suspicious messages, and adopt safe behaviors on the internet. The proposal also explores awareness of digital footprints and the impact of sharing data online, constantly reinforcing the importance of seeking help from an adult in situations of doubt. In addition, the plan addresses the relationship with sensitive topics, such as child abuse, helping children understand how to maintain their safety in the virtual environment. During the activities, skills such as critical thinking, creativity, and cooperation are worked on, promoting the construction of a more ethical and conscious digital environment. At the end, the children present the results of the activities on posters and pamphlets, reinforcing learning and sharing safe practices with the school community.

The “Topological Routine” design activity aims to introduce graph concepts and their application in logically organizing information and tasks, promoting the development of critical thinking. By creating a “routine map”, children learn to represent daily activities as vertices connected by edges, symbolizing the sequence and dependencies between actions. The proposal encourages children to reflect on healthy habits and how different orders can influence daily life, in addition to connecting these concepts to the functioning of computers, which use graphs to organize tasks and solve problems. During the activity, interactive practices are explored, such as drawing routines and creating prototypes with cards and arrows, allowing children to visualize and manipulate the concepts tangibly. The activity also promotes social skills, such as cooperation and communication, by involving group discussions and collective reviews of the “maps” created. At the end, children present their organized routines and discuss how the correct order of actions helps ensure efficient functioning in daily life and computer systems. This playful and practical approach connects technical learning to children’s reality, developing essential skills for computational thinking and logical organization.

The “Creating My Computer” design activity aims to teach children about the main components of a computer, such as the CPU, monitor, keyboard, and mouse, and their respective functions in the system. Children are encouraged to create device prototypes using recyclable materials and old components, connecting theory to practice through a playful and practical approach. During the activity, children learn that different devices, such as computers, tablets, and smartphones, share operating principles based on data input, processing, and output. The proposal also promotes skills such as creativity, cooperation, and critical thinking by engaging children in the construction, presentation,

and review of prototypes, constantly reflecting on how devices connect and help in daily activities. This activity brings children closer to technology meaningfully and develops an initial understanding of how computer systems work.

The design activity “How Do We Deal with Videos We Watch Online?” aims to raise awareness among children aged 4 and 5 about the healthy use of screens, promoting a balance between time spent on digital devices and other activities essential to development, such as playing, social interaction, and rest. Through discussions, comparisons between short and long videos, and the creation of scripts for videos, children are encouraged to reflect on the impact of screen time on their routines and understand how to use technology positively and responsibly. During the activity, they learn to identify healthy practices, analyzing how screen time can be better used for learning and fun without compromising physical and mental health. The proposal also stimulates skills such as critical thinking, creativity, and cooperation by involving children in the creation of digital content and in organizing balanced schedules. At the end, children share their reflections through drawings and group discussions, consolidating the concepts of balance and conscious use of technology.

The “Conscious Disposal” design activity aims to teach about the importance of proper disposal of electronic waste, promoting awareness of the environmental and social impacts related to technology. Through playful practices, such as exploring electronic components, creating stories about the life cycle of devices, and making prototypes of disposal boxes, children learn to identify materials present in computers and understand why their improper disposal can harm the environment. The activity also explores concepts of recycling and reuse, showing how materials such as copper and nickel can be reused to reduce the extraction of natural resources. During the process, children connect the concepts learned to their daily reality. At the end, they participate in reflective discussions and create educational posters that reinforce good disposal practices, sharing their learning with the school community. This practical and integrative approach aims to form a sustainable awareness from childhood, aligning the use of technology with respect for the environment.

4.5.1.1 Example of a Design Activity Plan

Below, in Table 18, is an example of a design activity developed with all sections outlined. In this design activity plan, the proposed activity is related to Data Processing. The title, “I can be an amazing programmer!”, is linked to the knowledge theme, which is the focus of the work with the children, specifically the concepts of algorithms and programming. The proposed age range is early childhood education (4 to 5 years old). Finally, the duration of the activity to be implemented with the children is stated, which in this example is approximately 4 hours. All activities include a note indicating that the duration is an estimated time and may be adjusted according to the class’s needs.

Table 18 – Sections: theme, title, knowledge, age range, and duration

Activity Design Plan	
Theme	Data processing
Title	I can be an amazign programmer!
Knowledge	Algorithms and Programming
Age Range	4 and 5 years old
Duration	4 hours ¹

Table 19 presents the computational knowledge related to the proposed activity. It is shown that the computer performs tasks based on detailed, precise, and ordered instructions. The activity seeks to develop notions of algorithms and programming, fostering the ability to organize ideas in logical sequence and solve problems in a structured manner.

Table 19 – Computer knowledge section.

Computer Knowledge:
Programming is the process of building algorithms. Algorithms are logical, ordered sequences of steps that allow a computer to solve problems or perform tasks. An algorithm must be clear, precise, finite, and free of ambiguities, so that it can be understood and executed by the computer reliably (Cormen et al., 2022). These fundamental aspects ensure that instructions are interpreted correctly and lead to the expected result. Programming is done through programming languages, which are formal tools used to communicate these instructions to the computer. According to Knuth (1997), "programming is the art of expressing efficient solutions to problems through a language that the computer can interpret". Examples of such languages include Python, Java, and Scratch. Scratch is a visual, block-based programming language widely used in educational settings to introduce programming concepts in a visually engaging and interactive manner. Computers, by their nature, are devices that perform operations according to a logical sequence of commands. However, for this to be possible, the instructions provided must be accurate, detailed, and organized into clear, step-by-step instructions. Any inaccuracy in the algorithm can lead to errors in execution, which reinforces the importance of designing well-structured instructions. For example, a detailed algorithm for brushing teeth could be described like this: 1. Go to where the toothbrush is stored. 2. Hold the toothbrush in one hand. 3. Take the tube of toothpaste with your other hand. 4. Open the cap of the toothpaste tube by turning it counterclockwise (or removing it if it is a snap-on cap). 5. Squeeze the toothpaste tube to apply a pea-sized amount to the bristles of the

toothbrush.

6. Close the cap on the toothpaste tube and store it in the appropriate place.
7. Open the tap.
8. Place the toothbrush under running water for 2 to 3 seconds to wet the bristles.
9. Close the tap.
10. Place the toothbrush in your mouth and brush your upper teeth, moving the brush back and forth in short strokes, for approximately 30 seconds.
11. Brush your lower teeth, repeating the short strokes, for another 30 seconds.
12. Brush the inside surfaces of your upper and lower teeth using vertical strokes.
13. Brush your tongue, moving the brush gently from back to front.
14. Turn the tap back on and rinse your mouth with water.
15. Rinse the toothbrush under running water to remove any toothpaste residue.
16. Close the tap.
17. Store your toothbrush in the appropriate place.

This example demonstrates how an algorithm should be detailed, describing each necessary step clearly and logically, without assuming implicit actions.

To teach computing, it is essential to understand that computers do not "think" or "interpret" like humans; they simply execute exact instructions as programmed. This means that any inaccuracy, such as a poorly defined or out-of-order step, can lead to errors in the result.

Fundamental characteristics of an algorithm:

- **Finiteness:** It must have a limited number of steps and end at some point.
- **Clarity:** Each step must be described precisely and unambiguously.
- **Order:** Instructions must follow a logical sequence.
- **Input and output:** An algorithm can receive input data and must produce a result.

By introducing children to programming, we are not only teaching them how to "give orders" to the computer, but also fostering important skills such as problem-solving, creativity, and the ability to organize thoughts logically. Teaching children to write clear, precise algorithms helps develop these essential skills.

The "Objective" section focuses on what the proposed activity aims to teach. In this example, the objective is to explore the programming profession, stimulating creativity, logical reasoning, and sequential organization of actions through the creation of group instructions and solutions (see Table 20).

Table 20 – Objective section.

Objective:
The goal of this activity is to help children learn more about the programming profession, exploring how people use programming to create solutions and control different everyday situations. The activity will also encourage children to come up with hypotheses about why programming is important, as well as stimulate creativity by allowing each child to create their own sequences and actions. In addition, the activity will help develop motor coordination when drawing or assembling physical representations of their ideas, and will promote social interactions, with group activities where children can exchange ideas and collaborate. Finally, the activity will seek to stimulate logical reasoning, teaching children to organize actions in a sequence and to think in an orderly and strategic way.

The “21st Century Skills” section of the activity plans addresses the skills that will be developed during the activity to solve the proposed problem when applied to the children. It is worth noting that not all 21st Century Skills will be present in each plan. In general, the 21st Century Skills present in the plans are among the Learning and Innovation skills: (I) creativity and innovation, and (II) critical thinking and problem-solving. In each plan, the skills to be developed depend on the proposed problem. In this example, as can be seen in Table 21, the skill expected to be developed in this plan is creativity and innovation. The skills, when included in the plan, are described according to the proposed problem for the activity.

Table 21 – 21st Century Skills section.

21st Century Skills:
Creativity and Innovation: The child will develop creativity while creating the signs/codes to be used.

The “BNCC Axes and Skills” section presents the learning and development objectives for early childhood education contained in the official federal government document produced by the Ministry of Education (BRASIL, 2021). For each activity, this topic lists which BNCC axis and skill are included in the activity in question. In addition to presenting the code contained in the official document, it is also detailed with a description. In this example, based on the proposed problem, the learning and development objectives for early childhood education are presented, such as EI03EF01 and EI03CG05. Table 22 shows the axes and skills present in the presented activity.

Table 22 – BNCC Axes and Skills section

BNCC Axes and Skills:
- “LISTENING, SPEAKING, THINKING AND IMAGINATION” (EI03EF01): Express ideas, desires, and feelings about your experiences, through oral and written language (spontaneous writing), photos, drawings, and other forms of expression.
- “BODY, GESTURES AND MOVEMENTS” (EI03CG05): Coordinate your manual skills to adequately meet your interests and needs in different situations.

Additionally, the “BNCC Computing Axes and Skills - Early Childhood Education” section presents the learning and development objectives for computer education in early childhood education, as set out in the official federal government document produced by the Ministry of Education (BRASIL, 2022). In this example, the activity addresses three learning and development objectives for computational thinking in early childhood education: EI03CO02, EI03CO03, and EI03CO04 (see Table 23).

Table 23 – BNCC Computing Axes and Skills - Early Childhood Education section.

BNCC Computing Axes and Skills - Early Childhood Education:
- “COMPUTATIONAL THINKING” (EI03CO02): Express the steps to perform a task in a clear and orderly manner.
- “COMPUTATIONAL THINKING” (EI03CO03): Experience the execution of algorithms by playing with (un)plugged objects.
- “COMPUTATIONAL THINKING” (EI03CO04): Create and represent algorithms to solve problems.

The “Materials needed for the activity” section refers to the list of materials needed to complete the activity. In this example (see Table 24), the materials required are construction paper, printed geometric shapes, scissors, and the book “Ada Lovelace, the Curious Contessa”. Therefore, before implementing the activity, the teacher should be aware of the materials required.

Table 24 – Materials needed for the activity section.

Materials needed for the activity:
- Cardboard or Eva’s
- Printed Geometric Shapes (Circle, Triangle, Square and Rectangle)
- Scissors
- Book “Ada Lovelace, the Curious Countess”

The “Activity Development” section contains the necessary instructions for implementing the proposal in a structured and progressive manner. In this example (see Table 25), the activity is organized into five main steps, beginning with the introduction of programming concepts through the story of Ada Lovelace. The teacher should playfully

present the topic, contextualizing programming as a set of clear and organized instructions for computers or robots to perform actions, using everyday examples to facilitate children's understanding.

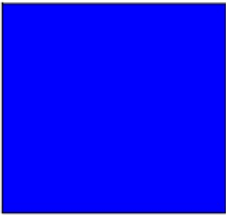
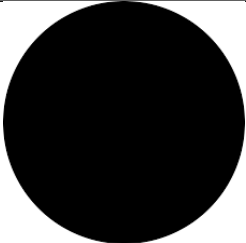
Next, the children are divided into groups and choose materials such as colored EVA foam and cut-out geometric shapes (circles, squares, and triangles) that will symbolize specific commands. The groups create associations between shapes and actions (for example, "circle" could mean "jump", and "square" could mean "clap"), thus forming a coded language that must be interpreted and executed by the opposing group.

In the third stage, students are guided to organize the forms and commands into a logical sequence, reinforcing the importance of clarity and logic in planning instructions. Next, the commands are executed, with one group presenting the sequence and the other interpreting and executing it. This encourages attention to detail and an understanding of the need to follow instructions precisely.

Finally, there's a moment of reflection and feedback. Children share their impressions, discuss whether the instructions were understandable, and suggest improvements. This stage reinforces the concepts of iteration, clear communication, and the importance of continuous improvement, which are fundamental to computational thinking and programming.

Table 25 – Activity Development section.

Activity development:
1. Introduction to Programming Concepts Read the book Ada Lovelace (see References), the Curious Countess, which presents playfully the story of Ada Lovelace, the first person to create a programming idea, inspiring children. Explain, in your own words, that programming is giving clear and organized instructions to a computer or robot. Relate the concept to everyday examples, such as "giving instructions to someone to find a lost object" or "following a cake recipe." Use Ada's story to contextualize the emergence of programming and emphasize how it paved the way for the creation of games, apps, and other technologies. 2. Choosing Materials and Forming Groups Divide the children into two groups. Allow each group to choose the color of foam they want to use and give them geometric shapes to cut out, such as circles, squares, and triangles. Show examples of ready-made cut-out geometric shapes and explain that each shape will represent an action or command. For example: "The circle could mean jump' and the square could mean 'clap'."

Explain that these shapes and actions will function as a “code” that the other group must interpret and execute. 3. Prototyping and Creating Commands Guide each group to decide which actions to create and how to arrange their geometric shapes to form a logical sequence. Explain that they are building an “action recipe” and encourage creativity when choosing commands. Highlight that organizing the shapes clearly and logically helps avoid confusion and ensures that the other group can follow the instructions. Tip: Draw the geometric shapes with their respective actions on the board or chalkboard so that the group performing the activity can easily consult them during the activity.	
Simbol	Instruction
	Jump
	Clap
Tip: If the sequences created by the groups are not clear, the teacher should intervene, using appropriate terms and suggesting specific adjustments, such as “Rethink this sequence so that it is more logical and easier to understand”. 4. Executing Commands Instruct each group to present their sequence of commands to the other group. Explain that the executing group must follow the actions in the order presented, correctly interpreting each form and carrying out the corresponding actions. Emphasize the importance of following the commands carefully so that the final result is as expected. 5. Reflection and Feedback Gather everyone together for a discussion circle and ask: “Were the instructions clear?” “Was it easy to follow the actions proposed by the other group?”	

“How could we improve the instructions to make them even easier to understand?”

Encourage children to share what they found fun and challenging about the activity. Explain that this step is crucial for reflecting on the clarity of instructions and the logic of actions, as it connects with the concept of iteration and improvement inherent in programming.

Tip: Use visual examples during the conversation circle, such as drawings or diagrams of the sequences created, to reinforce the points discussed.

The “This in My World” section is tied to children’s daily lives, thus drawing an analogy between the content taught and computing. In this example (see Table 26), the linked world knowledge is the experiences children have during play, listening to and creating commands with friends, or following daily commands such as packing their backpacks for school or putting their toys away.

Table 26 – This in My World section.

This in my world:
In our lives, we are always following and giving commands. When we play, for example, we need to listen to what our friend says to continue the game, such as jumping when they tell us to or clapping when they ask us to. Just as we did in the activity, where we created commands for our colleagues to follow, in our daily lives, we also need to understand and follow instructions. Whether it’s packing your backpack for school or putting your toys back in the box, there’s always an order to do things and rules to follow. This activity helps us think about how to organize and follow these instructions, making our tasks easier and helping us communicate what we want others to do.

In the “Assessment” section, an activity is suggested for the teacher to assess the child’s knowledge acquired after completing the activity. In this example (see Table 27), the suggested assessment is based on the teacher’s observation, considering aspects such as the logical sequence, the clarity of the instructions, and how the children explained the commands during the activity. Furthermore, a guided discussion is also proposed so that the children can self-assess and share their insights.

Table 27 – Assessment section

Assessment:
The evaluation of this activity will be carried out in two complementary stages: 1. Teacher’s Observation During the creation of codes and the execution of sequences, the teacher will observe the following points: - Logical Sequence: Were the children able to organize the commands logically and coherently? - Clarity of Instructions: Were the children able to create clear commands that the other group was able to interpret and execute correctly? - Explanation of Commands: Can children explain what each geometric shape represents and how the command should be followed? - Group Collaboration: Was there active participation by all group members in the decisions and execution of the activity? 2. Children’s Self-Assessment At the end of the activity, children will be invited to participate in a conversation to evaluate the process and share their perceptions. Some questions that can be asked: - What did you enjoy most about doing this activity? - What did you find easiest or hardest to understand? - Do you think the commands we created were clear? Why? - What could we do differently next time to improve? The teacher can record the children’s responses to identify aspects that worked well and points that can be improved in future activities. This approach allows children to reflect on the process and feel part of the assessment, valuing their perspective and promoting the development of metacognition skills. In addition, the teacher’s observations and the children’s feedback will be used to adjust and improve future activities.

4.6 Discussion and Conclusion

This study highlights the relevance of interdisciplinary collaboration between early childhood education teachers and undergraduate students in developing activities to teach computing to 4- and 5-year-old children. The action research approach facilitated the creation of practical tools that integrate fundamental computing concepts, such as binary numbers, algorithms, and data transmission, with pedagogical practices. By actively participating in the design process, teachers contributed their pedagogical expertise to teach age-appropriate activities. At the same time, undergraduate students brought contemporary computing and education knowledge, resulting in a balanced and practical framework.

However, the process revealed significant challenges, such as the need to translate technical concepts into accessible language for early childhood education. Many teachers, due to their predominantly pedagogical backgrounds, reported difficulties in understanding and applying computer-related topics. This gap underscores the importance of continuous professional development for teachers, tailored explicitly to computing education

in early childhood contexts. Providing teachers with well-structured support materials, such as glossaries and step-by-step guides, could help mitigate these challenges and enhance their confidence in introducing computational thinking to young learners. Despite these initial difficulties, the collaborative nature of the research facilitated knowledge exchange, fostering mutual learning among participants and enabling the co-construction of meaningful and effective educational solutions.

The implementation of design activities showcased their potential to transform teachers' perceptions of computing education. During the hands-on workshops, teachers began to recognize the value of these activities in fostering skills such as critical thinking, creativity, and problem-solving. As the workshops progressed, teachers noticed the potential for increased engagement among children and their ability to connect computational concepts to everyday experiences. This shift suggests that well-designed computing activities can positively impact children's cognitive and social development, particularly when integrated into playful, interactive learning environments. Furthermore, observing previous experiences in which children engaged in similar activities encouraged educators to appreciate the relevance and feasibility of computing education in early childhood settings.

The FG evaluated the design activities, which provided significant contributions to improving the activities. Participants highlighted the need for greater clarity and technical depth in the content presented to teachers, ensuring they feel confident in working with computational concepts. One of the key suggestions from the FG participants was the inclusion of practical examples and ready-to-use teaching strategies to bridge the gap between theory and practice. By incorporating hands-on examples and simplified explanations of complex concepts, teachers can be better equipped to deliver computing education effectively.

A widely debated issue was the duration of activities and their flexibility to accommodate classroom dynamics. Early childhood educators argued that young children's routines require adaptable schedules, whereas computing experts emphasized the importance of structure for effective learning. A compromise was reached by introducing recommended time estimates for each activity, accompanied by flexible implementation guidelines. This adaptive approach allows teachers to adjust the pace based on student engagement and classroom needs while maintaining the pedagogical integrity of the activities.

Another central discussion point was the assessment of children's learning. FG participants recommended integrating specific activities to assess understanding, such as sequencing tasks and storytelling exercises. This suggestion led to the development of more explicit assessment criteria, helping teachers identify children's progress in computational thinking, creative problem-solving, and logical reasoning. Future research could explore how these assessment methods can be further refined to provide quantifiable data on children's computational development.

Additionally, the design activities were praised for fostering the connection between computing and digital citizenship. Topics such as data privacy, online security, and responsible e-waste disposal were integrated into the activities, providing a critical and ethical perspective on computing education. In an era where children are increasingly exposed to technology, the ability to navigate digital spaces safely and responsibly is essential. By incorporating ethical discussions into computing education, this study demonstrates that digital literacy and social responsibility can be introduced from a young age. Teachers reported that these activities help children understand technology and empower them to become more conscious and responsible users.

The findings of this study contribute to the growing body of research on early childhood computing education by demonstrating the effectiveness of collaborative, interdisciplinary approaches. The study also provides a framework that can be adapted for different educational contexts, allowing educators worldwide to integrate computing concepts into early childhood curricula without requiring advanced technical training. Future studies could explore the long-term impact of these activities on children's computational thinking development and their transition into formal computer science education in later school years.

We conclude that teaching computing in early childhood education can be effective and engaging when grounded in collaborative and interdisciplinary practices. The activities developed in this study represent an innovative approach that combines technical rigor with pedagogical relevance, ensuring that computational concepts are integrated into young children's daily lives in a playful and meaningful way. This model demonstrates that it is possible to introduce computing education from the earliest years of schooling, preparing children for the challenges and opportunities of an increasingly digital world.

Chapter 5

Evaluating a Co-Design-Based Framework for Computing Education in Early Childhood

Article title: Evaluating a Co-Design-Based Framework for Computing Education in Early Childhood: A Mixed Qualitative Triangulation Study with Preschool Children

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This chapter presents the article “Evaluating a Co-Design-Based Framework for Computing Education in Early Childhood: A Mixed Qualitative Triangulation Study with Preschool Children” and constitutes the central empirical contribution of this doctoral thesis.

The chapter reports a quasi-experimental study conducted in real early childhood education classrooms, involving an experimental group and a control group. The proposed framework integrates co-design principles, unplugged activity plans, and assessment rubrics to identify evidence of creativity, critical thinking, and computational understanding in children aged 4 and 5.

Data collection involved pre- and post-interviews with children, creativity and critical thinking tests, teacher-applied rubrics, classroom observations, and researcher field notes. A qualitative triangulation approach was adopted to integrate multiple data sources and perspectives. The results indicate qualitative improvements in the experimental group, suggesting the framework’s effectiveness and providing empirical evidence to support the

use of co-design-based approaches in early childhood computing education.

5.1 Introduction

Teaching computing in early childhood has gained increasing attention in response to the growing presence of digital technologies in children’s everyday lives. From an early age, children engage with a wide array of digital devices and platforms at home and in educational settings, where digital play and technology-mediated activities constitute meaningful contexts for learning, creativity, and social interaction (CHU et al., 2024; PLOWMAN, 2016). In this sociotechnical landscape, educational systems have increasingly emphasized the need to foster competencies aligned with so-called 21st-century skills, including digital literacy, computational reasoning, and creative problem-solving (KONTKANEN et al., 2023; OECD, 2021). Consequently, international policy documents and curriculum guidelines have positioned these competencies as foundational elements of contemporary education, reinforcing the relevance of introducing computing concepts already in early childhood (AUSTRALIA, 2018; UNESCO, 2023).

Within this scenario, research in Child-Computer Interaction (CCI) and early computing education has shown that young children are capable of engaging in computational reasoning, creative problem-solving, and collaborative design when pedagogical approaches are tailored to their developmental characteristics (HARPER et al., 2024; ÇİFTÇİ; TOPCU, 2023). However, despite growing interest, the field still lacks structured, evidence-based frameworks to support teachers in designing and implementing computing activities that are both developmentally appropriate and pedagogically effective (HUANG; LOOI, 2021; SU; YANG, 2023b).

A central challenge is that many existing approaches to early computing education rely on isolated activities, such as unplugged tasks, robotics kits, or short-term interventions, or on teacher-centered instructional models that insufficiently consider children’s agency, creativity, and lived experiences (HUANG; LOOI, 2021; BERS, 2018). While these approaches have contributed valuable insights, they often lack continuity, pedagogical integration, and explicit support for teachers’ mediation practices (LYE; KOH, 2014). In parallel, Participatory Design (PD) and co-design approaches have demonstrated strong potential for involving children in the creation of technologies and learning experiences; however, their application with preschool-aged children (4–5 years old) remains limited and methodologically fragmented (FAILS et al., 2013; GUHA; DRUIN; FAILS, 2013). Although CCI research has long advocated for children’s involvement as informants, design partners, and co-researchers (DRUIN, 1999; DRUIN, 2010), translating these principles into formal early childhood educational settings and computing curricula remains relatively underexplored and under-theorized (LEHNERT et al., 2022; IVERSEN; HALSKOV; LEONG, 2017).

To address these gaps, we developed a comprehensive framework for computing education in early childhood that integrates three key components: (1) co-design principles tailored to children aged 4–5; (2) activity plans for teaching computing concepts through unplugged and design-oriented activities; and (3) assessment rubrics for identifying evidence of creativity and critical thinking in children’s behaviors and problem-solving processes. Framework-based approaches are commonly adopted in design-based research to articulate theory, pedagogical design, and empirical evaluation in educational contexts (BROWN, 1992; SANDOVAL, 2014; EASTERDAY; LEWIS; GERBER, 2014).

This article reports an empirical experiment conducted with two preschool classrooms, designed to evaluate the effectiveness of the framework in supporting the development of creativity, critical thinking, and foundational computing concepts in young children. A quasi-experimental design was employed, with one classroom serving as the control group and the other as the experimental group, an approach commonly used in educational research conducted in authentic school settings (CRESWELL; CRESWELL, 2017; BARAB; SQUIRE, 2004). Both groups participated in pre- and post-interviews to assess their relationship with technology, as well as in creativity and critical thinking tasks administered at the beginning and end of the study. The experimental group engaged in an eight-week intervention, during which the classroom teacher implemented the framework’s principles and activity plans as part of her regular teaching practice. Throughout the intervention, the researcher maintained a detailed observation diary. At the end of the study, both teachers participated in interviews and completed the rubrics in the framework to assess children’s development over time.

The evaluation adopted a triangulation approach, integrating data from multiple sources, interviews with children and teachers, creativity and critical thinking tests, classroom observations, and rubric assessments, to provide a rich, multilayered understanding of the framework’s impact. Triangulation enables convergence across perspectives, instruments, and contexts, thereby supporting a more reliable and less biased investigation of children’s experiences (DENZIN, 1978; CRESWELL; CRESWELL, 2017). Grounded in this methodological perspective, the study is guided by the following research questions:

RQ1: How do children in the experimental group demonstrate changes in creativity, critical thinking, and computing education when compared to the control group?

RQ2: How do teachers perceive children’s development throughout the study, and how do their assessments, as reflected in the framework’s rubrics, align with other sources of data?

This research makes contributions to the fields of Human-Computer Interaction (HCI), CCI, and early computing education. Theoretically, it offers empirical evidence for a co-design-based framework that addresses the developmental characteristics of young children, extending prior work on children’s participation in technology design into the context of computing curricula in early childhood education. Practically, it provides educa-

tors and designers with structured guidelines, activity plans, and assessment tools that can be readily integrated into early childhood classrooms, aligning with broader calls for concrete pedagogical frameworks to computing education, creativity, and critical thinking in early years education.

The remainder of the article is organized as follows. Section 2 presents related work on CCI, co-design with young children, and early computing education. Section 3 describes the study’s methodology, including participants, instruments, data collection procedures, and analytical approach. Section 4 presents the findings from data triangulation. Section 5 discusses the implications of the results for theory, practice, and design, outlines limitations, and future directions. Section 6 concludes the article.

5.2 Background and Related Work

5.2.1 CCI and early childhood development

CCI is an established subfield of HCI that examines how children perceive, use, and make meaning with interactive technologies. Foundational work in the area has emphasized that children’s interactions are shaped by their cognitive, motor, emotional, and social developmental characteristics, which require methods and design strategies distinct from those used with adults (HOURCADE, 2015). Read e Bekker (2011) argue that CCI research must account for children’s ways of playing, learning, and communicating, proposing frameworks that center playfulness, imagination, and symbolic expression as core mechanisms of interaction.

Early childhood development theories also inform CCI. Vygotskian perspectives highlight that learning in early childhood occurs through social mediation, language, symbolic play, and guided participation, all of which contribute to children’s emerging conceptual understanding and meaning-making (VYGOTSKY, 1978). Research has explored how digital technologies become part of children’s everyday symbolic play, offering new spaces for narrative construction, emotional expression, and cognitive exploration (WOHLWEND, 2015; MARSH, 2010). Plowman (2016) further emphasizes that digital artifacts support not only individual learning but also shared and collaborative forms of meaning-making among young children.

Taken together, these perspectives reinforce that play, imagination, and symbolic interaction are essential contexts for early childhood technology use. However, despite the large body of work exploring how children interact with digital media, fewer studies explicitly connect these developmental foundations to structured approaches for introducing computing concepts in early childhood settings. This gap motivates the need for frameworks that integrate CCI principles with pedagogical practices in computing education for preschoolers.

5.2.2 Co-design e PD with children

PD and Co-design approaches have long played a central role in CCI by involving children directly in the design of new technologies. Druin’s (DRUIN, 1999; DRUIN, 2010) conceptualized children as “users”, “informants”, and eventually as full “design partners”, arguing that intergenerational cooperation enriches both the design process and children’s agency. Cooperative Inquiry, developed by Druin and colleagues, formalizes techniques such as low-tech prototyping, contextual inquiry, and iterative feedback sessions tailored for work with children (GUHA; DRUIN; FAILS, 2013).

A substantial body of research has elaborated on these early frameworks, describing methods that include brainstorming, design games, storytelling, drawing, and tangible prototyping (GUHA; DRUIN; FAILS, 2013). Read and Bekker (READ; BEKKER, 2011) and Markopoulos and Bekker (MARKOPOULOS; BEKKER, 2003) expanded the theoretical foundations of CCI by categorizing children’s roles and articulating methodological considerations for designing with them in age-appropriate ways.

Nevertheless, most co-design studies in CCI involve children aged 7–12, as younger children present notable methodological challenges, including limited expressive language, shorter attention spans, developing fine motor skills, and difficulties with abstraction (GUHA; DRUIN; FAILS, 2013; LEHNERT et al., 2022). With early childhood-aged children (4–5 years old), researchers must adapt co-design methods to incorporate playful scaffolding, multi-modal expression, and ethically sensitive approaches that honor children’s voices beyond verbal communication. These challenges highlight the need for frameworks explicitly designed for early childhood classroom environments, where teachers may be the primary facilitators of design-based activities.

Although the literature offers rich insights into participatory approaches, few studies integrate co-design principles into structured curricular frameworks for teaching computing in early childhood. This limitation underscores the relevance of evaluating frameworks that combine design participation and computing education for young children.

5.2.3 Computing education in early childhood

Interest in computing education and Computational Thinking (CT) in early childhood has grown substantially over the past decade, driven by curricular reforms and international recommendations emphasizing the importance of digital competence from the early years (VINCENT-LANCRIN et al., 2019). Systematic reviews show that children as young as four can engage meaningfully in CT-related tasks when activities are developmentally appropriate, playful, and grounded in concrete experiences (SU; YANG, 2023a).

Unplugged computing approaches have been particularly influential in early childhood settings. The CS Unplugged movement proposes teaching computing concepts

through physical games, puzzles, and storytelling without the need for computers (BELL et al., 2011). Empirical studies demonstrate that unplugged activities help young children develop sequencing, abstraction, and problem-solving skills while maintaining high levels of engagement (OLMO-MUÑOZ; CÓZAR-GUTIÉRREZ; GONZÁLEZ-CALERO, 2020; LIN et al., 2024). Other work combines unplugged tasks with robotics or tangible programming tools to support CT and early engineering skills (BERS; GONZÁLEZ-GONZÁLEZ; ARMAS-TORRES, 2019).

Beyond discrete activities, research highlights the importance of integrating computing concepts into broader play-based, storytelling, and design-oriented learning experiences. Metin (METIN et al., 2025), for example, demonstrates how a design-based digital storytelling program fosters CT, creativity, and narrative competence in children aged 3–6. Tsortanidou et al. (TSORTANIDOU; DARADOUMIS; BARBERÁ, 2019) show that creative and problem-based learning activities can interweave CT with collaboration and imagination. Xing et al. (XING; CADY; WANG, 2025) argue that playful computing experiences, both digital and unplugged, support conceptual understanding, creativity, and persistence in early childhood.

Despite this growing interest, most interventions remain isolated activities or short-term projects rather than comprehensive frameworks. There remains a lack of integrated curricular models that combine developmentally appropriate design principles, structured activity plans, and systematic assessment tools to support teachers in implementing computing education in early childhood classrooms.

5.2.4 Assessing creativity and critical thinking in young children

Creativity and critical thinking are increasingly recognized as essential components of early learning, contributing to children’s problem-solving abilities, imagination, and emerging reasoning skills. However, assessing these constructs in early childhood remains a methodological challenge due to their fluid, emergent, and highly contextual nature. Traditional assessment tools often emphasize verbal reasoning or abstract cognitive processes that may not align with the developmental characteristics of preschool-aged children.

Rubric-based assessments offer an alternative approach, allowing teachers and researchers to observe creativity and critical thinking within authentic learning activities rather than through decontextualized testing. Frameworks such as the OECD Creative and Critical Thinking Competencies (VINCENT-LANCRIN et al., 2019) propose structured dimensions, e.g., idea generation, analytical reasoning, and problem framing, that can be adapted to different educational contexts. Studies show that rubrics can support formative assessment and help educators make children’s thinking visible through performance-based indicators (BESANÇON; LUBART, 2008; KAUFMAN; BEGHETTO, 2009). In early childhood settings, rubric-based approaches have been increasingly used to

assess creativity in playful inquiry, emergent design activities, and collaborative problem-solving.

Nevertheless, researchers consistently note that assessing creativity and critical thinking in young children requires methodological sensitivity. Because early learners often express ideas through embodied action, exploratory manipulation, or narrative fragments, rubrics designed for older students must be carefully adapted to avoid overestimating verbal or abstract reasoning abilities. Additionally, formal rubrics tend to impose categorical scoring structures that may not reflect the nonlinear, developmental progression characteristic of early childhood. For this reason, researchers argue that assessments should be complemented by qualitative methods, such as observational field notes, child interviews, and artifact analysis, to provide a more holistic understanding of children's emerging capabilities (EINARSDÓTTIR, 2007).

Together, these findings indicate that while existing frameworks provide valuable foundations for assessing creativity and critical thinking, applying them to preschool contexts requires thoughtful reinterpretation to accommodate young children's developmental profiles and expressive repertoires. This aligns with broader calls in early childhood research for assessments that are contextually grounded, multimodal, and sensitive to the dynamic nature of young children's learning.

5.2.5 Triangulation in HCI and early childhood education studies

Triangulation is widely recognized as a methodological strategy to enhance the credibility, depth, and robustness of findings in qualitative research. Creswell (CRESWELL; CRESWELL, 2017) defines triangulation as the use of multiple data sources, methods, or theoretical perspectives to validate interpretations, especially in complex social environments. In early childhood research, where children's communication is multimodal and context-sensitive, triangulation becomes essential for capturing diverse forms of expression, behavior, and meaning-making.

Several studies illustrate the value of triangulation in early childhood contexts. Jackson (JACKSON, 2009) combined classroom observations, teacher interviews, and children's artifacts to study stress behaviors in kindergarten, demonstrating how different data types provided complementary insights. Al-Khatib (AL-KHATIB, 2013) employed interviews, field notes, and document analysis to examine early childhood teachers' professional identities through a triangulated case study design. Vanner and Kimani (VANNER; KIMANI, 2017) used art-based methods alongside interviews and observations to explore children's lived experiences, highlighting triangulation as a way to ethically and comprehensively honor young children's voices. In teacher-focused research, Molbaek (MOLBÆK; KRISTENSEN, 2020) demonstrated that combining classroom video recordings

with reflective interviews yielded a more complete account of instructional practices.

Although triangulation is common in early childhood education research, it is less frequently applied in computing education and CCI studies. Several CT studies employ pre/post testing and observational notes (LIN et al., 2024; METIN et al., 2025), but few explicitly integrate tests, interviews, rubrics, and ethnographic field notes into a unified analytical framework. This highlights the need for mixed-methods qualitative triangulation to capture the multidimensional nature of children’s learning and behavior during computing activities.

5.3 Methodology

This study adopts a quasi-experimental design, with the constitution of an experimental group and a control group, both composed of early childhood education classes. The groups are formed from natural groupings already existing in the school context, groups defined based on the classroom’s pedagogical dynamics, in which children do not have fixed seating and are organized by the teacher according to their physical proximity at the time of each activity, resulting in a spontaneous and variable composition of groups, but without formal random assignment of participants, which is specific to educational investigations carried out in real teaching environments (CRESWELL; CRESWELL, 2017). The experimental group participated in the intervention guided by the proposed framework, while the control group maintained the school’s regular pedagogical routine during the same period, allowing for a comparison between the two contexts.

From an epistemological perspective, the research is grounded in a qualitative, interpretive approach, focusing on understanding learning processes, classroom interactions, and the perceptions of children and teachers throughout the experiment. This perspective prioritizes the interpretation of the meanings subjects attribute to their experiences, rather than an exclusively quantitative analysis of results.

As a central strategy for strengthening the validity of the findings, the study employs triangulation of methods and data sources, integrating interviews with children and teachers, creativity and critical thinking tests, assessment rubrics, and the researcher’s observation diary. Triangulation allows for the systematic comparison of multiple perspectives on the same phenomenon, increasing the interpretative credibility and analytical robustness of the results (DENZIN, 2017; CRESWELL; CRESWELL, 2017; RUNESON; HÖST, 2009).

Although the present stage of the investigation is configured as a quasi-experimental study of an evaluative nature, its methodological design engages with the assumptions of Design-Based Research (DBR), especially regarding the articulation between theoretical investigation, the development of educational artifacts, and empirical validation in a real-world context (BROWN, 1992; COLLINS; JOSEPH; BIELACZYK, 2016; COLLECTIVE,

2003). Furthermore, the active participation of the teacher from the experimental group in implementing the intervention and reflecting on its effects brings the study closer to the principles of action research, characterized by collaborative and reflective processes oriented towards the transformation of pedagogical practice (TRIPP, 2005; THIOLENT, 2025).

5.3.1 Participants and Setting

The research was conducted at a private school in São Carlos, São Paulo, Brazil, with two classes of Early Childhood Education. Twelve children, aged 4 to 6 years, participated in the study, divided into two groups: an experimental group of 8 children from the Infant 3 class and a control group of 4 children from the Infant 4 class. The choice of which class would serve as the control group was made randomly, through a draw. The group formation followed the natural organization of the institution's classes, a characteristic of quasi-experimental designs in real educational contexts. Table 28 presents details about the participants, including their group, age, gender, and previous technology use, collected during the initial characterization interviews.

Table 28 – Profile of child participants

Code	Group	Age	Gender	Previous technology use
E1	Experimental	4	M	Restricted use of tablet for gaming and watching videos.
E2	Experimental	4	M	Frequent use of smartphone for gaming and watching videos.
E3	Experimental	4	F	Frequent use of television for watching videos.
E4	Experimental	5	F	Frequent use of smartphone for gaming and watching videos.
E5	Experimental	5	F	Restricted use of smartphone and television for watching videos.
E6	Experimental	5	F	Restricted use of tablet for gaming and watching videos.
E7	Experimental	5	F	Frequent use of television for watching videos.
E8	Experimental	5	F	Frequent use of tablet for gaming and watching videos.
C1	Control	5	F	Restricted use of smartphone for gaming and watching videos.
C2	Control	5	M	Occasional use of tablet with adult mediation.
C3	Control	5	M	Occasional use of television.
C4	Control	6	M	Occasional use of smartphone and computer.

The experimental group participated in the pedagogical intervention based on the framework evaluated in this study for 8 weeks, while the control group maintained the school routine of pedagogical activities during the same time interval. This configuration

allowed for a comparison between the two groups regarding the changes observed in the aspects investigated, respecting the natural conditions of the school environment.

Regarding the participating teachers, each class had its respective teacher in charge. Both had experience in Early Childhood Education and regularly worked with the classes in which the research was conducted. In the experimental group, the teacher was responsible for implementing the intervention activities, while in the control group, the teacher maintained the usual pedagogical activities.

In order to ensure the consistent application of the proposed framework, initial training was conducted with the teacher of the experimental group. The training aimed to familiarize the teacher with the principles of co-design and activity plans, and to prepare her to act as a facilitator during activities with the children, preserving the children's protagonism. The training lasted 1 hour and 30 minutes. During this meeting, the framework was presented, and there was a discussion about the design principles that guide the collaborative process and how to apply them in interaction with children. In addition, design activity plans were explored.

5.3.2 The Framework to Be Evaluated

The experiment reported in this article focuses on evaluating a framework for teaching computing in early childhood education, designed to support teachers in implementing pedagogical practices that promote creativity, critical thinking, and children's engagement with computing concepts in a playful, contextualized way. The framework consists of three central components: (1) co-design principles, (2) activity plans, and (3) rubrics for assessing creativity and critical thinking. This article does not intend to exhaustively describe each component, but only to present the essential elements for understanding the experiment conducted.

The design principles of co-design were developed from a thematic analysis conducted on a set of scientific articles that address participatory design, co-design, and creative practices with young children. Based on the identification of patterns, recurrences, and gaps in the literature. These principles serve as a practical guide to ensure that children aged 4 and 5, in the final stage of Early Childhood Education, can actively participate in meaningful learning experiences that foster computational thinking, creativity, and collaboration. Table 29 summarizes the five principles identified, with concise descriptions that highlight their pedagogical focus.

The design activity plans were conceived and refined through a collaborative process with basic education teachers and students from the fields of pedagogy and computer science, in an action-research dynamic. Table 30 summarizes all design activities comprising details of title, computing concept covered, and computing knowledge area to which the design activity fits. Finally, the table presents the design process proposed in the activity.

Table 29 – Design principles for computing education in early childhood

Principle	Short description	Example of application
Consider the child's daily life	Connect computing concepts with children's everyday experiences to promote meaningful learning.	Organize a step-sequence game where children build a "recipe" (e.g., making a sandwich) to introduce algorithms.
Stakeholders must build the child protagonism	Encourage children's active participation in co-design, with teachers mediating and guiding autonomy.	Children design a maze on the floor with tape/chalk while the teacher guides peers to "program" one another through it.
Involve computer concepts	Introduce fundamental computing concepts (e.g., sequences, patterns, algorithms) as defined by Computing: Complement to the BNCC (??).	Use rhythmic clapping games to represent loops, or sorting toys to teach classification and pattern recognition.
Carry out collaborative activities	Foster collaboration among children, teachers, and peers through structured joint tasks.	Groups create a collective story where choices follow logical "if/then" structures, simulating conditionals.
Include fun activities	Use playful and thought-provoking experiences to engage children while exploring computational ideas.	Organize a treasure hunt with logical clues that use conditionals to lead to the next step.

All design activities involve computing education, product design (play, stories, posters, games, etc.), and the development of creative or critical thinking.

The rubrics for assessing creativity and critical thinking that make up the framework were adapted from the instrument proposed by Shively, Stith e Rubenstein (2018), originally developed to assess creativity, critical thinking, and design processes. The adaptation involved translating the original material and adapting the descriptors to the context of early childhood education and the children's age range, while preserving the conceptual structure of the instrument and adjusting its language and indicators to forms of expression typical of childhood.

In the present study, these three components are treated in an integrated manner, constituting the framework whose effectiveness is evaluated through comparisons between the experimental and control groups and through analyses of evidence from the different data sources mobilized throughout the experiment.

5.3.3 Procedure

The study was conducted in three main stages: a diagnostic phase, an intervention phase, and a final phase, involving both the experimental and control groups, according to the quasi-experimental design adopted. The Figure 7 shows the steps and activities that were performed.

5.3.3.1 Diagnostic phase

The diagnostic phase was conducted with both classes before the intervention to characterize the children's profiles and establish a baseline for analyzing changes throughout

Table 30 – Design Activities.

Title	Computing concept	Computing Knowledge Area	Design activity
Creating stories with Codes	Binary numbering	Computing Systems Fundamentals	Story creation
Sound Maze	Input - Processing - Output of data	Data and Information Management	Creating a maze
I can be an amazing programmer!	Algorithms and Programming Languages	Programming Languages	Creating algorithms with unplugged materials
Televising Ideas - Reporters in action	Data Transmission	Data and Information Management	Creation of a TV and remote control prototype using recyclable materials
Trail of the Internet Protectors	Information Security	Security Issues and Principles	Creating a board game and awareness posters
Virtual environment - Security beyond screens	Privacy and Data Security	Security Issues and Principles	Creation of awareness flyers
Topological routine	Organizational strategies (Topological Graphs)	Data Structures, Algorithms and Complexity	Graph creation
Creating my computer	Hardware concepts (Monitor, CPU, keyboard, and mouse)	Architecture and Organization	Prototyping electronic devices with recyclable materials
How do we deal with videos we watch online?	Abusive use of electronic devices	Social Issues and Professional Practice	Creating scripts for videos
Conscious Disposal	Electronic waste disposal	Social Issues and Professional Practice	Creation of a container for disposal of electronic waste

the study. Initially, individual interviews were conducted with the children, using a structured script appropriate to their age group, focusing on identifying their digital technology usage profile, prior experiences with electronic devices, and initial perceptions of technology. The interviews took place in a school setting, at times agreed upon with the teachers, to respect the children’s attention spans and emotional states.

Subsequently, initial creativity and critical thinking tests were conducted in groups, within playful contexts and mediated by the researcher. The experimental group participated in the tests, organized into two subgroups of four children each, while the control group performed the tests as a single group of four children. The tests were structured to encourage interaction, collaboration, creative expression, and joint problem-solving, taking into account the characteristics of the age group. At the end of the tests, the teachers of both classes completed the initial assessment rubrics, recording their perceptions of the levels of creativity and critical thinking demonstrated by the children at that initial moment.

An external researcher specializing in early childhood education observed the creativity and critical thinking assessments and supported the classroom teachers in completing the assessment rubrics. This researcher, who was not responsible for teaching the classes

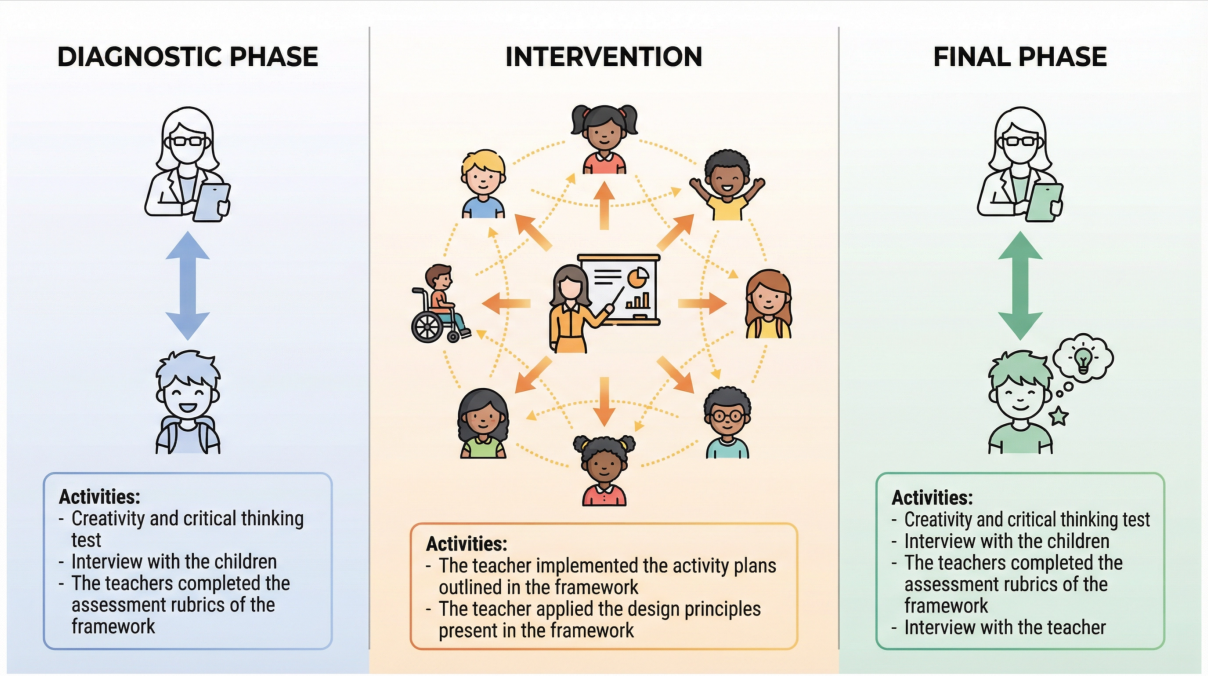


Figure 7 – Study structure.

involved in the study, contributed as an independent observer to document children’s participation and reasoning during the activities. These records, together with the interviews and tests, formed the diagnostic basis of the study.

5.3.3.2 Intervention

The intervention was conducted exclusively with the experimental group, comprising eight face-to-face meetings over a period of four weeks, each session lasting approximately 45 minutes. The activities were led by the class teacher and integrated into the early childhood education pedagogical routine.

During the meetings, four activity plans that integrate the evaluated framework were applied, organized in a way that explored computing concepts through games, narratives, problem-solving, and collaborative activities, always in accordance with the proposed co-design principles. The intervention comprised eight meetings, alternating between theoretical sessions and design activities. Meetings 1, 3, 5, and 7 were theoretical, while meetings 2, 4, 6, and 8 were design activities, as shown in the Table 31.

Throughout the intervention, the researcher conducted systematic classroom observations, recorded in a field diary, to document aspects such as children’s engagement, forms of interaction between peers, the teacher’s mediation strategies, evidence of creativity and critical thinking, and emerging situations during the activities.

The control group maintained its regular educational routine during the same period, without the inclusion of the framework activities.

Table 31 – Timeline used during the intervention with the experimental group.

Section	Design Activity plan	Educational Objective	What was made
First meeting	Creating my computer	To introduce the concept of a computer and its components in a concrete and contextualized way	The teacher presented the theoretical content showing images and hardware
Second meeting			Children collaboratively created computer prototypes using recyclable materials
Third meeting	Topological routine	Introducing the concept of graphs	The teacher presented the theoretical content using an example from the sequence of activities carried out in class
Fourth meeting			Children collaboratively created a poster depicting their routines using graph structure
Fifth meeting	Sound maze	Introduce the concept of data processing	The teacher presented the theoretical concept relating it to how they chose the videos they watched on their smartphones
Sixth meeting			Children collaboratively created commands to guide them through a maze
Seventh meeting	Creating stories with Codes	Introducing the concept of binary numbering	The teacher presented the theoretical concept by drawing an analogy with the game of dead or alive
Eighth meeting			Children created excerpts from stories and organized them according to binary numbering

5.3.3.3 Final Phase

At the end of the intervention, a final phase was carried out with both classes. The children again participated in individual interviews, conducted with a script similar to that used in the diagnostic phase, allowing for the identification of possible changes in how they related to technology and in their perceptions of activities involving computing.

Next, the final creativity and critical thinking tests were administered, again in groups, following the same organization as the diagnostic phase. This standardization enabled comparison of diagnostic and final-phase results under equivalent conditions.

After this stage, the teachers of both classes completed the final evaluation rubrics to record their perception of the children's progress throughout the study period. Finally, interviews were conducted with the teachers, with two objectives: (1) to understand their perceptions of the children's progress in terms of creativity, critical thinking, and engagement; and (2) in the case of the teacher of the experimental group, to understand her experience with the application of the framework, the challenges faced, the mediation strategies adopted, and the impacts perceived in her pedagogical practice.

5.3.4 Data Sources

The data used in this study came from multiple sources, in accordance with the triangulation approach adopted. Data sources included: interviews with children and teachers, creativity tests, critical thinking tests, rubrics for assessing creativity and critical thinking, and the researcher's observation diary. The integration of these sources enabled the capture of both performance evidence and perceptions, as well as process records, throughout the intervention.

5.3.4.1 Interviews with the children

The interviews were conducted at two points in time: before the intervention (diagnostic phase) and after its conclusion (final phase). In the diagnostic phase, the interviews aimed to identify the children's profile, their prior use of digital technologies, and their initial perceptions of computing. In the final phase, evidence of possible changes in these perceptions at the end of the process was sought. The interviews were conducted individually, using age-appropriate language, and were semi-structured, allowing for both standardization of questions and exploration of spontaneous responses. The interview guide is available in Appendix H and Appendix I.

For example, when asked about what technology is or how computers work, some children initially offered intuitive or imaginative explanations. In one diagnostic interview, E6 associated technology with connectivity by stating that "technology is Wi-Fi," while E4 referred to invisible elements in the environment, explaining that "there are things in the sky that we cannot see." Such responses illustrate how children articulated early understandings of technology using familiar references from their everyday experiences.

5.3.4.2 Creativity tests

The creativity tests were administered in groups during both the diagnostic and final phases, according to the class organization. The proposed activities sought to elicit manifestations of fluency of ideas, originality, flexibility, usefulness, and elaboration through problem-solving situations. The tests were designed to encourage interaction among the children and allow for the observation of creative processes emerging during the collective activity. The protocol for the creativity tests is available in Appendix J.

For instance, during the river-crossing challenge, children generated a variety of solutions using the available materials. One group suggested building a bridge using popsicle sticks reinforced with clips to strengthen the structure, while another child proposed a more imaginative alternative, suggesting that the character could cross the river through a "teleportation portal" and "fly away." These proposals illustrate the diversity of ideas produced during the activity and how children combined functional reasoning with imaginative elements.

5.3.4.3 Critical thinking tests

Similar to the creativity tests, the critical thinking tests were conducted in groups and at two different times (diagnostic and final phase). The activities focused on observing behaviors related to situation analysis, decision-making, and justification, considering forms of expression typical of childhood, such as speech and manipulation of materials. The protocol for the critical thinking tests is available in Appendix J

5.3.4.4 Assessment rubrics

The teachers of both classes completed the creativity and critical thinking assessment rubrics at two points in time: before the intervention began and after its completion. The rubrics aimed to record teachers' perceptions of children's performance throughout the investigated period, based on observable indicators during the tests. These records served as a fundamental source for triangulating evidence from tests, interviews, and the researcher's observations. The assessment rubrics are available in Appendix K and Appendix L.

For example, the creativity rubric included indicators such as the child's ability to propose multiple solutions to a problem, combine materials in different ways, and elaborate ideas through explanations or narratives.

5.3.4.5 Researcher's observation diary

During the intervention sessions with the experimental group, the researcher kept an observation diary in which aspects related to children's engagement, the interactions established, the teacher's mediation strategies, and the emerging difficulties observed during the activities were recorded. The diary served as a qualitative, process-oriented source, essential for understanding the dynamics of the framework's implementation and interpreting the results.

For example, during one session, the diary records that children explored a motherboard presented by the teacher and compared its structure to familiar environments. While observing the components, E6 commented that "it looks like a city," establishing an analogy between electronic elements and urban structures.

5.3.4.6 Interviews with the teachers

The interviews with the teachers were conducted at the end of the intervention to understand their perceptions of the children's development throughout the study and, in the case of the teacher in the experimental group, also about the use of the framework in pedagogical practice. The interviews were semi-structured, guided by a prepared script, which standardized the topics covered while also allowing exploration of emerging aspects from participants' statements.

In the specific case of the teacher from the experimental group, the interview also included questions focused on evaluating the framework, addressing topics such as ease of application of the activity plans, suitability of the co-design principles to the context of early childhood education, mediation strategies adopted, challenges faced during the intervention, and impacts perceived in her own pedagogical practice. The interview guide is available in Appendix M.

5.3.5 Data Analysis

The data analysis was conducted in an integrated manner, combining qualitative and comparative procedures in accordance with the study's quasi-experimental design, to understand both processes and results. The analytical strategies adopted for each data source and for the triangulation between them are described below.

5.3.5.1 Thematic Analysis of the Interviews

The interviews with children and teachers were analyzed using Thematic Analysis, following the method proposed by Braun and Clarke (BRAUN; CLARKE, 2006; BRAUN; CLARKE, 2013). The process involved six stages: (1) reading and familiarization with the transcripts, (2) generation of initial codes, (3) search for themes, (4) review of themes, (5) definition and naming of themes, and (6) production of the analytical report.

An inductive approach was used, allowing themes to emerge directly from the data, and an essentialist level of analysis, seeking to capture meanings explicitly expressed in the statements. Thematic analysis was conducted separately for each set of interviews (diagnostic phase and final phase with children and teachers) and subsequently articulated in the triangulation stage.

5.3.5.2 Qualitative Comparison: Diagnostic and Final Phase Results

The creativity and critical thinking tests, conducted in groups during the Diagnostic and Final phases, were analyzed qualitatively, focusing on the types of ideas generated, the justifications presented, the strategies used to solve challenges, and collaborative interactions.

The analysis was not based on quantitative scores but on comparative descriptions, allowing for the identification of changes in manifestations of creativity and critical thinking between the two periods. Observations made during the tests, as well as the products generated by the children, were examined as complementary evidence.

This procedure aimed to understand how (and not just if) the children modified their ways of thinking, creating, justifying, and solving problems throughout the intervention period.

5.3.5.3 Triangulation of Data Sources

This study adopted a methodological triangulation strategy to integrate evidence from multiple sources and strengthen the interpretative validity of the results. Triangulation was conducted between three types of data: (a) observational records produced by the researcher during the sessions, (b) evaluative products structured using the creativity and critical thinking rubrics, and (c) verbal accounts obtained from interviews with children and teachers.

Each source was initially analyzed independently: rubrics through descriptive analysis of indicators; observations through systematic field diary recording; and interviews through thematic analysis. Subsequently, the data were integrated to confirm, complement, or contrast evidence.

The triangulation assumed a convergent and complementary character. It was convergent when two or more sources supported the same interpretation (for example, individual improvement identified simultaneously in rubrics and in the teacher's reports), and complementary when different sources illuminated distinct dimensions of the same phenomenon (for example, rubrics indicating performance and interviews revealing justifications and cognitive strategies). In cases where there was a discrepancy between sources, the divergent interpretations were analyzed as analytical clues rather than inconsistencies, from the perspective that behavioral, discursive, and evaluative responses can express distinct aspects of child development.

Integration was conducted in the final stage of data analysis by creating convergence matrices that organized results by category and indicated which evidence supported each interpretation. This strategy allowed tracing the origin of each reported result, ensuring that the findings presented in the results sections were derived from multiple lines of evidence and not from a single isolated source.

This approach follows classic triangulation recommendations in interpretive research (DENZIN, 2017; MATHISON, 1988), increasing the credibility and robustness of the analysis by combining different perspectives on the same learning process.

5.3.5.4 Cross-analysis between control group and experimental group

In addition to the pre- and post-intervention comparison, a cross-analysis was conducted between the control group and the experimental group, seeking to identify:

- ❑ Differences in manifestations of creativity and critical thinking at the end of the study.
- ❑ Differences in teachers' perceptions of children's development.
- ❑ Differences in interactions observed throughout the activities (in the experimental group, specifically during the intervention).

This comparison was conducted qualitatively, reflecting the naturalistic nature of the groups and acknowledging that participants were not randomly assigned. The cross-analysis helped identify potential impacts attributable to the framework, distinguishing them from changes that could occur independently of the intervention.

5.3.6 Ethical considerations

All stages of this research rigorously followed the ethical principles applicable to studies involving human subjects, with special attention to the specificities of young children's participation. Before data collection began, the study was presented to the school administration and the teachers in charge, and all procedures were approved by the institution. The study was reviewed and approved by the Ethics Committee of Federal University of São Carlos, under protocol number 87136225.9.0000.5504.

The children's participation only occurred after their legal guardians signed the Informed Consent Form, which detailed the research objectives, the voluntary nature of participation, the instruments used, the possible risks and benefits, and the audio, image, and observation recording procedures. The guardians also signed the Image Use Authorization Form, allowing the recording of activities for exclusively scientific purposes.

In addition to parental consent, each child underwent a Free and Informed Assent process, conducted in an accessible language appropriate to their age group (4 to 6 years), using illustrations to exemplify each stage of the research. The children were informed that they could participate only if they wished to. This procedure ensured that children's autonomy was respected, in accordance with international ethical recommendations for research with children.

The teachers of both classes also signed the corresponding Informed Consent Form, authorizing their participation in the interviews and research-related activities, as well as the use of their evaluation records and pedagogical perceptions in the analyzed dataset.

5.4 Findings

To synthesize the evidence from the various instruments used in this study, Figure 8 presents a Sankey diagram illustrating how the data sources converged on the analytical themes. The diagram was constructed based on the coding process carried out during the thematic analysis. Initially, the qualitative materials from interviews, observation diaries, and notes related to creativity and critical thinking tests were inductively coded to identify recurring patterns in the data. These codes were then grouped into broader subthemes through iterative comparison, which subsequently formed the basis for the six interpretive themes reported in the results.

The diagram depicts three layers: (1) data sources, including children's interviews in the diagnostic and final phases, teacher interviews, observation diaries, and performance

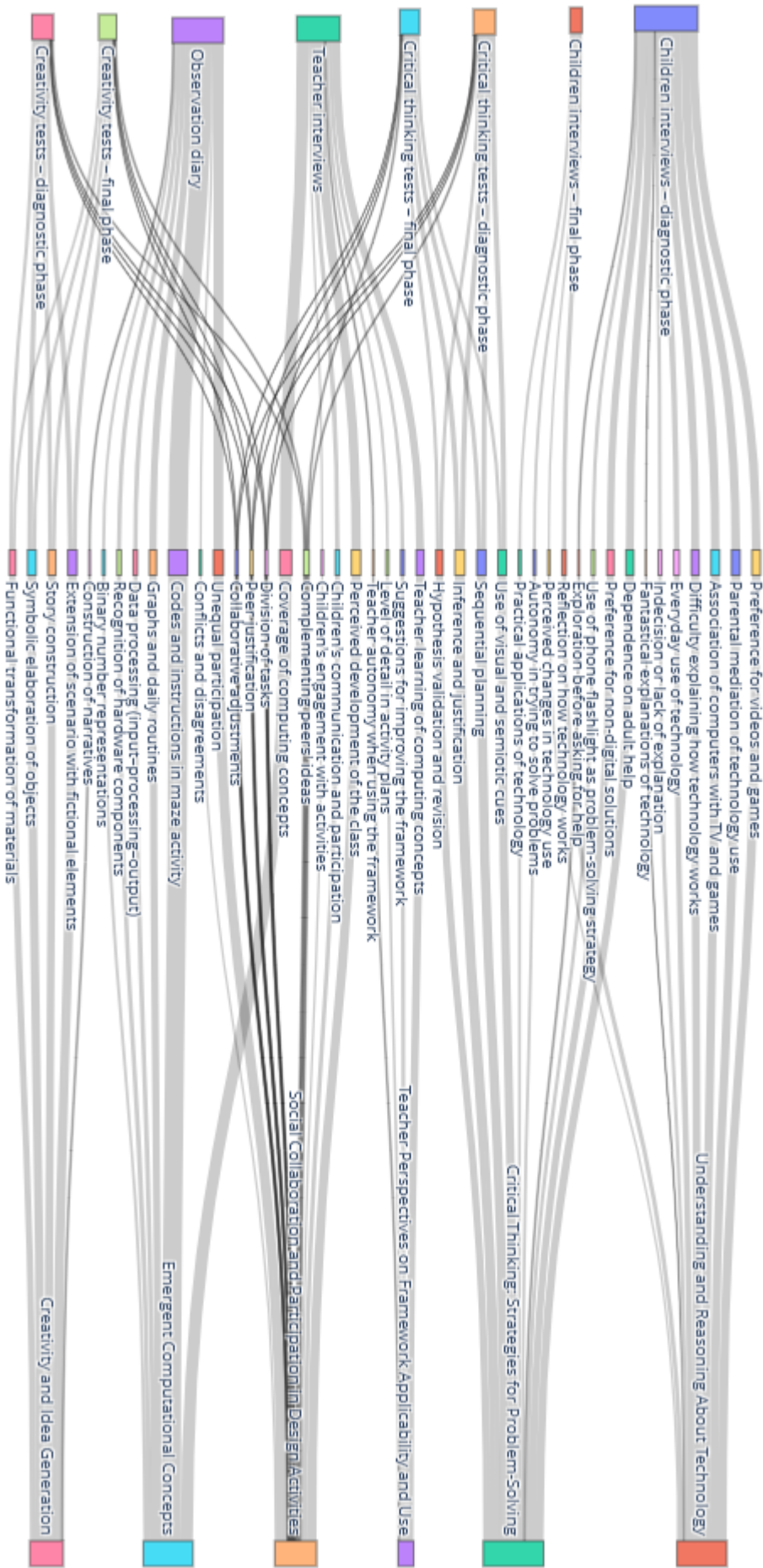


Figure 8 – Relationships between conceptual dimensions, codes, and data collection instruments represented through a sankey diagram.

in critical thinking and creativity tests across diagnostic and final phases; (2) coded sub-themes emerging from the thematic analysis; and (3) the six final interpretative themes derived in the findings. As shown, evidence is not concentrated in a single source, but instead flows from multiple instruments toward the same subthemes and themes. This representation highlights that the themes reported in this section are not tied to a single modality of data collection, but emerge from convergent patterns across interview excerpts, behavioral observations, and task performance, reinforcing the robustness of the results described below.

5.4.1 Understanding and Reasoning About Technology

Analysis of the qualitative data indicates that the children in the experimental group developed, throughout the intervention, a more structured understanding of what technology is and how digital devices work. This development is evidenced by an increased ability to identify components, establish cause-and-effect relationships, and explain the functioning of different technological artifacts. In the control group, on the other hand, the conceptions expressed during the diagnostic phase remained essentially unchanged in the final phase.

At the beginning of the intervention, the children in both groups offered vague, intuitive, or imaginative explanations about what technology is or how computers and smartphones work. Their responses included broad or vague associations, such as relating technology to “Wi-Fi” or “things in the sky,” as reported by E4 and E6, respectively, on the first day of the intervention: “my father told me that there are things in heaven that we can’t see” and “the technology is Wi-Fi”. These statements reveal an initial level of technological awareness, but still without a clear conceptual framework.

In the final phase of the interview, the children in the experimental group began to use more specific terms and to justify their answers with references to internal parts or functionalities of the devices. Attributions such as “it has parts inside”, “it works with buttons”, “the computer thinks”, or “we write, and it appears on the screen” became more frequent. For example, E1 explained: “Inside there’s a mechanism that forms a button, and when he presses it, he appears very quickly”, illustrating an association between input actions (typing/clicking) and visible output (content appearing on screen). The observed evolution is associated with the greater repertoire built during the framework activities, which explored components, basic functioning, and relationships between input, processing, and output. In contrast, the children in the control group maintained explanations similar to those from the diagnostic phase, with generic and vague descriptions, showing no evidence of conceptual advancement, as C1 explained: “We can write something that’s like... It’s like writing...”.

The researchers’ observation diary shows that throughout the eight sessions, the children in the experimental group demonstrated increasing interest and the ability to relate

concrete elements of the activities to the functioning of real devices. In the first meetings, their speech still reflected generalized curiosity, with children asking about “how things appear on the screen” and showing interest in cables, buttons, and visible components. During one session, after the teacher presented the CPU and software, children manipulated a motherboard, and E6 commented that “It looks like a city”, an analogy indicating the emergence of symbolic mappings about internal computational structure

Activities that revisited the concepts discussed, such as input, processing, and output, also allowed us to observe that the children began to complete the teacher’s explanations with greater confidence, demonstrating an understanding that different parts of the computer perform distinct and complementary functions.

The experimental group teacher reported clear progress in how the children explained and justified their ideas about technology. According to her, there was an increase in their ability to formulate hypotheses, relate content discussed over the weeks, and use more specific vocabulary. The teacher also highlighted that the children became more actively involved in discussions about how computers work, demonstrating greater intellectual autonomy. One interview excerpt illustrates this shift, as E7 stated: “Computer numbers are different. Because 2 is 10.” when asked about computational numbers, indicating that children were beginning to reason about representational systems even when not fully understanding them. The teacher in the control group, on the other hand, observed no noticeable changes in the children’s understanding of technology over the same period.

The triangulation of interviews, observations, and teacher reports demonstrates that the framework significantly supported the development of technological understanding among the experimental group’s children. They began to identify components and functions of devices, establish relationships between actions and effects, justify explanations with more specific references, use initial technical vocabulary, and build more coherent mental models about how computers work. In the control group, such changes were not observed.

These results suggest that structured activities that explore and manipulate computational concepts, adapted for early childhood education, can foster a more sophisticated technological awareness from an early age.

5.4.2 Critical Thinking: Strategies for Reasoning and Problem-Solving

The analysis of critical thinking activities, comparing the diagnostic and final phases, reveals important differences between the groups in how children organize information, construct sequences, justify choices, and reason about problems.

The records from the control group show that, from the diagnostic phase onwards, the children demonstrated a strong capacity for logical organization and sequencing. The

children analyzed the figures before hearing the entire story; they correctly organized the six images immediately after the first reading; they justified their choices with evidence from the narrative; and they coherently revised their decisions after the second reading.

An example of this behavior appears when C2 and C4 rearrange the final images after questioning the position of the “gray-haired boy” (who was not referenced in the text), discussing implications and narrative consistency. C3 asked that the story be read in two parts, “to be able to think” separating the figures during reading, correcting the position of the final image when they noticed a contradiction with the last sentence.

The rubrics from the diagnostic phase confirm these observations: the control children consistently organized information, established assumptions linked to the text, constructed viewpoints based on experience, and demonstrated the ability to analyze and interpret data. In the final phase, the rubrics again indicate high performance across all criteria but do not suggest substantial progress, suggesting stability in the development of reasoning strategies.

In the experimental group, during the diagnostic phase, although some children demonstrated initial logical reasoning, most struggled to concentrate on the task, experienced conflicts within the group that hindered the organization of the sequence, showed less clarity in justifying their choices, and made limited use of prior information to validate their decisions.

The notes from the diagnostic phase record episodes of lack of collaboration, disputes over materials, and interruptions that made joint construction impossible, mainly in Group 1 (E7, E3, E1, and E4) and Group 2 (E2, E6, E5, and E8). At times, the children assembled correct sequences, but without clear justification or without demonstrating analysis during the process. The assessment rubrics reflect this scenario: despite demonstrating “consistent ability” to organize information, they also showed limitations in communicating their point of view, analyzing data, and formulating implications, especially when compared to the control group.

In the records from the final phase, it is observed that some children began to demonstrate greater familiarity with the task, recognizing the need to analyze the images and compare them with the story; there were cases of children trying to justify choices based on excerpts from the narrative; however, collaboration among group members again proved weak, directly affecting the execution of the activity.

Several behaviors negatively impacted group performance, including constant disagreements over the order of the images, difficulty reaching an agreement, disputes over who should place a particular card, lack of listening, frequent interruptions, and overlapping speech that prevented the activity from continuing.

Thus, although individual children showed signs of improvement in their ability to analyze the narrative and offer logical justifications, the group as a whole failed to transform this reasoning into an organized collective solution. The rubrics reflect this: there

are indications of individual progress in items such as analysis and justification, but the inconsistency in collaboration affected the pairs' final performance.

The teacher of the experimental class reported that during the diagnostic phase, the children had difficulty collaborating, which directly affected the construction of the sequences. According to her, many children could not hear one another, interrupted each other, and fought over the cards, slowing the organization and making it less structured. She explained that "In general, in their day-to-day lives, they have difficulty working in groups [...] it's hard for them to learn to share, to wait", indicating that social dynamics interfered in the execution of the task.

Although some children demonstrated occasional signs of reasoning, such as identifying story parts or suggesting logical order, the lack of collective coordination prevented these contributions from consolidating into a shared solution. The teacher noted that the same pattern persisted in the final phase: "They were very, very disconnected [...] they didn't organize anything. Each one wanted something different, at a different time". Even with greater familiarity with the activity format, collaboration remained fragile, and she observed that "E4 stood out because the others didn't even understand what they were supposed to do", illustrating that individual advances did not translate into collective performance.

Thus, despite recognizing improvements in isolated behaviors, such as attention, analysis, and justification, the teacher emphasized that group dynamics remained an obstacle to the full expression of critical reasoning.

The teacher of the control group described a different scenario. In the diagnostic phase, she observed that the children worked fluently, collaborating to assemble the sequences quickly and appropriately. As she stated, "They assembled it very quickly", noting that they used logic even before the story was read. She also highlighted the role of prior knowledge, explaining that "they already remembered the previous activity", which facilitated both organization and justification. In the final phase, her report indicated continuity rather than change: she explained that "the second time they did it very quickly as well, and they discussed amongst themselves what the order was", and that "they talked and reached a consensus without needing me". These remarks reinforce the consistency observed across the instruments used, indicating that critical thinking skills, such as sequencing, evidence checking, and consensus building, were already present at the outset and remained stable over time, with no significant variation.

Data triangulation indicates that:

- ❑ In the control group, critical thinking was already structured at diagnosis and remained stable in the final phase, with strong collaboration and consistency in justifications.
- ❑ In the experimental group, there were indications of improvement in individual

reasoning, but final performance was hampered by the collective dynamics, marked by conflicts, difficulty listening, and disorganization.

It is also important to consider the age composition of the groups when interpreting these results. The control group consisted of 4 children aged 5 and 6 years, while the experimental group included eight children aged 4 and 5 years. Although both groups shared a similar age range, the experimental group included slightly younger participants. In early childhood education, even small age differences may influence aspects such as attention span, communication, and collaborative negotiation. Therefore, some of the observed differences in group dynamics and task execution may also be partially associated with developmental factors. Nevertheless, the presence of children of similar ages across groups suggests that age alone does not fully explain the patterns observed in the results.

The development of critical thinking depends on both individual abilities and the socio-collaborative conditions of the task, especially in activities that require consensus to organize information. Thus, the intervention provided opportunities for individual advancement, but the full expression of critical thinking was limited by the challenges of group work during the evaluation process.

5.4.3 Creativity: Idea Generation and Imagination

The creativity tests involved a problem-solving challenge in which children had to help a character cross a river using various materials. Data analysis reveals clear differences between the groups, not only in the quantity of ideas generated but also in how these ideas were developed, narratively articulated, and integrated into the problem context. The triangulation between assessment rubrics, activity records, and classroom observations allows us to understand how creativity manifested and evolved in each class.

In the control group, the diagnostic phase already revealed high creative fluency, with the children quickly proposing solutions to the challenge. The field notes show an intense generation of ideas from the outset, such as a bridge made using 3 popsicle sticks with clips to make the structure stronger, as suggested by C2, and a bridge made using two popsicle sticks, with a piece of cut-up disposable cup held in place by a paperclip, functioning as a walkway, as suggested by C4. However, the most striking aspect observed throughout the activities was the construction of a broader narrative around the river setting, going beyond the simple act of crossing it.

As documented, after establishing structural solutions, the children began to imagine that the character could remain near the river, leading them to develop solutions that considered this possibility. Among the proposed ideas, the following stand out: the construction of huts to shelter the character; the inclusion of a sleeping bag, indicating a concern for rest; the use of a fishing rod, suggesting the acquisition of food; and the combination of these elements with bridges and support structures. One of the teachers

reinforced this observation in her post-activity account, noting that the children “they constructed a story for the indicated scene [...] thinking not only about the bridge, but about what would happen afterwards”, identifying elaboration beyond functional constraints.

These choices demonstrate a high level of creative elaboration, in which the children expand on the initial problem and construct a coherent story, considering the character’s practical and narrative needs. Creativity, in this case, manifests itself not only in the variety of solutions but also in the ability to imagine alternative and extended scenarios, integrating different materials around a central idea.

In the final phase, the control group maintained this pattern. The children continued to propose functional and narrative solutions, articulating elements of transition and permanence within a context of relative stability. The creativity rubrics reflect this behavior: fluency and flexibility remain high, as does elaboration, without significant qualitative changes, indicating that this type of creativity was already present from the beginning.

In the experimental group, during the diagnostic phase, the children demonstrated good fluency of ideas, with varied proposals for crossing the river, such as tunnels, passageways, and structural combinations. Documentation indicates ideas like a tunnel made with a roll of paper, a walkway made with a roll cut in half, as suggested by E7, and a bridge using a string as a base, as suggested by E4, and even unexpected solutions such as a teleportation portal proposed by E1, who argued that “the doll would pass through the portal and fly away”. The children showed a willingness to experiment and modify solutions, suggesting alternatives throughout the activity.

However, unlike the control group, the experimental group’s creativity was more focused on the structural variation of solutions than on the construction of an expanded narrative. Ideas emerged sequentially, often replacing the previous proposal, with less depth in the same solution or in alternative scenarios for the character. The diagnostic records indicate that the teacher noted that “the group worked in a more individualized way [...] the ideas were individual.” and that access to materials frequently shaped participation, as seen when “E3 complained about not being able to access the materials”.

In the final phase, some children began to refine the same idea, adjusting materials and forms to enhance the initially proposed solution. For example, E7 iteratively improved a passarela structure by adding small pieces to prevent the doll from falling. This reflects a shift from replacement to incremental improvement. E6 introduced adjustments to ensure balance and safety, such as adding a string for the doll to balance on. A teacher described this behavior by saying that the children “kept improving on the same idea, adjusting it to work better” during the final phase.

The rubrics from the experimental group indicate slight progress in elaboration and flexibility in the final phase, but this progress is heterogeneous across children and less consistent than in the control group.

The comparison between the groups reveals two distinct patterns of creative expression:

- ❑ In the control group, creativity is strongly expressed through narrative elaboration, expanding the initial problem and constructing complete stories involving the character, the environment, and their needs.
- ❑ In the experimental group, creativity appears mainly in the variation of structural solutions and in specific increments to existing ideas, with less emphasis on extended narratives.

Both groups demonstrated creative fluency, but differed in how they developed and contextualized their ideas.

In summary, the data indicate that creativity was present in both groups, but manifested itself in distinct ways. The control group showed, from the beginning, a creativity strongly based on the elaboration and construction of narratives, articulating multiple elements to compose complex scenarios around the challenge. The experimental group, in turn, demonstrated creativity mainly through the exploration of different structures and functional increments, with punctual advances over time, but with less narrative development. These results reinforce the idea that creativity in early childhood education can emerge both through the imaginative expansion of the problem and through the structural experimentation with solutions, depending on the dynamics and experiences of the children.

5.4.4 Emergent Computational Concepts

Analysis of the data indicates that, throughout the intervention, the children in the experimental group appropriated fundamental concepts of Computing and worked on them in a concrete and situated way within the framework's activity plans.

One of the computational concepts most explicitly adopted by the children was information representation, especially through binary logic. In the final interviews, the children demonstrated an understanding that the computer uses its own system to represent information, distinct from the way humans communicate. This understanding is clearly evident in the statement of E6, who explained that "1 is 1, 2 is 10, 3 is 11" and that "0 is off, and 1 is on". Complementarily, E7 stated that "they are different, because 2 is 10", reinforcing the idea that numbers can be represented in different ways on the computer. These statements demonstrate an initial appropriation of the concept of binary numbering.

Another set of statements reveals the appropriation of the concept of computer operation as a command-based system, associated with the input-processing-output model. When explaining how the computer works, E2 stated that "you just press some buttons

and then the computer turns on”, while E7 explained that “you have to speak, then it shows you. It appears quickly”. These explanations suggest that the children understand that the computer does not act autonomously, but rather responds to commands provided by the user, demonstrating an initial grasp of data processing and instruction execution.

Beyond these concepts, the activities carried out during the intervention allowed for the appropriation of notions related to data organization and modeling. During the activity in which the children collectively constructed a poster representing their daily routine, the observation diary notes that the teacher introduced the idea of organizing events as interconnected elements, associated with “vértices e arestas”. The diary also documents that children such as E6 attempted to reproduce this structure, using arrows to indicate ordering, and that other children reorganized or expanded their drawings while explaining connections. This activity mobilized concepts associated with graphs, understood here as structures that represent relationships between entities.

Another computational concept explored was that of an algorithm, understood as an ordered sequence of instructions. In the maze activity, the children created code to guide a character to a goal, using commands such as “walk”, “turn”, and “stop”. Upon realizing that the path was not working correctly, they revised the code they had created, demonstrating an understanding that correct execution depends on the precise order of instructions, a central principle of programming. This process also involved debugging, in which the children adjusted commands after identifying errors.

In summary, the data show that the children in the experimental group appropriated fundamental computational concepts, including information representation, command-based computer operation, execution conditions, relational data modeling, and algorithms. These concepts emerged in an integrated manner through the playful, collaborative experiences proposed by the framework, as evidenced in both the children’s speech and actions. The results reinforce that computing can be introduced in early childhood education through concrete, meaningful practices, enabling the construction of initial understandings aligned with the fundamentals of the field.

5.4.5 Social Collaboration and Participation in Design Activities

The data analysis shows that collaboration and social participation played a central role in how children engaged in the design activities proposed throughout the study. More than just a backdrop for learning, collaboration constituted a structuring element of the process, directly influencing the quality of interactions, the construction of solutions, and the manifestation of creativity, critical thinking, and emerging computational skills.

From the initial stages, it was observed that group activities required children to negotiate ideas, share materials, and make collective decisions. However, the way this

collaboration was established varied significantly across groups and over time, revealing both the potential and the challenges associated with young children's participation in collaborative design processes. These contrasting patterns within the same class highlight that collaboration is not merely a static skill, but is mediated by task structure, group composition, and available scaffolding.

In the control group, collaboration remained relatively stable throughout the study. In group activities, the children demonstrated greater ease in dividing tasks, listening to their peers' proposals, and reaching consensus on the solutions to be developed. During the creativity task, field notes describe that conflict was minimal and turn-taking emerged spontaneously, with different children proposing narrative elements and collectively integrating them into a single scenario. During the critical thinking task, the group again demonstrated high coordination, as documented when C2 and C4 reorganized image sequences based on details from the story and accepted each other's revisions without conflict. The teacher of the control class corroborated these observations, reporting that the children "talked and reached a consensus without needing me", indicating that this pattern of interaction was already part of the class routine, which contributed to consistent performance.

In the experimental group, on the other hand, collaboration was more fluctuating and challenging, especially in activities that required collective decision-making. During the intervention, there were recurring episodes of disputes over materials, overlapping speech, and difficulty listening among peers. This was documented in the critical thinking task, where "The group was unable to work collaboratively [...] E1 and E3 practically didn't participate in the activity" and, simultaneously, other children held the cards, preventing shared access to the task resources. Similar patterns emerged during the creativity task, where the teacher noted that "Group 1 worked in a more individualized way [...] I had to reinforce several times that the activity was a group effort". At various times, the children demonstrated individual initiative and engagement with the task but struggled to integrate their ideas with those of their peers, which affected the progress of the activities.

These challenges became particularly visible in design activities that required consensus, such as the collective construction of solutions or the definition of codes in groups. In some situations, the lack of coordination led to interruptions in the activity's flow or the need for teacher mediation. Even so, the observations also record specific moments of effective collaboration, in which the children negotiated decisions, revised proposals, and built solutions together, especially when the task offered a clearer structure or when teacher mediation was more prominent.

Interviews with the teachers reinforce this interpretation by noting that, although the children in the experimental group demonstrated progress in autonomy and understanding of the content, collaboration remained a challenge throughout the process. The teacher highlighted that many children had good individual ideas but found it difficult to share

them, listen to their peers, or uphold collective agreements. She said, “It’s difficult for them to learn to share, to wait”, and that in the final task some were “very, very disconnected”. In contrast, the teacher of the control group described a more fluid scenario, stating that in both phases the children “discussed among themselves what the order was and what they should do”, reinforcing the stability of collaborative practices in that class.

From a participation standpoint, the data indicate that the design activities created real opportunities for children to take a stand, express opinions, and make decisions. Even during moments of conflict, the children’s active participation demonstrates that they recognized themselves as agents in the process, assuming roles of proposing, arguing, and, in some cases, leading. Field notes from creativity tasks highlight leadership behaviors: in both groups, one child acted more as a leader (E7 in Group 1 and E6 in Group 2), while others occupied quieter positions or negotiated resource access. This participation is particularly relevant in the context of early childhood education, as it shows that young children are capable of engaging in design processes, even if they need support to develop more structured collaborative practices.

The comparison between the groups suggests that collaboration is not merely an individual condition, but a phenomenon strongly influenced by the social context, the class culture, and the mediation strategies adopted. While the control group presented a more fluid collaborative dynamic, the experimental group revealed that active participation does not, in itself, guarantee effective collaboration, especially in activities that require negotiation and consensus.

In summary, the results indicate that collaboration and social participation played a decisive role in the analyzed design processes. The proposed activities favored children’s active participation, allowing them to express themselves and make decisions, while also highlighting the challenges inherent to collaborative work in early childhood education. The data show that collaboration can both enhance and limit the expression of creativity, critical thinking, and emerging computational concepts, reinforcing the importance of pedagogical strategies that explicitly support the development of collaborative practices in design processes with young children.

5.4.6 Teacher Perspectives on Framework Applicability and Use

Analysis of the interview conducted with the experimental group teacher shows that the framework was perceived as applicable to the context of early childhood education, offering concrete support to teaching practice. One of the aspects most highlighted by the teacher refers to the clarity and level of detail in the activity plans. According to her, the plans were “very detailed [...] with step-by-step instructions and everything”, which facilitated understanding and reduced uncertainties regarding implementation. This organization was highlighted as a factor that favored understanding the purpose of each

activity, as she explained that “the playful aspect [...] makes all the difference, because they will be able to absorb more”.

The teacher also emphasized that the level of information in the activity plans enabled autonomous use of the material without the need for constant monitoring by the researcher. She stated that “even if you weren’t in the room, I think it would flow smoothly”, highlighting that the structure of the plans enabled their independent application, provided that teachers had minimal preparation. This perception reinforces the notion that the framework does not depend on external mediation to function, a relevant aspect for validating its usability in real-world contexts.

Another recurring point in the interview concerns the integration of the framework into teaching practice. The teacher reported that the activities could be incorporated into the daily school routine, noting that “suddenly, I can think of other things to address this same topic”, indicating that the experience expanded her pedagogical repertoire. She also mentioned that the proposals dialogued with everyday classroom dynamics, especially when activities involved problem-solving, negotiation, and shared decisions. This integration was perceived not only at the level of lesson planning, but also in the way the teacher began to observe and mediate the children’s interactions during implementation.

Furthermore, the teacher highlighted that the use of the framework contributed to a shift in perspective on children’s development, favoring a more attentive observation of processes rather than just final products. She stated that, after the intervention, she began to notice more clearly the way children “participate much more [...] they expose ideas more [...] and they also acquired autonomy”. The assessment rubrics were perceived as instruments that supported pedagogical reflection, helping monitor children’s reasoning and participation. Although the rubrics were not used to classify children, their structure encouraged intentional observation during the activities.

Overall, the teacher’s perception indicates that the framework not only enabled the application of the proposed activities but also positively impacted her teaching practice, offering new references for planning, mediation, and evaluation. She explicitly reported that “today I know a little more than I knew before [...] and that adds value for me as well”. These results reinforce the applicability of the framework in real classroom contexts and suggest its potential as a resource to support computer science education in early childhood.

5.5 Discussion

The results of this study provide empirical evidence that a framework structured from co-design principles, detailed activity plans, and assessment rubrics can significantly support the teaching and learning of computing in early childhood education (BERS; GONZÁLEZ-GONZÁLEZ; ARMAS-TORRES, 2019; KAFAI; BURKE, 2014; RESNICK;

ROBINSON, 2017). This finding aligns with research showing that developmentally appropriate approaches to computing, especially those combining unplugged activities, storytelling, and tangible artifacts, can foster meaningful engagement and conceptual appropriation in early childhood (STRAWHACKER; BERS, 2019; LYE; KOH, 2014). The combination of an interpretive qualitative approach with a quasi-experimental design allowed us to understand not only whether changes occurred, but also how these changes manifested in children’s interactions, in their ways of explaining technology, in their creative and critical processes, and in teaching practice.

From a theoretical perspective, the findings directly engage with Vygotsky’s socio-cultural approach, especially with the concepts of Zone of Proximal Development (ZPD) and mediation (VYGOTSKY, 1978). The transformations observed in children’s explanations of technology, problem-solving processes, and the appropriation of computational concepts emerged in contexts mediated by social interactions, concrete materials, and the teacher’s actions. The difficulties identified in collaborative activities, particularly in the experimental group, should not be interpreted as process failures, but as indications that the children were engaged in challenges that went beyond already consolidated practices, placing them within their ZPD. This interpretation is consistent with sociocultural perspectives that view learning as a socially mediated process (ROGOFF, 1990), in which scaffolded participation and guided interaction support the emergence of higher-level forms of reasoning (WOOD; BRUNER; ROSS, 1976; BRUNER, 1985). In this sense, moments of conflict, negotiation, and revision assume a productive role, contributing to cognitive and social development.

The results also reinforce central discussions in the field of CCI regarding the involvement of young children in design processes. In line with the intergenerational models proposed by Druin (DRUIN, 2010) and further explored in participatory design research with children (FAILS et al., 2013; IVERSEN; HALSKOV; LEONG, 2017; MORAIS; FALCÃO; TEDESCO, 2024), the children in this study did not act merely as users or informants, but as active participants in the creation of representations, solutions, and code. Although participation was mediated and marked by collaborative challenges, the data indicate that children aged 4 to 6 are capable of engaging in co-design activities when these are adequately structured and sensitive to the characteristics of child development (FAILS et al., 2013; IVERSEN; HALSKOV; LEONG, 2017). These results expand previous findings by showing that structured activity plans and formative assessment tools can scaffold participation even among younger children (4–6 years old), a group often considered challenging in participatory design research (DRUIN, 2010; FAILS et al., 2013; IVERSEN; HALSKOV; LEONG, 2017).

The findings related to emerging computational concepts contribute specifically to the field of computer science education in early childhood. Children’s explanations of binary representation, command-based computer operation, execution conditions, and

instruction sequences indicate that fundamental computer science concepts can be meaningfully appropriated at an early age when worked on through concrete, unplugged, and design-oriented activities. These results are consistent with research advocating a broader view of computational thinking, understood as a set of emergent practices and reasoning methods, rather than simply as the early introduction of formal programming (BRENNAN; RESNICK, 2012). This aligns with research arguing that CT in early childhood emerges as a set of practices, such as problem decomposition, sequencing, and symbolic representation, embedded in playful and constructionist activities (PAPERT, 1980; ??; STRAWHACKER; BERS, 2019).

The framework played a central role in mediating these processes. The principles of co-design guided pedagogical practices that valued listening, participation, and children's authorship, aligning with participatory design research that emphasizes children's active involvement as contributors in design processes (DRUIN, 2010; GUHA; DRUIN; FAILS, 2013). At the same time, the framework offered a clear pedagogical structure, which is considered essential in design-based research for supporting teachers' autonomy and fostering the sustainable adoption of educational innovations (BROWN, 1992; EASTERDAY; LEWIS; GERBER, 2014; SANDOVAL, 2014).

The teacher's perception regarding the clarity, level of detail, and applicability of the activity plans suggests the ecological validity of the framework, understood as its capacity to integrate into authentic classroom routines without disrupting existing practices (BRONFENBRENNER, 1977; BARAB; SQUIRE, 2004). This alignment between design principles, pedagogical structure, and classroom context suggests that the framework is suitable for real-world implementation in early childhood education settings.

Furthermore, the use of assessment rubrics was perceived as supporting pedagogical reflection, contributing to a more attentive observation of children's creativity and critical thinking processes. This result aligns with studies that advocate the use of formative assessment instruments in early childhood education, not as classification mechanisms, but as tools to support teaching practice and pedagogical decision-making (BLACK; WILLIAM, 1998; BROOKHART, 2013). In early childhood education, formative assessment has been shown to enhance both teacher intentionality and children's engagement in exploratory tasks (FLECK, 2020).

From the perspective of HCI and CCI research, this study contributes by presenting an empirical evaluation of an educational framework applied in a real-world classroom context, integrating multiple data sources and perspectives. The results reinforce the importance of approaches that articulate computing, creativity, and critical thinking, especially in contexts where social and emotional development is as relevant as cognitive development.

5.5.1 Limitations

This study has some limitations that should be considered when interpreting its results. First, the small sample size of participants, consisting of two early childhood education classes. Although the depth of the qualitative analysis allows for a rich understanding of the processes experienced by the children and the teacher, the results should not be interpreted as representative of broader contexts without further investigation.

Furthermore, the research was conducted in a single school setting, a private school located in a specific city. Institutional, cultural, and organizational factors specific to this context may have influenced both the implementation of the framework and the observed interactions. Although efforts were made to establish partnerships with public schools through contact with the local Department of Education, access was not granted within the required timeframe due to administrative and bureaucratic constraints, which restricted the study to the private school context. Future studies conducted across different types of schools, such as public institutions and diverse sociocultural contexts, could broaden understanding of the framework's applicability and robustness.

Another limitation is that the intervention was conducted by a single teacher. While this allowed for in-depth monitoring of teaching practice and perceptions of the framework's use, it also limited the analysis of variations that could arise from different teaching styles, levels of experience, or distinct teacher backgrounds. Replicating the study with multiple teachers could help evaluate the consistency of the results across different pedagogical practices.

The researcher's role as an observer should also be considered. The researcher's presence during the intervention and the recording of observations in the field diary may have influenced, even unintentionally, the behavior of the children and the teacher. Despite efforts to maintain an observational and reflective stance, this dual role can introduce interpretive biases, common in qualitative research conducted in natural settings.

The research aimed to understand processes, meanings, and interactions in depth. The findings offer relevant analytical and theoretical contributions to HCI and to computer science education in early childhood, and may serve as a basis for future investigations with complementary designs.

5.5.2 Future Work

The results of this study open up different possibilities for future research that could deepen and broaden the understanding of the use of frameworks for teaching computing in early childhood education. An important first step is to replicate the study in other educational contexts. Applying the framework across schools, including public and private institutions, and in diverse sociocultural contexts can help evaluate its adaptability, robustness, and sensitivity to different educational realities.

Conducting longitudinal studies is also a relevant direction. Investigations that follow children over longer periods could provide evidence on the continuity and consolidation of developed creativity, critical thinking, and computing skills, as well as on possible transfers to other learning contexts. This type of study would allow for a better understanding of the medium- and long-term effects of the framework on child development.

Finally, future research could explore evaluating the impact of the framework in schools with distinct characteristics, considering factors such as class size, teacher training, available infrastructure, and adopted pedagogical practices. Comparative analysis across contexts can help identify conditions that enhance or limit the implementation of the framework, supporting its adaptation and scalability.

Taken together, these research directions reinforce the framework's potential as a basis for new investigations in HCI and computer science education, broadening its reach and deepening the understanding of how young children can meaningfully engage with computational concepts through design and collaborative practices.

5.6 Conclusion

This study presents and evaluates a framework for teaching computing in early childhood education, structured around principles of co-design, activity plans, and assessment rubrics, intending to promote creativity, critical thinking, and an understanding of emerging computational concepts in young children. The results show that the framework proved effective in supporting children's engagement in design activities, problem-solving, and reflection on technology, as well as providing concrete support for teaching practice.

The framework's effectiveness is evident in both the advances observed in the children's explanations of technology and computing, and in the creative and critical processes mobilized throughout the activities. The children in the experimental group demonstrated a greater ability to justify decisions, revise solutions, apply fundamental computational concepts, such as information representation, command-based computer operation, and sequential instruction execution. These findings indicate that computing can be meaningfully addressed in early childhood education when integrated with playful, collaborative, and design-oriented practices.

The triangulation of methods and data sources was a central element for the robustness of the results. The convergence between interviews with children, creativity and critical thinking tests, assessment rubrics, observation diary, and teacher perceptions allowed for a comprehensive understanding of the framework's effects, mitigating the limitations inherent in isolated instruments. This approach proved especially relevant in research with young children, where the complexity of cognitive and social processes demands multiple analytical lenses.

Beyond the observed impacts on children's development, the study also highlights the

framework's contribution to teaching practice. The teacher's perception in the experimental group regarding the clarity, level of detail, and the possibility of autonomous use of the activity plans reinforces the applicability of the framework in real classroom contexts. The use of rubrics as formative instruments supported observation and pedagogical reflection, broadening the perspective on children's learning processes.

From a scientific contribution standpoint, this work advances the HCI field, especially the CCI area, by offering empirical evidence on how co-design-based educational frameworks can support computer science learning at an early age. In early childhood education, the study demonstrates that design and collaboration practices can be integrated into daily school life in ways that are sensitive to children's development. In the field of computer science education, the results reinforce the viability of approaches that prioritize emergent computational concepts, creativity, and critical thinking over an early, formal introduction to programming.

In summary, this study contributes by demonstrating that teaching computing in early childhood education can be conceived as a participatory, mediated, and reflective process, in which children and teachers act as protagonists. The evaluated framework provides a conceptual and practical basis for future research and interventions, broadening the debate on how computing can be meaningfully, ethically, and contextually integrated into young children's educational experiences.

Chapter 6

Considerações Finais

The increasing presence of computing in children's daily lives from their earliest years poses challenges for early childhood education, especially in introducing computational concepts in meaningful, developmentally appropriate ways. For this integration to go beyond instrumental use of technology, it is essential to consider children's cognitive, social, and emotional characteristics and to promote essential 21st-century skills such as creativity and critical thinking.

In this context, collaborative processes, such as co-design, offer a promising approach by fostering children's active participation, valuing their experiences, and enabling the collective construction of meaning. However, the systematic literature mapping conducted in this thesis revealed that, despite the growing interest of the scientific community in co-design and participatory design with children, there is a scarcity of structured proposals that practically guide the use of these approaches in computing education in early childhood. In particular, the absence of frameworks that support teachers in planning, conducting activities, and evaluating the development of skills such as creativity and critical thinking was observed.

To help fill this gap, this thesis proposed a framework for teaching computing in early childhood education, based on co-design processes and focused on developing children's creativity and critical thinking skills aged 4 and 5. The framework comprises co-design principles, design activity plans, and assessment rubrics, conceived in an integrated way to support pedagogical practices in real classroom contexts.

This chapter presents, in Section 6.1, a synthesis of the main contributions of this thesis. Section 6.2 discusses final reflections and lessons learned from the development of the framework and the methodological approach adopted. Section 6.3 presents perspectives for future work. Finally, Section 6.4 presents all publications produced during this

doctoral period.

6.1 Summary of Contributions

A key contribution of this research is the systematization of existing knowledge on co-design and participatory design with young children, through a systematic literature mapping. This study identified important gaps, including the lack of standardized methodologies, limited detailing of children's roles in design processes, and a reduced focus on learning outcomes and the development of broader cognitive skills. These findings conceptually grounded the need for a structured proposal specifically aimed at early childhood computer science education.

As its main scientific contribution, this thesis presents an integrated framework to computing education in early childhood, composed of three complementary pillars: (i) co-design principles to guide the conduct of collaborative processes with young children; (ii) design activity plans that operationalize these principles in real educational contexts; and (iii) adapted assessment rubrics to observe evidence of creativity and critical thinking in 4- and 5-year-old children. Unlike proposals based on isolated activities or specific tools, the framework offers a conceptual and practical structure that supports the teacher at different stages of the pedagogical process.

Another important contribution concerns the participatory process used to construct the framework, which involved early childhood education teachers, undergraduate students in pedagogy and computer science, and specialists in education and computer science. This collaborative approach balanced theoretical rigor, practical feasibility, and pedagogical suitability, thereby strengthening the framework's applicability in real classroom contexts.

Finally, the empirical evaluation of the framework, conducted through a quasi-experimental study in an early childhood education school, provides qualitative evidence that the co-design-based approach fosters children's engagement, exploration of ideas, development of problem-solving strategies, and a more critical and creative relationship with technology. Furthermore, the results indicate that the framework is understandable and usable for teachers, thereby contributing to the integration of computing into pedagogical practices in early childhood education.

6.2 Final Reflections and Lessons Learned

Throughout the development of this research, it became evident that teaching computing in early childhood education is not limited to the early introduction of technical concepts, but also involves creating pedagogical experiences that respect the playful, exploratory, and relational nature of childhood. One of the main lessons learned is that

co-design processes, when properly adapted, can act not only as strategies for creating artifacts but as powerful pedagogical tools to promote learning, participation, and the development of cognitive and socio-emotional skills.

Another important point to consider concerns the role of the teacher. The research results indicate that the early childhood education teacher assumes a central role as a mediator in co-design processes, being responsible for translating abstract principles into concrete pedagogical practices, balancing listening to children with educational objectives, and creating a safe environment for the expression of ideas. In this sense, structured frameworks are fundamental for supporting teachers, especially in contexts where there is still insecurity and a scarcity of materials for teaching computing at this stage of basic education.

The research also showed that children aged 4 and 5 can actively participate in collaborative design processes, expressing ideas, justifying choices, and reflecting on solutions when methodologies, language, and materials are appropriately adapted. However, the results also indicate that collaboration among young children is not always stable and may fluctuate depending on group dynamics and interaction patterns. While the children were initially able to negotiate ideas and reach consensus during the diagnostic activities, difficulties related to listening to peers, sharing materials, and managing leadership roles emerged during some activities and became more evident in the final tests. These findings reinforce both the potential of young children to engage in design processes and the importance of pedagogical strategies that actively support collaborative interaction in early childhood contexts.

Beyond methodological and pedagogical insights, it is also important to reflect on the context in which the study was conducted. A relevant aspect in interpreting the results refers to the setting in which the empirical evaluation was carried out. The study was conducted in a private school due to limitations in establishing partnerships with public institutions within the available timeframe. Although the results present evidence of the potential of the proposed structure, they are based on a specific educational context, which may differ from public schools in terms of resources, infrastructure, and pedagogical conditions. This issue is particularly relevant in the Brazilian context, where there are significant differences between the public and private education systems. In this sense, the importance of future investigations that replicate and adapt the proposed structure in public education settings is highlighted, contributing to a broader understanding of its applicability, scalability, and impact in different educational realities.

6.3 Future Works

Despite the contributions presented, this research has limitations that offer opportunities for future investigation. The framework evaluation was conducted in a single school

context and with a limited number of classes. Future studies could apply the framework across different educational contexts, including schools with distinct socioeconomic, cultural, and regional profiles, to investigate its adaptability and robustness.

Another possibility for future work is conducting longitudinal studies that follow children over longer periods, enabling analysis of the evolution of creativity, critical thinking, and computational concept development. Furthermore, investigations combining qualitative and quantitative methods can strengthen the empirical evidence on the framework's impacts.

Also highlighted as a future perspective is the exploration of integration with specific digital technologies, such as tangible devices, visual programming environments, or interactive resources, while maintaining a focus on the principles of co-design and the protagonism of children.

6.4 Final Considerations

This thesis stems from the understanding that early childhood computer science education should go beyond the instrumental use of technology, seeking to develop children capable of understanding, questioning, and creating solutions critically and creatively. By proposing and evaluating a co-design-based framework, this work offers a concrete contribution to researchers, educators, and educational policymakers interested in promoting more humane, inclusive, and meaningful pedagogical practices in computer science education.

By integrating design principles, design activity plans, and assessment tools into a coherent structure, the proposed framework seeks to support early childhood education teachers in building learning experiences that value children's active participation and respect the specificities of child development. It is hoped that the results of this research will inspire new investigations and pedagogical practices that strengthen the role of computing as a tool for the holistic development of children from the earliest years of schooling.

6.5 Publications

This section presents all articles published and submitted during the doctoral period.

6.5.1 Published articles

- MENEZES, Stefane; DE CASTRO FREITAS, Andre Luis. Realidade virtual como meio de conscientização da etiqueta higiênica com foco em crianças com Transtorno do Espectro do Autismo. *Revista Thema*, v. 21, p. 507–520, 2022.

- ❑ MENEZES, Stefane Vieira; PICCOLO, Lara. O ensino de computação para além dos muros da escola: análise crítica dos caminhos no Brasil e no Reino Unido. *Cadernos CEDES*, Campinas, v. 43, p. 108–115, 2023.
- ❑ MENEZES, Stefane Vieira; NERIS, Luciano de Oliveira; VIVALDINI, Kelen Cristiane Teixeira; ARCE, Alessandra; MIGUEL, Carolina Costa; NERIS, Vânia Paula de Almeida. Um arcabouço teórico para o ensino de computação para crianças de 4 e 5 anos pautado no codesign. In: *SIMPÓSIO BRASILEIRO DE INFORMÁTICA NA EDUCAÇÃO (SBIE)*, 34., 2023, Brasil. *Anais do XXXIV Simpósio Brasileiro de Informática na Educação*. Porto Alegre: SBC, 2023. v. 34, p. 948–959.
- ❑ CASTRO JUNIOR, Amaury Antonio de; ISHIKAWA, Edson; FERNANDES, Jorge Heniaga Cabral; RIBEIRO, Leila; CAVALHEIRO, Simone André da Costa; RODRIGUES, Stefane Menezes. Computação na Educação Básica. In: *SOCIEDADE BRASILEIRA DE COMPUTAÇÃO*. *Grandes desafios da educação em computação no Brasil 2025–2035*. Porto Alegre: SBC, 2025. p. 22–34.
- ❑ NERIS, Vânia Paula de Almeida; SOUZA, Paula M.; BORGES, Alessandro C.; ANCIOTO, Alex Sandro R.; RIBEIRO, Evandro Y. A.; SILVA, Grasiane C.; DOMINGUETE, Gustavo L.; RODRIGUES, Stefane Menezes; ALVES, Vanessa C. Emoção, saúde, personalização e empoderamento de usuário: pesquisas do LIFeS alinhadas ao GrandIHC-BR 2025–2035. In: *SIMPÓSIO BRASILEIRO SOBRE FATORES HUMANOS EM SISTEMAS COMPUTACIONAIS (IHC)*, 24., 2025, Brasil. *Anais Estendidos do XXIV Simpósio Brasileiro sobre Fatores Humanos em Sistemas Computacionais*. Porto Alegre: SBC, 2025. p. 410–417.
- ❑ RODRIGUES, Stefane Menezes; NERIS, Vânia Paula de Almeida. Design principles for computing education in early childhood. In: *SIMPÓSIO BRASILEIRO DE INFORMÁTICA NA EDUCAÇÃO (SBIE)*, 36., 2025, Curitiba. *Anais do XXXVI Simpósio Brasileiro de Informática na Educação*. Porto Alegre: SBC, 2025. p. 564–577.
- ❑ Systematic Mapping of Co-Design and Participatory Design with Preschool Children: Techniques, Roles, and Methodological Challenges. Accepted for publication in: *Journal of the Brazilian Computer Society*.

6.5.2 Submitted articles

- ❑ Early childhood teachers and undergraduate students prototyping design activities to Computing Education.
- ❑ Evaluating a Co-Design-Based Framework for Computing Education in Early Childhood: A Mixed Qualitative Triangulation Study with Preschool Children.

Bibliography

ABDULLAH, M. H. L.; BRERETON, M. Mycalendar: Fostering communication for children with autism spectrum disorder through photos and videos. In: **Proceedings of the Annual Meeting of the Australian Special Interest Group for Computer Human Interaction**. New York, NY, USA: Association for Computing Machinery, 2015. (OzCHI '15), p. 1–9. ISBN 9781450336734. Disponível em: <<https://doi.org/10.1145/2838739.2838785>>.

ADRIANA-MIHAELA, G.; GRIGORETA-SOFIA, C.; ANAMARIA, M. Applying ucd for designing learning experiences for romanian preschoolers. a case study. In: LAMAS, D. et al. (Ed.). **Human-Computer Interaction – INTERACT 2019**. Cham: Springer International Publishing, 2019. p. 589–594. ISBN 978-3-030-29390-1.

AL-KHATIB, A. J. **A case study of an early childhood minority teacher and how she formed her professional identity**. Dissertação (Mestrado) — Kent State University, Kent, Ohio, 2013.

ALHATEM, M. et al. Children involvement in participatory design process: A background review. **International Journal of Advanced Trends in Computer Science and Engineering**, v. 8, n. 1.4, p. 474–483, 2019. Disponível em: <<https://www.warse.org/IJATCSE/static/pdf/file/ijatcse75814sl2019.pdf>>.

ALSEBAYEL, G. et al. Articumotion: Towards assessing motor speech disorders via gamification. In: **Proceedings of the 23rd Annual ACM Interaction Design and Children Conference**. New York, NY, USA: Association for Computing Machinery, 2024. (IDC '24), p. 232–247. ISBN 9798400704420. Disponível em: <<https://doi.org/10.1145/3628516.3655815>>.

ARETIO, L. G. et al. Necesidad de una educación digital en un mundo digital. **RIED. Revista Iberoamericana de Educación a Distancia**, 2019.

Association for Computing Machinery; IEEE Computer Society; Association for Information Systems. **Computing Curricula 2020: Paradigms for Global Computing Education**. ACM, 2020. Accessed: 2024-09-27. Disponível em: <<https://www.acm.org/education/curricula-recommendations>>.

AUSTRALIA, E. C. Statement on young children and digital technologies. **Retrieved September**, v. 8, p. 2018, 2018.

AUSUBEL, D. P. **Aquisição e retenção de conhecimentos: uma perspectiva cognitiva**. [S.l.]: Lisboa, 2003. v. 1.

BAILIN, S. **Achieving Extraordinary Ends: An Essay on Creativity**. Springer Netherlands, 2012. (Humanities, Social Sciences and Law). ISBN 9789400927803.

Disponível em: <<https://books.google.com.br/books?id=wpSeBQAAQBAJ>>.

BARAB, S. A.; SQUIRE, K. Design-based research: Putting a stake in the ground. **Journal of the Learning Sciences**, v. 13, n. 1, p. 1–14, 2004.

BARBOUR, R. **Grupos Focais: Coleção Pesquisa Qualitativa**. Bookman, 2009. ISBN 9788536321455. Disponível em: <<https://books.google.com.br/books?id=iwav7cXD4YwC>>.

BARRAGÁN, P. P. et al. Designing collaborative scratchjr for multi-touch tabletops. In: IEEE. **2024 International Symposium on Computers in Education (SIIE)**. [S.l.], 2024. p. 1–6.

BEKKER, T. et al. Teaching children digital literacy through design-based learning with digital toolkits in schools. **International Journal of Child-Computer Interaction**, Elsevier, v. 5, p. 29–38, 2015.

BELL, T. et al. Ensinando ciência da computação sem o uso do computador. **Computer Science Unplugged ORG**, 2011.

BENTON, L. et al. Developing ideas: supporting children with autism within a participatory design team. In: **Proceedings of the SIGCHI Conference on Human Factors in Computing Systems**. New York, NY, USA: Association for Computing Machinery, 2012. (CHI '12), p. 2599–2608. ISBN 9781450310154. Disponível em: <<https://doi.org/10.1145/2207676.2208650>>.

BERS, M. U. Coding as a playground: Programming and computational thinking in the early childhood classroom. **Routledge**, 2018.

BERS, M. U.; GONZÁLEZ-GONZÁLEZ, C.; ARMAS-TORRES, M. B. Coding as a playground: Promoting positive learning experiences in childhood classrooms. **Computers & Education**, Elsevier, v. 138, p. 130–145, 2019.

BERS, M. U.; STRAWHACKER, A.; SULLIVAN, A. The state of the field of computational thinking in early childhood education. **OECD education working papers**, OECD Publishing, 2022.

BESANÇON, M.; LUBART, T. Differences in the development of creative competencies in children schooled in diverse learning environments. **Learning and individual differences**, Elsevier, v. 18, n. 4, p. 381–389, 2008.

BLACK, P.; WILIAM, D. Assessment and classroom learning. **Assessment in Education**, v. 5, n. 1, p. 7–74, 1998.

BODEN, M. Creativity and knowledge. **Creativity in education**, p. 95–102, 2001.

BODROVA, E.; LEONG, D. **Tools of the mind: The Vygotskian approach to early childhood education**. [S.l.]: Taylor & Francis, 2024.

BRASIL. **Lei nº 14.533, de 11 de janeiro de 2023. Institui a Política Nacional de Educação Digital**. 2023. <https://www.planalto.gov.br/ccivil_03/_ato2023-2026/2023/lei/114533.htm>. Acesso em: 30 mar. 2026.

BRASIL, M. d. E. **Base Nacional Comum Curricular**. 2021. Disponível em: <<http://basenacionalcomum.mec.gov.br/>>. Acesso em: 10/ago/2025.

_____. **Computação - Complemento à BNCC**. 2022. Disponível em: <<http://portal.mec.gov.br/docman/fevereiro-2022-pdf/236791-anexo-ao-parecer-cneceb-n-2-2022-bncc-computacao/file>>.

BRAUN, V.; CLARKE, V. Using thematic analysis in psychology. **Qualitative research in psychology**, Taylor & Francis, v. 3, n. 2, p. 77–101, 2006.

_____. **Successful qualitative research: A practical guide for beginners**. Sage publications ltd, 2013.

BRENNAN, K.; RESNICK, M. New frameworks for studying and assessing the development of computational thinking. **Proceedings of the 2012 Annual Meeting of the American Educational Research Association**, 2012.

BRINCK, J. et al. Zones of participation—a framework to analyse design roles in early childhood education and care (ecec). **CoDesign**, Taylor & Francis, v. 18, n. 2, p. 208–226, 2022.

BRONFENBRENNER, U. Toward an experimental ecology of human development. **American Psychologist**, v. 32, n. 7, p. 513–531, 1977.

BROOKHART, S. **How to Create and Use Rubrics for Formative Assessment and Grading**. ASCD, 2013. ISBN 9781416615521. Disponível em: <https://books.google.com.br/books?id=v_9QBAAQBAJ>.

BROWN, A. L. Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. **The journal of the learning sciences**, Taylor & Francis, v. 2, n. 2, p. 141–178, 1992.

BROWN, T. et al. Design thinking. **Harvard business review**, v. 86, n. 6, p. 84, 2008.

BRUNER, J. Child's talk: Learning to use language. **Child Language Teaching and Therapy**, v. 1, n. 1, p. 111–114, 1985. Disponível em: <<https://doi.org/10.1177/026565908500100113>>.

CAPIO, C. M. et al. Integrating fundamental movement skills and mathematics in early childhood: A pilot study. **Children**, MDPI, v. 11, n. 4, p. 457, 2024.

CARLSON, S. M. Developmentally sensitive measures of executive function in preschool children. In: **Measurement of executive function in early childhood**. [S.l.]: Psychology Press, 2016. p. 595–616.

CAVEDINI, P. et al. Educational game for laterality development in early childhood and the importance of participatory design. In: A. MENDES A.J., D. J. B. (Ed.). [S.l.]: CEUR-WS, 2020. v. 2733. ISSN 16130073. Cited By 0.

CHANG, Y.-L. et al. Investigating the synergy of critical thinking and creative thinking in the course of integrated activity in taiwan. **Educational Psychology**, v. 35, p. 341 – 360, 2015.

CHU, C. et al. Digital play in the early years: A systematic review. **International Journal of Child-Computer Interaction**, Elsevier, v. 40, p. 100652, 2024.

ÇİFTÇİ, A.; TOPCU, M. S. Improving early childhood pre-service teachers' computational thinking skills through the unplugged computational thinking integrated stem approach. **Thinking Skills and Creativity**, Elsevier, v. 49, p. 101337, 2023.

COLLECTIVE, D.-B. R. Design-based research: An emerging paradigm for educational inquiry. **Educational researcher**, Sage Publications Sage CA: Thousand Oaks, CA, v. 32, n. 1, p. 5–8, 2003.

COLLINS, A.; JOSEPH, D.; BIELACZYK, K. Design research: Theoretical and methodological issues. In: **Design-based research**. [S.l.]: Psychology Press, 2016. p. 15–42.

COMMITTEE, K.-. C. S. F. S. et al. **K-12 computer science framework**. [S.l.]: ACM, 2016.

CORE, C. et al. Designing a musical playground in the kindergarten. **Electronic Visualisation and the Arts (EVA 2017)**, p. 1–12, 2017.

CRAFT, A. The limits to creativity in education: Dilemmas for the educator. **British journal of educational studies**, Taylor & Francis, v. 51, n. 2, p. 113–127, 2003.

CRESWELL, J.; CRESWELL, J. **Research Design: Qualitative, Quantitative, and Mixed Methods Approaches**. SAGE Publications, 2017. ISBN 9781506386690. Disponível em: <<https://books.google.com.br/books?id=335ZDwAAQBAJ>>.

CRITTEN, V.; HAGON, H.; UNLU, M. A. A curriculum framework and assessment approach for computational thinking in the early years. **International Journal of Computer Science Education in Schools**, v. 6, n. 4, 2024.

DAHLBÄCK, N.; JÖNSSON, A.; AHRENBERG, L. Wizard of oz studies: why and how. In: **Proceedings of the 1st International Conference on Intelligent User Interfaces**. New York, NY, USA: Association for Computing Machinery, 1993. (IUI '93), p. 193–200. ISBN 0897915569. Disponível em: <<https://doi.org/10.1145/169891.169968>>.

DAVIES, T. Taking risks as a feature of a creativity in the teaching and learning of design and technology. **Aspects of Teaching Secondary Design and Technology: Perspectives on Practice**, Routledge, p. 118, 2003.

DENZIN, N. K. **The Research Act: A Theoretical Introduction to Sociological Methods**. [S.l.]: McGraw-Hill, 1978.

_____. **The research act: A theoretical introduction to sociological methods**. [S.l.]: Routledge, 2017.

DINDLER, C.; IVERSEN, O. S. Fictional inquiry—design collaboration in a shared narrative space. **CoDesign**, Taylor & Francis, v. 3, n. 4, p. 213–234, 2007.

DOURISH, P. **Where the action is: the foundations of embodied interaction**. [S.l.]: MIT press, 2001.

DRUIN, A. Cooperative inquiry: developing new technologies for children with children. In: **Proceedings of the SIGCHI conference on Human Factors in Computing Systems**. [S.l.: s.n.], 1999. p. 592–599.

_____. The role of children in the design of new technology. **Behaviour and information technology**, Citeseer, v. 21, n. 1, p. 1–25, 2002.

_____. Children as codesigners of new technologies: Valuing the imagination to transform what is possible. **New directions for youth development**, Wiley Online Library, v. 2010, n. 128, p. 35–43, 2010.

EASTERDAY, M.; LEWIS, D.; GERBER, E. Design-based research in education. **International Journal of Design-Based Learning**, v. 4, n. 1, p. 1–22, 2014.

ECKHOFF, A. Images of play experiences through a child's lens: An exploration of play and digital media with young children. **International Journal of Early Childhood**, Springer Netherlands, v. 49, n. 1, p. 113–129, 2017. ISSN 00207187. Cited By 3.

EDWARDS, S. et al. Rationale, design and methods protocol for participatory design of an online tool to support industry service provision regarding digital technology use 'with, by and for' young children. **International Journal of Environmental Research and Public Health**, MDPI AG, v. 17, n. 23, p. 1–12, 2020. ISSN 16617827. Cited By 0.

EHN, P. Scandinavian design: On participation and skill. In: **Participatory design**. [S.l.]: CRC Press, 2017. p. 41–77.

EHSAN, H. et al. Engineering design and children: A systematic literature review. **International Journal of Education in Mathematics, Science and Technology**, v. 11, n. 3, p. 775–803, 2023.

EINARSDÓTTIR, J. Research with children: Methodological and ethical challenges. **European early childhood education research journal**, Taylor & Francis, v. 15, n. 2, p. 197–211, 2007.

ENGLAND, N. National curriculum in england: computing programmes of study. **Gov. Uk**, 2013.

FAILS, J. A. et al. Methods and techniques for involving children in the design of new technology for children. **Foundations and Trends® in Human–Computer Interaction**, Now Publishers, Inc., v. 6, n. 2, p. 85–166, 2013.

FALKENBERG, K. et al. Creating digital musical instruments with and for children: Including vocal sketching as a method for engaging in codesign. **Human Technology**, Open Science Center, University of Jyväskylä, v. 16, n. 3, p. 348–371, 2020. ISSN 17956889. Cited By 0.

FANG, K.; AZIZAN, S. A.; HUANG, H. Gis-based intelligent planning approach of child-friendly pedestrian pathway to promote a child-friendly city. **Scientific reports**, Nature Publishing Group UK London, v. 14, n. 1, p. 8139, 2024.

FIELDS, D. A.; GIANG, M.; KAFI, Y. Programming in the wild: trends in youth computational participation in the online scratch community. In: **Proceedings of the 9th Workshop in Primary and Secondary Computing Education**. New York, NY, USA: Association for Computing Machinery, 2014. (WiPSCE '14), p. 2–11. ISBN 9781450332507. Disponível em: <<https://doi.org/10.1145/2670757.2670768>>.

FINCH, L.; MORENO, C.; SHAPIRO, R. B. Luminous science: Teachers designing for and developing transdisciplinary thinking and learning. **Cognition and Instruction**, Taylor & Francis, v. 39, n. 4, p. 512–560, 2021.

FISCHER, G. et al. Meta-design: a manifesto for end-user development. **Communications of the ACM**, ACM New York, NY, USA, v. 47, n. 9, p. 33–37, 2004.

FISCHER, G.; SCHARFF, E. Meta-design: design for designers. In: **Proceedings of the 3rd Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques**. New York, NY, USA: Association for Computing Machinery, 2000. (DIS '00), p. 396–405. ISBN 1581132190. Disponível em: <<https://doi.org/10.1145/347642.347798>>.

FLECK, R. Creativity in early childhood: Educational strategies. **International Journal of Child-Computer Interaction**, v. 24, p. 100187, 2020.

FLOOD, V. J.; WANG, X. C.; SHERIDAN, M. Embodied responsive teaching for supporting computational thinking in early childhood. In: INTERNATIONAL SOCIETY OF THE LEARNING SCIENCES. **Proceedings of the 16th International Conference of the Learning Sciences-ICLS 2022**, pp. 855–862. [S.l.], 2022.

FORMAN, E. A.; CAZDEN, C. B. Exploring vygotskian perspectives in education: The cognitive value of peer interaction. In: **Learning relationships in the classroom**. [S.l.]: Routledge, 2013. p. 189–206.

GIZZI, V.; DIO, S. D.; SCHILLACI, D. Junkbox, a waste management educational game for preschool kids. **Interaction Design and Architecture(s)**, Scuola Iad, n. 40, p. 46–56, 2019. ISSN 18269745. Cited By 1.

GLENBERG, A. M. Embodiment as a unifying perspective for psychology. **Wiley interdisciplinary reviews: Cognitive science**, Wiley Online Library, v. 1, n. 4, p. 586–596, 2010.

GRETTER, S.; YADAV, A. Computational thinking and media information literacy: An integrated approach to teaching twenty-first century skills. **TechTrends**, v. 60, p. 510–516, 2016.

GRIZIOTI, M.; KYNIGOS, C. Children as players, modders, and creators of simulation games: A design for making sense of complex real-world problems: Children as players, modders and creators of simulation games. In: **Proceedings of the 20th Annual ACM Interaction Design and Children Conference**. New York, NY, USA: Association for Computing Machinery, 2021. (IDC '21), p. 363–374. ISBN 9781450384520. Disponível em: <<https://doi.org/10.1145/3459990.3460706>>.

- GUHA, M. L.; DRUIN, A.; FAILS, J. A. Cooperative inquiry revisited: Reflections of the past and guidelines for the future of intergenerational co-design. **International Journal of Child-Computer Interaction**, Elsevier, v. 1, n. 1, p. 14–23, 2013.
- GURAN, A.-M.; COJOCAR, G.-S.; MOLDOVAN, A. Play to learn! nurturing fundamental digital skills of romanian preschoolers by developing edutainment applications. In: ZAPHIRIS, P.; IOANNOU, A. (Ed.). **Learning and Collaboration Technologies. Human and Technology Ecosystems**. Cham: Springer International Publishing, 2020. p. 230–240. ISBN 978-3-030-50506-6.
- HAI, A. A. et al. Aprendendo e experimentando tecnologia e ciências na educação de crianças de 4 a 5 anos. Pedro João Editores, p. 231–, 2020.
- _____. Descobrindo o computar: tecnologia, ciências, design e computação para crianças de 4 e 5 anos. **Cadernos CEDES**, SciELO Brasil, v. 43, n. 120, p. 5–18, 2023.
- HARPER, F. K. et al. An unplugged remix of culturally responsive computing for early childhood education. **Future in Educational Research**, Wiley Online Library, v. 2, n. 4, p. 478–497, 2024.
- HELJAKKA, K.; IHAMÄKI, P. Comicubes—a playful tool to stimulate (design) creativity, celebration contemplation. In: **10th International Conference on Design & Emotion**. [S.l.: s.n.], 2016. p. 27–30.
- HELJAKKA, K.; IHAMÄKI, P. Digital natives and cardboard cubes: Co-creating a physical play(ful) ideation tool with preschool children. In: **Proceedings of the 2017 Conference on Interaction Design and Children**. New York, NY, USA: Association for Computing Machinery, 2017. (IDC '17), p. 541–547. ISBN 9781450349215. Disponível em: <<https://doi.org/10.1145/3078072.3084322>>.
- HEYMAN, G. D.; LEGARE, C. H. Children's evaluation of sources of information about traits. **Developmental Psychology**, American Psychological Association, v. 41, n. 4, p. 636, 2005.
- HINIKER, A. et al. Coco's videos: An empirical investigation of video-player design features and children's media use. In: **Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems**. New York, NY, USA: Association for Computing Machinery, 2018. (CHI '18), p. 1–13. ISBN 9781450356206. Disponível em: <<https://doi.org/10.1145/3173574.3173828>>.
- HINIKER, A.; SOBEL, K.; LEE, B. Co-designing with preschoolers using fictional inquiry and comicboarding. In: **Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems**. New York, NY, USA: Association for Computing Machinery, 2017. (CHI '17), p. 5767–5772. ISBN 9781450346559. Disponível em: <<https://doi.org/10.1145/3025453.3025588>>.
- HOURLCADE, J. P. Child-computer interaction. **Self, Iowa City, Iowa**, 2015.
- HOWARD, Z.; SOMERVILLE, M. M. A comparative study of two design charrettes: implications for codesign and participatory action research. **CoDesign**, Taylor & Francis, v. 10, n. 1, p. 46–62, 2014.

HUANG, W.; LOOI, C.-K. A critical review of literature on “unplugged” pedagogies in k-12 computer science and computational thinking education. **Computer Science Education**, Taylor & Francis, v. 31, n. 1, p. 83–111, 2021.

HUBBARD, L. J. et al. The dimensions of reflection coding scheme: A new tool for measuring the impact of designing for reflection in early childhood. In: **Proceedings of the 15th Conference on Creativity and Cognition**. New York, NY, USA: Association for Computing Machinery, 2023. (CC '23), p. 519–528. ISBN 9798400701801. Disponível em: <<https://doi.org/10.1145/3591196.3593512>>.

HUH, J. et al. Service design of artificial intelligence voice agents as a guideline for assisting independent toilet training of preschool children. In: . Korean Society of Design Science, 2022. v. 35, n. 3, p. 81–93. ISSN 1226-8046. Disponível em: <https://aodr.org/_common/do.php?a=full&b=12&bidx=3034&aidx=33895>.

HUYBRECHTS, L.; BENESCH, H.; GEIB, J. Institutioning: Participatory design, co-design and the public realm. **CoDesign**, Taylor & Francis, v. 13, n. 3, p. 148–159, 2017.

IVERSEN, O. S.; HALSKOV, K.; LEONG, T. W. A democratic design perspective on participatory design. **Proceedings of the ACM on Human-Computer Interaction**, v. 1, n. CSCW, p. 1–27, 2017.

JACKSON, L. A. Observing children’s stress behaviors in a kindergarten classroom. **Early childhood research & practice**, ERIC, v. 11, n. 1, p. n1, 2009.

KAFAL, Y. B.; BURKE, Q. Connected code: Why children need to learn programming. **MIT Press**, 2014.

KAFAL, Y. B.; PROCTOR, C. A revaluation of computational thinking in k–12 education: Moving toward computational literacies. **Educational Researcher**, SAGE Publications Sage CA: Los Angeles, CA, v. 51, n. 2, p. 146–151, 2022.

KALMPOURTZIS, G. Developing kindergarten students’ game design skills by teaching game design through organized game design interventions. **Multimedia Tools and Applications**, Springer, v. 78, n. 14, p. 20485–20510, 2019.

KALMPOURTZIS, G. et al. The role of early childhood students in the design of digital and physical games. In: ACADEMIC CONFERENCES AND PUBLISHING LIMITED. **ECGBL 2018 12th European Conference on Game-Based Learning**. [S.l.], 2018. p. 274.

KALMPOURTZIS, G.; VRYSIS, L.; VEGLIS, A. Teaching game design to students of the early childhood through forest maths. In: **2016 11th International Workshop on Semantic and Social Media Adaptation and Personalization (SMAP)**. [S.l.: s.n.], 2016. p. 123–127.

KAPANEN, H. et al. Children’s turn to participate! educational co-design with children. **Tarbiya: revista de investigación e innovación educativa**, 2019.

KAUFMAN, J. C.; BEGHETTO, R. A. Beyond big and little: The four c model of creativity. **Review of general psychology**, SAGE Publications Sage CA: Los Angeles, CA, v. 13, n. 1, p. 1–12, 2009.

KEETLEY, R. et al. Enabling participation in community-dwelling children and young people with acquired brain injuries and their families: a theory-based, evidence-based and person-based approach to intervention development. **BMJ open**, British Medical Journal Publishing Group, v. 14, n. 12, p. e088516, 2024.

KENSKI, V. **Educação e tecnologias: O novo ritmo da informação**. Papirus Editora, 2003. ISBN 9788530810429. Disponível em: <<https://books.google.com.br/books?id=ZneADwAAQBAJ>>.

KONTKANEN, S. et al. Children's digital competence in early childhood education: A comparative analysis of curricula. Swinburne, 2023.

KORTE, J.; POTTER, L. E.; NIELSEN, S. The impacts of deaf culture on designing with deaf children. In: **Proceedings of the 29th Australian Conference on Computer-Human Interaction**. New York, NY, USA: Association for Computing Machinery, 2017. (OZCHI '17), p. 135–142. ISBN 9781450353793. Disponível em: <<https://doi.org/10.1145/3152771.3152786>>.

KRUEGER, R. **Focus Groups: A Practical Guide for Applied Research**. SAGE Publications, 2014. ISBN 9781483365237. Disponível em: <<https://books.google.com.br/books?id=8wASBAAAQBAJ>>.

"KUEHL, R. O. "design of experiments : statistical principles of research design and analysis". "Duxbury", "2000". Disponível em: <"<https://cir.nii.ac.jp/crid/1970586434817086778>">.

LAI, E. R. Critical thinking: A literature review. **Pearson's Research Reports**, Citeseer, v. 6, n. 1, p. 40–41, 2011.

LEHNERT, F. K. et al. Child–computer interaction: From a systematic review towards an integrated understanding of interaction design methods for children. **International Journal of Child-Computer Interaction**, Elsevier, v. 32, p. 100398, 2022.

LIN, P.; BRUMMELEN, J. V. Engaging teachers to co-design integrated ai curriculum for k-12 classrooms. In: **Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems**. New York, NY, USA: Association for Computing Machinery, 2021. (CHI '21). ISBN 9781450380966. Disponível em: <<https://doi.org/10.1145/3411764.3445377>>.

LIN, Y. et al. Comparing the effects of plugged-in and unplugged activities on computational thinking development in young children. **Education and Information Technologies**, Springer, v. 29, n. 8, p. 9541–9574, 2024.

LISZIO, S.; BASU, O.; MASUCH, M. A universe inside the mri scanner: An in-bore virtual reality game for children to reduce anxiety and stress. In: **Proceedings of the Annual Symposium on Computer-Human Interaction in Play**. New York, NY, USA: Association for Computing Machinery, 2020. (CHI PLAY '20), p. 46–57. ISBN 9781450380744. Disponível em: <<https://doi.org/10.1145/3410404.3414263>>.

LIU, J.; ROTO, V. Chinese preschoolers as design partners – lessons learned. In: **Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems**. New York, NY, USA: Association for Computing

- Machinery, 2017. (CHI EA '17), p. 951–958. ISBN 9781450346566. Disponível em: <<https://doi.org/10.1145/3027063.3053343>>.
- LIU, R.; LUO, F.; ISRAEL, M. Technology-integrated computing education in early childhood: A systematic literature review. **Journal of Educational Computing Research**, v. 61, p. 1275 – 1311, 2023.
- LOVELESS, A. Literature review in creativity, new technologies and learning. Citeseer, 2002.
- LUCAS, B.; GREANY, T. **Learning to learn: setting the agenda for schools in the 21st century**. [S.l.]: Network Educational Press, 2000.
- LYE, S. Y.; KOH, J. H. L. Review on teaching and learning of computational thinking through programming. **Computers in Human Behavior**, v. 41, p. 51–61, 2014.
- MAHAMA, I. et al. Relationship between creative thinking and students academic performance in english language and mathematics: The moderating role of gender. **Journal of Education, Society and Behavioural Science**, 2019.
- MAJALI, S. A. The digital world for children and its relationship with personality disorders: Exploring emerging technologies. **International Journal of Emerging Technologies in Learning (iJET)**, International Journal of Emerging Technology in Learning, v. 15, n. 1, p. 213–221, 2020.
- MANCHES, A.; PLOWMAN, L. Computing education in children's early years: A call for debate. **Br. J. Educ. Technol.**, v. 48, p. 191–201, 2017.
- MARKOPOULOS, P.; BEKKER, M. **Interaction design and children**. 2003. 141-149 p. Disponível em: <[https://doi.org/10.1016/S0953-5438\(03\)00004-3](https://doi.org/10.1016/S0953-5438(03)00004-3)>.
- MARSH, J. **Popular Culture, New Media and Digital Literacy in Early Childhood**. RoutledgeFalmer, 2005. ISBN 9780415335737. Disponível em: <https://books.google.com.br/books?id=6dMWD_62AC0C>.
- _____. Young children's play in online virtual worlds. **Journal of early childhood research**, SAGE Publications Sage UK: London, England, v. 8, n. 1, p. 23–39, 2010.
- MARTENS, M.; RINNERT, G.; ANDERSEN, C. Child-centered design: Developing an inclusive letter writing app. **Frontiers in Psychology**, Frontiers Media S.A., v. 9, n. DEC, 2018. ISSN 16641078. Cited By 6.
- MARTINS, E. C. Atividades didáticas para o ensino de computação na pré-escola. Universidade Federal de São Carlos, 2021. Disponível em: <<https://repositorio.ufscar.br/bitstream/handle/ufscar/13823/Dissertac%cc%a7a%cc%83o%20final.pdf?sequence=1&isAllowed=y>>.
- MARTINS, E. C.; SILVA, L. G. Z. da; NERIS, V. P. de A. Systematic mapping of computational thinking in preschool children. **International Journal of Child-Computer Interaction**, Elsevier, v. 36, p. 100566, 2023.
- MASON, S. L.; RICH, P. J. Preparing elementary school teachers to teach computing, coding, and computational thinking. **Contemporary Issues in Technology and Teacher Education**, Society for Information Technology & Teacher Education, v. 19, n. 4, p. 790–824, 2019.

MATHISON, S. Why triangulate? **Educational researcher**, Sage Publications Sage CA: Thousand Oaks, CA, v. 17, n. 2, p. 13–17, 1988.

MECHELEN, M. V. et al. Analyzing children's contributions and experiences in co-design activities: Synthesizing productive practices. In: **Proceedings of the 2017 Conference on Interaction Design and Children**. New York, NY, USA: Association for Computing Machinery, 2017. (IDC '17), p. 769–772. ISBN 9781450349215. Disponível em: <<https://doi.org/10.1145/3078072.3081314>>.

MENEZES, S. et al. Um arcabouço teórico para o ensino de computação para crianças de 4 e 5 anos pautado no codesign. In: **Anais do XXXIV Simpósio Brasileiro de Informática na Educação**. Porto Alegre, RS, Brasil: SBC, 2023. p. 948–959. ISSN 0000-0000. Disponível em: <<https://sol.sbc.org.br/index.php/sbie/article/view/26725>>.

METIN, Ş. et al. Design-based digital story program: Enhancing coding and computational thinking skills in early childhood education. **Early Childhood Education Journal**, Springer, v. 53, n. 6, p. 2255–2274, 2025.

MOLBÆK, M.; KRISTENSEN, R. M. Triangulation with video observation when studying teachers' practice. **Qualitative Research Journal**, Emerald Publishing Limited, v. 20, n. 1, p. 152–162, 2020.

MORAIS, D. C. S. de; FALCÃO, T. P.; TEDESCO, P. Promoting children's participation in a participatory design process in a rural school: A new role needed? **Journal of the Brazilian Computer Society**, v. 30, n. 1, p. 116–132, 2024.

MORAN, J. M. A integração das tecnologias na educação. **Salto para o Futuro**, v. 204, p. 63–91, 2005.

MORAVEJI, N. et al. Comicboarding: using comics as proxies for participatory design with children. In: **Proceedings of the SIGCHI Conference on Human Factors in Computing Systems**. New York, NY, USA: Association for Computing Machinery, 2007. (CHI '07), p. 1371–1374. ISBN 9781595935939. Disponível em: <<https://doi.org/10.1145/1240624.1240832>>.

MORGAN, D. L. Focus groups. **Annual review of sociology**, Annual Reviews 4139 El Camino Way, PO Box 10139, Palo Alto, CA 94303-0139, USA, v. 22, n. 1, p. 129–152, 1996.

MULLER, M. J. Participatory design: The third space in hci-handbook of hci. **Mahway NJ USA: Erlbaum**, 2003.

MURAVEVSKAIA, E.; GARDNER-MCCUNE, C. Designing a virtual reality empathy game framework to create empathic experiences for children. **International Journal of Child-Computer Interaction**, Elsevier, v. 35, p. 100561, 2023.

NERIS, V. A.; HAI, A. A. **TECNOLOGIA E EDUCAÇÃO: CIÊNCIAS, COMPUTAÇÃO (DES)PLUGADA E PENSAMENTO COMPUTACIONAL NA EDUCAÇÃO DE CRIANÇAS DE 4 A 10 ANOS**. CEDES - Centro de Estudos Educação e Sociedade, 2023. 2–4 p. Disponível em: <<https://doi.org/10.1590/CC271503>>.

NETO, B. S.; NERIS, V. Towards an interaction model for the programming of devices by children in the age of internet of things. In: **Proceedings of the 17th Brazilian Symposium on Human Factors in Computing Systems**. New York, NY, USA: Association for Computing Machinery, 2018. (IHC '18). ISBN 9781450366014. Disponível em: <<https://doi.org/10.1145/3274192.3274245>>.

NETO, B. S.; NERIS, V.; RODRIGUEZ, C. Building an iot programming environment with and for preschool children. In: **Proceedings of the XX Brazilian Symposium on Human Factors in Computing Systems**. New York, NY, USA: Association for Computing Machinery, 2021. (IHC '21). ISBN 9781450386173. Disponível em: <<https://doi.org/10.1145/3472301.3484361>>.

NETO, B. S.; RODRIGUEZ, C.; NERIS, V. Buttons, devices, and adults: How preschool children designed an iot programming tool. **Interacting with Computers**, Oxford University Press, v. 35, n. 2, p. 301–314, 2023.

NICOLOPOULOU, A. Worldmaking and identity formation in children's narrative play-acting. In: **Sociogenetic perspectives on internalization**. [S.l.]: Psychology Press, 2013. p. 165–196.

NIELSEN, J. **Usability Engineering**. Elsevier Science, 1994. (Interactive Technologies). ISBN 9780125184069. Disponível em: <<https://books.google.com.br/books?id=95As2OF67f0C>>.

OECD. **The Future of Education and Skills 2030**. Paris, France, 2021.

OLMO-MUÑOZ, J. del; CÓZAR-GUTIÉRREZ, R.; GONZÁLEZ-CALERO, J. A. Computational thinking through unplugged activities in early years of primary education. **Computers & Education**, Elsevier, v. 150, p. 103832, 2020.

PAIVA, N. M. N. D.; COSTA, J. A influência da tecnologia na infância: desenvolvimento ou ameaça. **Psicologia**. pt, v. 1, p. 1–13, 2015.

PANTOJA, L. S. et al. Play-based design: Giving 3- to 4-year-old children a voice in the design process. In: **Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems**. New York, NY, USA: Association for Computing Machinery, 2020. (CHI '20), p. 1–14. ISBN 9781450367080. Disponível em: <<https://doi.org/10.1145/3313831.3376407>>.

PAPERT, S. **Mindstorms: Children, Computers, and Powerful Ideas**. [S.l.]: Basic Books, 1980.

PAUL, R.; ELDER, L. **The Miniature Guide to Critical Thinking Concepts and Tools**. Bloomsbury Publishing, 2019. (Thinker's Guide Library). ISBN 9798765194232. Disponível em: <<https://books.google.com.br/books?id=-fiAEQAAQBAJ>>.

PETERSEN, K. et al. Systematic mapping studies in software engineering. In: **Ease**. [S.l.: s.n.], 2008. v. 8, p. 68–77.

PETERSEN, K.; VAKKALANKA, S.; KUZNIARZ, L. Guidelines for conducting systematic mapping studies in software engineering: An update. **Information and software technology**, Elsevier, v. 64, p. 1–18, 2015.

PLOWMAN, L. Rethinking context: Digital technologies and children's everyday lives. **Children's Geographies**, Taylor & Francis, v. 14, n. 2, p. 190–202, 2016.

PLOWMAN, L.; STEPHEN, C. Children, play, and computers in pre-school education. **Br. J. Educ. Technol.**, v. 36, p. 145–157, 2005.

PORCINO, T. et al. A participatory approach for game design to support the learning and communication of autistic children. In: CHORIANOPOULOS, K. et al. (Ed.). **Entertainment Computing - ICEC 2015**. Cham: Springer International Publishing, 2015. p. 17–31. ISBN 978-3-319-24589-8.

PROCTOR, C.; BIGMAN, M.; BLIKSTEIN, P. Defining and designing computer science education in a k12 public school district. In: **Proceedings of the 50th ACM Technical Symposium on Computer Science Education**. New York, NY, USA: Association for Computing Machinery, 2019. (SIGCSE '19), p. 314–320. ISBN 9781450358903. Disponível em: <<https://doi.org/10.1145/3287324.3287440>>.

RAMÍREZ-BENAVIDES, K.; LÓPEZ, G.; GUERRERO, L. A. Designing tools that allows children in the early childhood to program robots. In: ZAPHIRIS, P.; IOANNOU, A. (Ed.). **Learning and Collaboration Technologies. Technology in Education**. Cham: Springer International Publishing, 2017. p. 71–89. ISBN 978-3-319-58515-4.

READ, J. C.; BEKKER, M. M. The nature of child computer interaction. In: BCS LEARNING & DEVELOPMENT. **Proceedings of HCI 2011 the 25th BCS conference on human computer interaction**. [S.l.], 2011.

RESNICK, M. et al. Scratch: programming for all. **Communications of the ACM**, ACM New York, NY, USA, v. 52, n. 11, p. 60–67, 2009.

RESNICK, M.; ROBINSON, K. **Lifelong Kindergarten: Cultivating Creativity Through Projects, Passion, Peers, and Play**. MIT Press, 2017. (Naître & grandir). ISBN 9780262037297. Disponível em: <<https://books.google.com.br/books?id=nGYyDwAAQBAJ>>.

ROCHE, M. **Developing children's critical thinking through picturebooks: A guide for primary and early years students and teachers**. [S.l.]: Routledge, 2014.

RODRIGUES, S.; NERIS, V. Design principles for computing education in early childhood. In: **Anais do XXXVI Simpósio Brasileiro de Informática na Educação**. Porto Alegre, RS, Brasil: SBC, 2025. p. 564–577. ISSN 0000-0000. Disponível em: <<https://sol.sbc.org.br/index.php/sbie/article/view/38451>>.

ROGOFF, B. **Apprenticeship in Thinking: Cognitive Development in Social Context**. [S.l.]: Oxford University Press, 1990.

_____. **The cultural nature of human development**. [S.l.]: Oxford university press, 2003.

ROSE, S.; HABGOOD, M. J.; JAY, T. An exploration of the role of visual programming tools in the development of young children's computational thinking. **Electronic journal of e-learning**, v. 15, n. 4, p. pp297–309, 2017.

RUNESON, P.; HÖST, M. Guidelines for conducting and reporting case study research in software engineering. **Empirical software engineering**, Springer, v. 14, n. 2, p. 131–164, 2009.

SAIGER, M. J.; DETERDING, S.; GEGA, L. Children and young people's involvement in designing applied games: Scoping review. **JMIR Serious Games**, JMIR Publications Toronto, Canada, v. 11, p. e42680, 2023.

SANDERS, E. B.-N.; STAPPERS, P. J. Co-creation and the new landscapes of design. **Co-design**, Taylor & Francis, v. 4, n. 1, p. 5–18, 2008.

SANDOVAL, W. A. Conjecture mapping: An approach to systematic educational design research. **Journal of the Learning Sciences**, v. 23, n. 1, p. 18–36, 2014.

SCOTT, L. A. 21st century learning for early childhood: Framework. **Battelle for Kids**, v. 20, 2017.

_____. 21st century learning for early childhood: Guide. **Battelle for Kids**, 2017.

SENTANCE, S.; CSIZMADIA, A. Computing in the curriculum: Challenges and strategies from a teacher's perspective. **Education and Information Technologies**, v. 22, p. 469–495, 2017.

SHIVELY, K.; STITH, K. M.; RUBENSTEIN, L. D. Measuring what matters: Assessing creativity, critical thinking, and the design process. **Gifted Child Today**, SAGE Publications Sage CA: Los Angeles, CA, v. 41, n. 3, p. 149–158, 2018.

SMITH, L. M. 8: An evolving logic of participant observation, educational ethnography, and other case studies. **Review of research in education**, Sage Publications Sage CA: Thousand Oaks, CA, v. 6, n. 1, p. 316–377, 1978.

SÖDERGREN, A. C.; MECHELEN, M. van. Towards a child-led design process a pilot study: When pre-schoolers' play becomes designing. In: **Proceedings of the 18th ACM International Conference on Interaction Design and Children**. New York, NY, USA: Association for Computing Machinery, 2019. (IDC '19), p. 629–634. ISBN 9781450366908. Disponível em: <<https://doi.org/10.1145/3311927.3325330>>.

SOSA-ALONSO, J. J. et al. Adoption of digital educational resources by early childhood education teachers: A fad or a conviction? **Computers & Education**, Elsevier, v. 238, p. 105396, 2025.

STANGL, A. et al. The sel transition wheel: Designing for early childhood social emotional learning. In: **Proceedings of the 2017 Conference on Interaction Design and Children**. New York, NY, USA: Association for Computing Machinery, 2017. (IDC '17), p. 334–339. ISBN 9781450349215. Disponível em: <<https://doi.org/10.1145/3078072.3079746>>.

STERNBERG, R. J. Critical thinking: Its nature, measurement, and improvement. ERIC, 1986.

STIGBERG, H.; STIGBERG, S.; MAUGESTEN, M. Introducing teacher students to digital fabrication to support children's mathematical learning. **International Journal of Child-Computer Interaction**, Elsevier, v. 40, p. 100643, 2024.

- STRAWHACKER, A.; BERS, M. Assessment of computational thinking in early childhood. **Journal of Educational Computing Research**, v. 57, n. 2, p. 337–360, 2019.
- STÅLBERG, A. et al. The child's perspective as a guiding principle: Young children as co-designers in the design of an interactive application meant to facilitate participation in healthcare situations. **Journal of Biomedical Informatics**, Academic Press Inc., v. 61, p. 149–158, 2016. ISSN 15320464. Cited By 24.
- SU, J.; YANG, W. A systematic review of integrating computational thinking in early childhood education. **Computers and Education Open**, Elsevier, v. 4, p. 100122, 2023.
- SU, J.; YANG, Y. A systematic review of computational thinking in early childhood education. **Educational Technology Research and Development**, v. 71, p. 1123–1147, 2023.
- SWANSON, H. et al. How co-designing computational modeling activities helped teachers implement responsive teaching strategies. In: **Proceedings of the 2023 Symposium on Learning, Design and Technology**. [S.l.: s.n.], 2023. p. 79–86.
- THELEN, E. Grounded in the world: Developmental origins of the embodied mind. **Infancy**, Wiley Online Library, v. 1, n. 1, p. 3–28, 2000.
- THIOLLENT, M. Metodologia da pesquisa-ação. In: **Metodologia da pesquisa-ação**. [S.l.: s.n.], 1988. p. 108–108.
- _____. **Metodologia da pesquisa-ação**. Cortez Editora, 2025. ISBN 9786555555790. Disponível em: <<https://books.google.com.br/books?id=BW14EQAAQBAJ>>.
- TOIKKANEN, T.; KEUNE, A.; LEINONEN, T. Designing edukata, a participatory design model for creating learning activities. In: **Re-engineering the Uptake of ICT in Schools**. [S.l.]: Springer International Publishing Cham, 2015. p. 41–58.
- TORRANCE, E. P. Torrance tests of creative thinking. **Educational and Psychological Measurement**, 1966.
- TRAD, L. A. B. Grupos focais: conceitos, procedimentos e reflexões baseadas em experiências com o uso da técnica em pesquisas de saúde. **Physis: revista de saúde coletiva**, SciELO Public Health, v. 19, p. 777–796, 2009.
- TRIPP, D. Pesquisa-ação: uma introdução metodológica. **Educação e pesquisa**, SciELO Brasil, v. 31, p. 443–466, 2005.
- TSORTANIDOU, X.; DARADOUMIS, T.; BARBERÁ, E. Connecting moments of creativity, computational thinking, collaboration and new media literacy skills. **Information and Learning Sciences**, Emerald Publishing Limited, v. 120, n. 11/12, p. 704–722, 2019.
- UNESCO. **Guidance for Generative AI in Education and Research**. Paris, France, 2023.

VALENTE, J. A. Informática na educação no brasil: análise e contextualização histórica. **O computador na sociedade do conhecimento**. Campinas: UNICAMP/NIED, p. 1–13, 1999.

_____. O computador na sociedade do conhecimento. **Campinas: Unicamp/NIED**, p. 75, 1999.

_____. Pesquisa, comunicação e aprendizagem com o computador. **O papel do computador no processo ensino-aprendizagem**. In: ALMEIDA, MEB, p. 22–31, 2005.

VANNER, C.; KIMANI, M. The role of triangulation in sensitive art-based research with children. **Qualitative research journal**, Emerald Publishing Limited, v. 17, n. 2, p. 77–88, 2017.

VINCENT-LANCRIN, S. et al. Fostering students' creativity and critical thinking: What it means in school. **Educational research and innovation**, OECD publishing, 2019.

VYGOTSKY, L. S. **Mind in society: The development of higher psychological processes**. [S.l.]: Harvard university press, 1978. v. 86.

WILSON, M. Six views of embodied cognition. **Psychonomic bulletin & review**, Springer, v. 9, n. 4, p. 625–636, 2002.

WING, J. M. Computational thinking. **Communications of the ACM**, ACM New York, NY, USA, v. 49, n. 3, p. 33–35, 2006.

WOHL, B.; PORTER, B.; CLINCH, S. Teaching computer science to 5-7 year-olds: An initial study with scratch, cubelets and unplugged computing. In: **Proceedings of the Workshop in Primary and Secondary Computing Education**. New York, NY, USA: Association for Computing Machinery, 2015. (WiPSCE '15), p. 55–60. ISBN 9781450337533. Disponível em: <<https://doi.org/10.1145/2818314.2818340>>.

WOHLWEND, K. **Playing Their Way into Literacies: Reading, Writing, and Belonging in the Early Childhood Classroom**. Teachers College Press, 2015. (Language & Literacy). ISBN 9780807771853. Disponível em: <<https://books.google.com.br/books?id=-Rp7DvdUZu8C>>.

WOOD, D.; BRUNER, J. S.; ROSS, G. The role of tutoring in problem solving. **Journal of child psychology and psychiatry**, Blackwell Publishing Ltd Oxford, UK, v. 17, n. 2, p. 89–100, 1976.

XING, G. Y.; CADY, A. G.; WANG, X. C. Playful computational thinking learning in and beyond early childhood classrooms: Insights from collaborative action research of two teacher-researchers. **Education Sciences**, MDPI, v. 15, n. 7, p. 840, 2025.

YU, J. **A Design Exploration of Leveraging Physical Play to Support Computational Learning for Young People**. Tese (Doutorado) — University of Colorado at Boulder, 2022.

YU, J.; HAYDEN, R.; ROQUE, R. Exploring computational thinking with physical play through design. In: **Proceedings of the 22nd Annual ACM Interaction Design and Children Conference**. [S.l.: s.n.], 2023. p. 124–136.

ZENG, Y.; YANG, W.; BAUTISTA, A. Teaching programming and computational thinking in early childhood education: a case study of content knowledge and pedagogical knowledge. **Frontiers in Psychology**, Frontiers Media SA, v. 14, p. 1252718, 2023.

Appendix

APPENDIX A

Adaptation process of creativity and critical thinking assessment rubrics for early childhood education

This appendix describes the process used to translate, adapt, and evaluate the creativity and critical thinking rubrics used in this thesis. The original instruments were proposed by Shively, Stith, and Rubenstein in their work "Measuring What Matters: Assessing Creativity, Critical Thinking, and the Design Process" (SHIVELY; STITH; RUBENSTEIN, 2018) and were adapted to the context of early childhood education, considering children aged 4 and 5 and pedagogical activities based on design processes.

A.1 Instruments of origin

The original rubrics were extracted from the study Measuring What Matters, which presents instruments for evaluating creativity, critical thinking, and the design process in educational contexts based on the Design Thinking Model. These instruments were originally designed for older students, with descriptors that presuppose levels of abstraction, language, and metacognition that are not compatible with early childhood education.

In this thesis, the rubrics of creativity and critical thinking were specifically considered, as these skills constitute the main constructs investigated in the proposed framework.

A.2 Translation process

The initial translation of the instruments was carried out by the author of this thesis in conjunction with her advisor, who is fluent in English and has international academic experience. The translation process sought to maintain semantic and conceptual fidelity in relation to the original instrument.

In cases where terminological doubts or ambiguities arose, the Cambridge Dictionary was used as a guide, ensuring greater linguistic precision. This step resulted in a literal translation, used as the basis for the subsequent adaptation process.

A.3 Adaptation process for early childhood children

Following the literal translation, the instruments underwent adaptation to align with the cognitive, linguistic, and expressive characteristics of children in early childhood education.

This process involved:

- ❑ The removal of criteria that required abstract, metalinguistic, or formal argumentation skills incompatible with the age range of the participants;
- ❑ Simplifying the language, prioritizing observable descriptors in children's behavior during activities;
- ❑ The reorganization of the way rubrics are presented, to facilitate their application by teachers and researchers in real classroom contexts;
- ❑ The suitability of the descriptors to emphasize qualitative evidence of the process, and not just of the final product.

The adaptation focused on ensuring that the rubrics would allow for the identification of signs of creativity and critical thinking demonstrated by the children throughout the activities proposed in the framework, while respecting their own forms of expression and interaction.

A.4 Assessment of adaptation by experts

The adapted rubrics were submitted for evaluation by a group of five experts in Computing and Education. The evaluation was conducted through a focus group, held in two online meetings, each lasting approximately 1 hour and 30 minutes. The profile of the experts participating in the focus group is presented in Table 32.

Table 32 – Details about participants.

ID	Gender	Level of education	Field of Study	Experience Time	
				Computer Science	Education
P1	F	Master degree	Education	Between 1 year and 5 years	Between 6 and 10 years
P2	F	Postdoc	Education	Less than 1 year	More than 10 years
P3	F	Postdoc	Education	Between 1 year and 5 years	More than 10 years
P4	F	Postdoc	Computer Science	More than 10 years	Between 1 year and 5 years
P5	M	Master degree	Computer Science	More than 10 years	Less than 1 year

Before the meetings, the adapted rubrics were sent to the specialists for individual analysis. During the synchronous meetings, participants collectively discussed the instruments, debating possible adjustments, improvements, and adaptations to improve clarity of the descriptors, relevance of the criteria, and feasibility of application in the context of early childhood education.

The experts' contributions led to final adjustments to the instruments, refining the wording of the descriptors and enhancing alignment among the assessment criteria, the pedagogical objectives of the framework, and the characteristics of the child audience.

A.5 Final Consideration

The translation, adaptation, and expert evaluation process aimed to ensure that the rubrics used in this thesis were methodologically consistent and suitable for the context of early childhood education. It is important to note that the instruments are not diagnostic or psychometric in nature, but rather used as qualitative tools to support the analysis of the learning processes, creativity, and critical thinking of the participating children.

APPENDIX B

All articles analyzed in the thematic analysis

Title	Authors
Discovering Computing	
Descobrendo o Computar: tecnologia, ciências, design e computação para crianças de 4 e 5 anos	(HAI et al., 2023)
Buttons, devices, and adults: how preschool children designed an IoT programming tool	(NETO; RODRIGUEZ; NERIS, 2023)
Tecnologia e Educação: ciências, computação (des)plugada e pensamento computacional na educação de crianças de 4 a 10 anos	(NERIS; HAI, 2023)
Systematic mapping of computational thinking in preschool children	(MARTINS; SILVA; NERIS, 2023)
Um arcabouço teórico para o ensino de computação para crianças de 4 e 5 anos pautado no codesign	(MENEZES et al., 2023)
Building an IOT programming environment with and for preschool children	(NETO; NERIS; RODRIGUEZ, 2021)
Aprendendo e experimentando tecnologia e ciências na educação de crianças de 4 a 5 anos	(HAI et al., 2020)
Towards an Interaction Model for the Programming of Devices by Children in the Age of Internet of Things	(NETO; NERIS, 2018)
Manual Search	
Exploring Computational Thinking with Physical Play through Design	(YU; HAYDEN; ROQUE, 2023)
Embodied responsive teaching for supporting computational thinking in early childhood	(FLOOD; WANG; SHERIDAN, 2022)
Children as players, modders, and creators of simulation games: A design for making sense of complex real-world problems	(GRIZIOTI; KYNIGOS, 2021)
Teaching Computer Science to 5-7 year-olds: An initial study with Scratch, Cubelets and unplugged computing	(WOHL; PORTER; CLINCH, 2015)
Teaching children digital literacy through design-based learning with digital toolkits in schools	(BEKKER et al., 2015)

APPENDIX C

Results of thematic analysis

Table 33 – Details of the themes, their codes, and occurrences

Theme	Codes	Occurrence
Consider the child's daily life	Exploration of materials from children's everyday lives	24
	Use of technology in everyday life	10
	Need for prior knowledge	6
	Exploration of everyday situations	4
	Encouraging exploration of everyday life	4
	Encouraging the use of materials from children's everyday lives	1
The child must be the protagonist	Encouraging children's active involvement	19
	Adults as support	16
	Encouraging autonomy	6
	Children as decision makers	5
Adopt collaborative processes	Collaborative processes with children	21
	Benefits of participating in design processes	7
	Encouraging collaboration with children	2
	Integration of multidisciplinary knowledge and computing	22
	Introduction to logic concepts	16
	Introduction to data processing concepts	10

	Introduction to prototyping concepts	10
	Encouraging the teaching of digital literacy	9
	Introduction to computational thinking concepts	8
	Introduction to electronics concepts	8
	Introduction to abstraction concepts	7
	Encouraging computer teaching	6
	Introduction to debugging concepts	6
	Encouragement of multidisciplinary teaching	5
	Introduction to data transmission concepts	5
	Benefits of teaching computing	4
	Encouraging IoT teaching	4
	Encouraging programming teaching	3
	Introduction to the concept of pattern recognition	3
	Introduction to boolean logic concepts	3
	Introduction to parallelism concepts	1
	Introduction to robotics concepts	1
Include playfulness	Encouraging play and entertainment	9
	Need to adapt the design process	3
	Integration of fun and game elements	1

APPENDIX D

Reviewed Co-design papers and
identification numbers.

Table 34 – Reviewed Co-design papers and identification numbers.

ID	Title	Authors
CO-DESIGN		
ID-1	Child-centered design developing an inclusive letter writing app	(MARTENS; RINNERT; ANDERSEN, 2018)
ID-2	Coco’s video: An empirical investigation of video-player design features and children’s media use	(HINIKER et al., 2018)
ID-3	Co-design with preschoolers using fictional inquiry and comicboarding	(HINIKER; SOBEL; LEE, 2017)
ID-4	Creating digital music instruments with and for children: Including vocal sketching as a method for engaging in codesign	(FALKENBERG et al., 2020)
ID-5	Designing a music playground in the kindergarten	(CORE et al., 2017)
ID-6	Designing Collaborative ScratchJr for Multi-touch Tabletops	(BARRAGÁN et al., 2024)
ID-7	Enabling participation in community-dwelling children and young people with acquired brain injuries and their families: a theory-based, evidence-based and person-based approach to intervention development	(KEETLEY et al., 2024)
ID-8	Integrating Fundamental Movement Skills and Mathematics in Early Childhood: A Pilot Study	(CAPIO et al., 2024)
ID-9	Junkbox: A waste management educational game for preschool kids	(GIZZI; DIO; SCHILLACI, 2019)
ID-10	Play to learn! Nurturing fundamental digital skills of Romanian preschoolers by developing edutainment applications	(GURAN; COJOCAR; MOLDOVAN, 2020)
ID-11	Play-Based Design: Giving 3- to 4-Year-Old Children a Voice in the Design Process	(PANTOJA et al., 2020)
ID-12	Service design of artificial intelligence voice agents as a guideline for assisting independent toilet training of preschool children	(HUH et al., 2022)
ID-13	The dimensions of reflection coding scheme: A new tool for measuring the impact of designing for reflection in early childhood	(HUBBARD et al., 2023)
ID-14	The SEL transition wheel: Designing for early childhood social-emotional learning	(STANGL et al., 2017)
ID-15	Towards a child-led design process A pilot study: when preschoolers play becomes designing	(SÖDERGREN; MECHELEN, 2019)

APPENDIX E

Reviewed PD papers and
identification numbers.

Table 35 – Reviewed PD papers and identification numbers.

ID	Title	Authors
PARTICIPATORY DESIGN		
ID-16	A Participatory Approach for Game Design to Support the Learning and Communication of Autistic Children	(PORCINO et al., 2015)
ID-17	A Universe Inside the MRI Scanner: An In-Bore Virtual Reality Game for Children to Reduce Anxiety and Stress	(LISZIO; BASU; MASUCH, 2020)
ID-18	Applying UCD for Designing Learning Experiences for Romanian Preschoolers. A Case Study	(ADRIANA-MIHAELA; GRIGORETA-SOFIA; ANA-MARIA, 2019)
ID-19	ArticuMotion: Towards Assessing Motor Speech Disorders via Gamification	(ALSEBAYEL et al., 2024)
ID-20	Chinese Preschoolers as Design Partners – Lessons Learned	(LIU; ROTO, 2017)
ID-21	Designing a Virtual Reality Empathy Game Framework to Create Empathic Experiences for Children	(MURAVEVSKAIA; GARDNER-MCCUNE, 2023)
ID-22	Designing Tools that Allows Children in the Early Childhood to Program Robots	(RAMÍREZ-BENAVIDES; LÓPEZ; GUERRERO, 2017)
ID-23	Developing kindergarten students’ game design skills by teaching game design through organized game design interventions	(KALMPOURTZIS, 2019)
ID-24	Digital Natives and Cardboard Cubes: Co-Creating a Physical Play(ful) Ideation Tool with Preschool Children	(HELJAKKA; IHAMÄKI, 2017)
ID-25	Educational Game for Laterality Development in Early Childhood and the Importance of Participatory Design	(CAVEDINI et al., 2020)
ID-26	GIS-based intelligent planning approach of child-friendly pedestrian pathway to promote a child-friendly city	(FANG; AZIZAN; HUANG, 2024)
ID-27	Images of Play Experiences Through a Child’s Lens: An Exploration of Play and Digital Media with Young Children	(ECKHOFF, 2017)
ID-28	MyCalendar: Fostering Communication for Children with Autism Spectrum Disorder Through Photos and Videos	(ABDULLAH; BRERETON, 2015)
ID-29	Rationale, Design and Methods Protocol for Participatory Design of an Online Tool to Support Industry Service Provision Regarding Digital Technology Use ‘with, by and for’ Young Children	(EDWARDS et al., 2020)
ID-30	Teaching game design to students of the early childhood through Forest Maths	(KALMPOURTZIS; VRYSIS; VEGLIS, 2016)
ID-31	The child’s perspective as a guiding principle: Young children as co-designers in the design of an interactive application meant to facilitate participation in healthcare	(STÅLBERG et al., 2016)
ID-32	The role of early childhood students in the design of digital and physical games	(KALMPOURTZIS et al., 2018)
ID-33	YoungDeafDesign: A Method for Designing with Young Deaf Children	(KORTE; POTTER; NIELSEN, 2017)
ID-34	Zones of participation – a framework to analyze design roles in early childhood education and care (ECEC)	(BRINCK et al., 2022)

APPENDIX F

The framework - portuguese version

Princípios para o codesign de sistemas computacionais

Este conjunto de princípios é direcionado ao professor responsável por planejar o processo de design e tem como objetivo garantir que serão oferecidas condições para que essas crianças possam colaborar ativamente no desenvolvimento de novas ferramentas e produtos em computação, de forma que o processo seja significativo para a criança.

Os princípios foram amadurecidos e formalizados a partir de experiências conduzidas pelos participantes do projeto Descobrimos o Computar, como a execução do projeto “Aprendendo e Experimentando tecnologia e ciências na educação de crianças de 4 a 5 anos” realizada em uma creche da USP, no campus de São Carlos, e na realização da ACIEPE intitulada “Educação em Computação para crianças de 4 e 5 anos: preparando professores para a formação de usuários ativos de tecnologia”.

1. **Considere o cotidiano da criança:** Acredita-se que partindo de vivências e artefatos do cotidiano da criança, como instalar um jogo em um smartphone ou usar o controle remoto da televisão, é possível trabalhar conhecimentos de diferentes áreas básicas, como física e matemática, até áreas tecnológicas como computação e engenharia.

De acordo com Ausubel (2003), quando atribuímos significados a um conhecimento a partir da interação com os conhecimentos prévios, se estabelece a aprendizagem significativa. MOREIRA (2016) afirma que:

“É importante reiterar que a aprendizagem significativa se caracteriza pela interação entre conhecimentos prévios e conhecimentos novos, e que essa interação é não literal e não arbitrária. Nesse processo, os novos conhecimentos adquirem significado para o sujeito e os conhecimentos prévios adquirem novos significados ou maior estabilidade cognitiva” (MOREIRA, 2016, p.2).

As crianças são inspiradas a aprender devido ao desejo de saber como fazer algo ou interagir com outras pessoas (SCOTT, 2017). Dessa forma, a criança será capaz de construir significados sobre si, os outros e o mundo social e natural (MEC, 2021).

Neste estudo, defende-se que essas práticas devem estar refletidas em processos de design para favorecer o processo de construção de conhecimentos.

2. **As partes interessadas (stakeholders) devem construir o protagonismo da criança:** quando falamos de crianças e sua relação com processos de design, percebe-se que há um crescimento relacionado à inserção de crianças em processos de design. Porém, quando se fala de crianças em idade pré-escolar, ainda há um grande número de estudos em que as crianças são apenas observadas utilizando uma tecnologia pronta ou servem como informantes para aqueles que querem desenvolver ou melhorar uma solução de tecnologia.

Para que o processo de ensino e aprendizagem aconteça, e seja significativo para a criança, é necessário envolvê-la em processos de design como protagonista do processo, visando melhorar a relação dela com a tecnologia e com o mundo onde vivem. Nesse contexto, o **ensino por argumentação e experimentação** é um fator essencial para fomentar a participação ativa das crianças, permitindo que construam conhecimento a partir da interação com o meio e da troca de ideias. A argumentação no contexto educacional possibilita que as crianças desenvolvam habilidades de raciocínio lógico, justifiquem escolhas e reflitam criticamente sobre suas ações (JIMÉNEZ-ALEIXANDRE; PEREIRO-MUÑOZ, 2002). Além disso, o ensino baseado na experimentação oportuniza um aprendizado ativo, em que as crianças testam hipóteses, exploram diferentes possibilidades e refinam suas ideias por meio da prática (CHIN; OSBORNE, 2010).

O objetivo é que as crianças possam atuar como protagonistas durante os processos de design, sendo o adulto aquele que prepara as situações de aprendizagem, fornecendo os meios, intermediando e estimulando adequadamente o desenvolvimento da criança, oportunizando o pensamento compartilhado sustentado (*sustained shared thinking*) (SIRAJ-BLATCHFORD; SYLVA, 2004). Dessa forma, o envolvimento da criança em processos de design não apenas aprimora sua relação com a tecnologia, mas também fortalece sua capacidade de argumentação, tomada de decisão e experimentação, tornando seu aprendizado mais dinâmico e significativo.

3. **Realize atividades colaborativas:** A aprendizagem pelo design aborda a atividade de design como um processo de projetar, fazer e avaliar, no qual são inseridas condições motivadoras que apoiam o pensamento projetista como um processo (FLEER, 2021). Embora existam estudos com o foco no “pensamento-designer”, poucos deles exploram o desenvolvimento inicial desse pensamento na infância. De acordo com Fleer (2021), ainda é necessário pesquisar como crianças muito pequenas iniciam esse desenvolvimento e como ele pode ser estimulado desde cedo.

Nesse sentido, é fundamental transformar culturas e oferecer condições para que essas crianças possam colaborar ativamente no desenvolvimento de novas ferramentas e produtos em computação, bem como se tornarem contribuintes ativos em atividades pessoalmente significativas (FISCHER; SCHARFF, 2000; FISCHER; FOGLI; PICCINNO, 2017; FISCHER et al., 2004), deixando de ser meros usuários passivos. Para que isso aconteça, é necessário oferecer condições para que os usuários finais possam colaborar no desenvolvimento de novas ferramentas e produtos em computação (FISCHER; FOGLI; PICCINNO, 2017; FISCHER et al., 2004; FISCHER; SCHARFF, 2000). Uma das pré-condições críticas para isso é uma mentalidade cultural em que a participação desempenha o papel principal. Para isso, é preciso fornecer a oportunidade e recursos para o debate social, discussão e conhecimento colaborativo (FISCHER; SCHARFF, 2000).

As interações entre pares são importantes para a aprendizagem. Quando envolvidas em brincadeiras colaborativas, as crianças observam os outros, imitam ou

desenvolvem o que observam. Elas adquirem habilidades sociais e emocionais ao se esforçarem para criar jogos e coordenar atividades entre si (SCOTT, 2017). Nesse processo, o professor desempenha um papel fundamental como mediador e guia do trabalho de codesign, estruturando oportunidades para o pensamento compartilhado sustentado (*sustained shared thinking*) (SIRAJ-BLATCHFORD; SYLVA, 2004). Esse tipo de interação permite que as crianças façam conexões significativas, reflitam sobre suas ações e avancem no desenvolvimento de novas ideias por meio do diálogo e da troca com colegas e adultos.

Além disso, crianças da faixa etária de 4 a 5 anos são plenamente capazes de participar de atividades de criação conjunta, explorando diferentes materiais e técnicas para expressar suas ideias e colaborar em processos de design. Seja manipulando blocos de construção, desenhando protótipos em papel ou experimentando materiais digitais, elas contribuem ativamente para a concepção e aprimoramento de novas soluções, reforçando a ideia de que podem ser cocriadoras em experiências de aprendizado autênticas. A mediação do professor nesse processo é essencial para orientar a exploração, incentivar a experimentação e garantir que todas as crianças tenham oportunidades de participação ativa e significativa.

4. **Envolva conceitos em computação:** Os conceitos em computação incluem as habilidades do pensamento computacional, que englobam aspectos como decomposição, reconhecimento de padrões, abstração e algoritmos para a resolução de problemas no ambiente computacional e também na vida real (MARTINS, 2021). Outras áreas igualmente abarcadas pela computação são a inteligência artificial associada aos computadores, a computação gráfica e de redes, os sistemas de bases de dados, a matemática dos computadores e diferentes tipos de engenharias relacionadas com a máquina (CC2020, 2020). A Base Nacional Comum Curricular Complementar para Computação (BRASIL, 2022) reconhece a importância desses conceitos desde a educação infantil, articulando-os aos campos de experiência, eixos e objetivos de aprendizagem para que sejam abordados de maneira lúdica e significativa.

A partir do ensino de computação para crianças de 4 a 5 anos, espera-se produzir a alfabetização digital, habilidades envolvendo o uso da tecnologia de forma segura, fundamentos da computação e a aplicação dos conceitos computacionais para apoiar atividades em diversas áreas. Aqui, reconhecemos que alguns desses conceitos já fazem parte do cotidiano da criança, em uma menor escala ou proporção quando comparados a um adulto, e contribuem para o processo de design. Em contraponto, também acreditamos que durante a prática de design esses conceitos e habilidades prévias serão evoluídos e melhorados, pois serão retroalimentados pela prática (FLEER, 2021).

Para que essa aprendizagem ocorra de maneira efetiva, é essencial que professores e crianças se apropriem dos conceitos computacionais, compreendendo sua importância para a relação cotidiana com as tecnologias digitais. Esse processo exige estudo prévio pelos professores, que devem estar preparados para mediar e

contextualizar as atividades computacionais dentro do universo infantil. Assim, a formação docente e o desenvolvimento contínuo de estratégias pedagógicas tornam-se elementos centrais para garantir uma abordagem significativa e alinhada às necessidades das crianças na sociedade digital.

5. **Inclua atividades divertidas:** Bannon (2011) argumenta que o design centrado no humano é mais do que considerar o usuário durante o desenvolvimento de um produto, e sim considerar seus valores, preocupações, atividades e compreensão de mundo durante o desenvolvimento. No ensino de computação por meio de design para crianças pequenas, é essencial proporcionar atividades instigantes e provocantes que promovam a exploração de conceitos de computação de maneira divertida.

É necessário um direcionamento intencional que oportunize o pensamento compartilhado sustentado, em que a criança, guiada pelo professor, possa explorar, refletir e aprender de maneira colaborativa (Siraj-Blatchford; Sylva, 2004). Scott (2017) destaca que a aprendizagem ocorre quando as crianças têm a oportunidade de expressar suas ideias e interagir com os conceitos apresentados.

Assim, ao ensinar computação, é importante criar um ambiente que propicie essa interação, com atividades cuidadosamente planejadas, que desafiem as crianças a pensar criticamente e a resolver problemas. As atividades devem ser provocantes, incentivando as crianças a formular hipóteses, testar suas ideias e refletir sobre os resultados. Nesse contexto, o papel do professor é fundamental, pois ele deve conduzir as interações e proporcionar momentos significativos de aprendizado que estejam alinhados aos objetivos educacionais (Hai et. al., 2020).

É importante estruturar atividades que incentivem a experimentação e o questionamento, promovendo uma abordagem que vá além da simples execução de tarefas (Hai et. al., 2020). No ensino de computação, isso significa criar atividades que sejam desafiadoras e que façam as crianças questionarem e pensarem de maneira crítica sobre os problemas apresentados. Ao mesmo tempo, as atividades devem ser divertidas e proporcionar um sentimento de conquista, tornando o aprendizado significativo e motivador para as crianças.

Referências:

AUSUBEL, D. P. Aquisição e retenção de conhecimentos: uma perspectiva cognitiva. [S.l.]: Lisboa, 2003. v. 1.

BANNON, L. Reimagining hci: toward a more human-centered perspective. *interactions*, ACM New York, NY, USA, v. 18, n. 4, p. 50–57, 2011.

FISCHER, G.; FOGLI, D.; PICCINNO, A. Revisiting and broadening the meta-design framework for end-user development. In: *New perspectives in end-user development*. [S.l.]: Springer, 2017. p. 61–97.

FISCHER, G. et al. Meta-design: a manifesto for end-user development. *Communications of the ACM*, ACM New York, NY, USA, v. 47, n. 9, p. 33–37, 2004.

FISCHER, G.; SCHARFF, E. Meta-design: design for designers. In: *Proceedings of the 3rd conference on Designing interactive systems: processes, practices, methods, and techniques*. [S.l.: s.n.], 2000. p. 396–405.

FLEER, M. The genesis of design: learning about design, learning through design to learning design in play. *International Journal of Technology and Design Education*, Springer, p. 1–28, 2021.

MARTINS, E. C. Atividades didáticas para o ensino de computação na pré- escola. Universidade Federal de São Carlos, 2021. Disponível em: <<https://repositorio.ufscar.br/bitstream/handle/ufscar/13823/Dissertac%cc%a7a%cc%83o%20final.pdf?sequence=1&isAllowed=y>>.

MEC. Base nacional comum curricular. 2021. Disponível em: <<http://basenacionalcomum.mec.gov.br/>>. Acesso em: 20/nov/2023.

MOREIRA, M. A. O que é afinal aprendizagem significativa? 2010. Instituto de Física–UFRGS. Porto Alegre, 2016.

SCOTT, L. A. 21st century learning for early childhood: Guide. Battelle for Kids, 2017.

SIRAJ-BLATCHFORD*, I.; SYLVA, K. Researching pedagogy in English pre-schools. [S.l.]: Taylor & Francis, 2004. 713–730 p.

Plano de Atividade

Tema	Processamento de dados
Título	Rotina topológica
Conhecimento	Estratégias de organização
Faixa Etária	4 e 5 anos
Duração	3 horas ¹

Conhecimento em Computação:

Grafos são ferramentas matemáticas usadas para organizar informações e mostrar como diferentes elementos se conectam entre si. Na computação, eles são amplamente utilizados para resolver problemas que envolvem sequências, relacionamentos e dependências, como planejamento de rotas, organização de tarefas e até mesmo o funcionamento de redes sociais (Cormen et al., 2009). Um grafo é composto por pontos, chamados de "vértices", e linhas que os conectam, chamadas de "arestas". Esses elementos ajudam a representar visualmente a relação entre ações ou itens.

Para facilitar o entendimento, podemos imaginar um grafo como um "mapa da rotina" de uma criança. Cada vértice representa uma atividade, como acordar, escovar os dentes, tomar café da manhã ou brincar. As arestas mostram a ordem em que essas atividades acontecem, indicando, por exemplo, que primeiro acordamos, depois escovamos os dentes, e só então tomamos o café da manhã. Essa organização ajuda a entender como algumas ações dependem de outras para serem realizadas. Por exemplo, não é possível colocar a mochila antes de terminar de guardar os materiais escolares.

Em um outro exemplo, podemos imaginar um grafo que representa as etapas para vestir-se. Cada vértice corresponde a uma peça de roupa, e as arestas mostram a sequência lógica em que essas peças devem ser colocadas. Na figura abaixo, retirada do livro *Introduction to Algorithms* (Cormen et al., 2009, p. 467), podemos ver um grafo onde a camisa deve ser vestida antes do paletó e da gravata. Este exemplo ajuda a ilustrar como grafos podem ser usados para organizar tarefas que dependem de uma sequência específica.

¹ Esta duração é uma estimativa de tempo e pode ser flexibilizada de acordo com a demanda da turma.

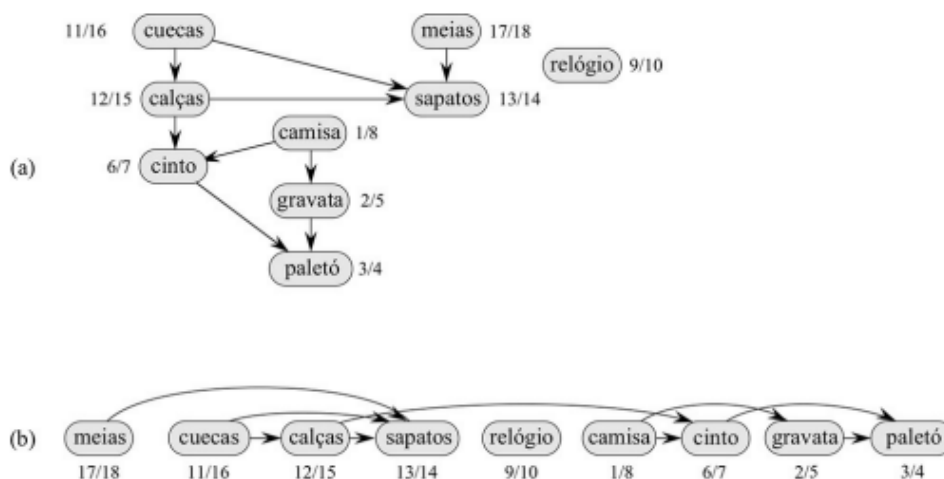


Figura 1: Grafo retirado do livro “*Introduction to Algorithms*”, versão inglesa, pág. 467.

Na computação, um exemplo clássico de aplicação de grafos é o cálculo de dependências em tarefas. Quando um programa precisa executar várias ações em ordem, ele pode usar um grafo para garantir que cada tarefa seja realizada na sequência correta. Um exemplo prático seria a execução de atividades em jogos eletrônicos, onde cada fase só pode ser acessada depois de concluída a anterior.

Além disso, os grafos podem ser usados para planejar rotas. Pense em um aplicativo de mapas: ele utiliza um grafo para representar ruas e conexões entre elas, identificando o caminho mais rápido entre dois pontos. A relação entre grafos e computação é fundamental para muitas áreas, pois eles são usados para modelar problemas e encontrar soluções eficientes. Um exemplo clássico é o uso de grafos na otimização de redes de computadores, onde cada vértice representa um dispositivo e cada aresta, uma conexão. Compreender como essas conexões funcionam ajuda a garantir que dados sejam transmitidos de maneira rápida e segura (Sedgewick e Wayne, 2011).

Esse processo de decisão se baseia nos mesmos conceitos que as crianças podem aprender ao organizar suas próprias rotinas. Por meio dos grafos, podemos ensinar às crianças a importância de seguir uma ordem, compreender conexões e organizar suas atividades de maneira lógica.

Objetivo:

O objetivo desta atividade é desenvolver o pensamento crítico, avaliando quais hábitos são saudáveis em sua rotina diária. Além disso, elas vão representar esses hábitos em um grafo que mostra a ordem em que cada ação deve acontecer, aprendendo sobre organização e sequência de atividades.

Habilidades do Século XXI:

- **Pensamento crítico e resolução de problemas:** nesta atividade a criança deve avaliar aquilo que é ou não viável para uma rotina saudável, desenvolvendo o pensamento

Este plano foi inspirado no plano de atividades criado pelos participantes da Atividade Curricular de Integração Ensino, Pesquisa e Extensão (ACIEPE) “Educação em Computação para crianças de 4 e 5 anos: preparando professores para a formação de usuários ativos de tecnologia”

crítico. Além disso, a criança deve assimilar o conceito do “certo e errado” dentro da sua rotina e distinguir atitudes que seriam viáveis, inviáveis ou absurdas, envolvendo o conceito de resolução de problemas.

Eixos e Habilidades da BNCC:

- **“O EU, O OUTRO E O NÓS” (EI03EO01):** Demonstrar empatia pelos outros, percebendo que as pessoas têm diferentes sentimentos, necessidades e maneiras de pensar e agir.
- **“O EU, O OUTRO E O NÓS” (EI03EO02):** Agir de maneira independente, com confiança em suas capacidades, reconhecendo suas conquistas e limitações.
- **“O EU, O OUTRO E O NÓS” (EI03EO03):** Ampliar as relações interpessoais, desenvolvendo atitudes de participação e cooperação.
- **“O EU, O OUTRO E O NÓS” (EI03EO04):** Comunicar suas ideias e sentimentos a pessoas e grupos diversos.
- **“CORPO, GESTOS E MOVIMENTOS” (EI03CG04):** Adotar hábitos de autocuidado relacionados à higiene, alimentação, conforto e aparência.
- **“CORPO, GESTOS E MOVIMENTOS” (EI03CG05):** Coordenar suas habilidades manuais no atendimento adequado a seus interesses e necessidades em situações diversas.
- **“TRAÇOS, SONS, CORES E FORMAS” (EI03TS02):** Expressar-se livremente por meio de desenho, pintura, colagem, dobradura e escultura, criando produções bidimensionais e tridimensionais.
- **“ESCUTA, FALA, PENSAMENTO E IMAGINAÇÃO” (EI03EF01):** Expressar ideias, desejos e sentimentos sobre suas vivências, por meio da linguagem oral e escrita (escrita espontânea), de fotos, desenhos e outras formas de expressão.
- **“ESPAÇOS, TEMPOS, QUANTIDADES, RELAÇÕES E TRANSFORMAÇÕES” (EI03ET07):** Relacionar números às suas respectivas quantidades e identificar o antes, o depois e o entre em uma sequência.

Eixos e Habilidades da BNCC Computação - Educação Infantil:

- **“PENSAMENTO COMPUTACIONAL” (EI03CO02):** Expressar as etapas para a realização de uma tarefa de forma clara e ordenada.
- **“PENSAMENTO COMPUTACIONAL” (EI03CO05):** Comparar soluções algorítmicas para resolver um mesmo problema.

Material necessário para a atividade:

- Folha sulfite
- Cartões ou blocos feitos de cartolina
- Lápis de cor/giz de cera
- Lápis
- Caneta

Desenvolvimento da atividade:

1. Exploração Inicial: Conversa sobre a Rotina

- Inicie uma roda de conversa com as crianças, perguntando sobre suas rotinas diárias. Pergunte, por exemplo:
 - "O que vocês fazem assim que acordam?"
 - "O que vêm depois de tomar o café da manhã?"
 - "Como vocês se preparam para ir à escola?"
- Explique que algumas ações precisam ser feitas em uma ordem específica. Diga: "Por exemplo, para calçar os sapatos, você precisa colocar as meias primeiro. Já outras ações, como tomar suco antes ou depois de comer, podem variar."
- Relacione a rotina das crianças com o funcionamento dos computadores, dizendo: "Na computação, também precisamos organizar as tarefas em uma sequência para que o sistema funcione corretamente."

2. Ideação: Desenhar a Rotina e Explorar Alternativas

- Peça às crianças que desenhem sua rotina em uma folha de papel, representando cada ação como um desenho ou símbolo simples.
- Sugira que pensem em como as ações se conectam. Pergunte: "O que acontece se mudarmos a ordem? Por exemplo, se vocês escovarem os dentes antes de tomar o café, isso funciona? Como seria diferente?"
- Relacione essas escolhas ao ambiente computacional, dizendo: "Nos computadores, algumas tarefas podem ser feitas fora de ordem sem problemas, mas outras dependem de uma sequência certa. Por exemplo, você não pode imprimir um arquivo antes de criá-lo."

3. Prototipagem: Criando um Protótipo com Materiais Concretos

- Distribua cartões ou blocos para que cada criança represente suas atividades diárias de forma concreta. Cada cartão pode ser uma etapa da rotina.
- Peça que as crianças organizem os cartões no chão ou em uma mesa, conectando as etapas com setas que mostrem a ordem das ações.
- Diga que as conexões entre os cartões são como as conexões em um grafo. Use exemplos como: "Se você troca a ordem dos cartões, o que muda? Isso ainda funciona?"

4. Compartilhamento e Colaboração: Roda de Conversa e Discussão

- Conduza uma discussão coletiva sobre os mapas criados. Pergunte:
 - "Quais ações precisam ser feitas em uma ordem específica?"
 - "Quais ações podem mudar de ordem e ainda funcionar bem?"
- Relacione as dependências encontradas com a lógica dos grafos na computação. Explique: "Em computadores, às vezes uma tarefa depende da outra. Por exemplo, você precisa baixar um jogo para conseguir jogá-lo."

5. Construção Coletiva: Criação do "Mapa da Rotina da Turma"

- Guie a turma na criação de um grande mapa coletivo que represente a rotina de todos. Use o quadro ou uma folha grande, conectando as ações com setas.
- Mostre como algumas ações se conectam diretamente, enquanto outras podem ser feitas de diferentes formas. Diga: "Isso é como no computador, onde algumas tarefas precisam de uma ordem fixa e outras podem ser mais flexíveis."

6. Iteração e Refinamento: Revisitar e Aprimorar

- Conduza uma roda de conversa ao final da atividade, incentivando as crianças a refletirem sobre as sequências e conexões. Pergunte:
 - "Vocês acham que mudar a ordem de algumas ações pode causar problemas? Em quais casos?"
 - "Como isso se parece com o que acontece nos computadores?"
- Conclua relacionando a atividade com os grafos na computação. Diga: "Os mapas que vocês criaram são como grafos, que usamos para organizar tarefas nos computadores. Eles ajudam a garantir que as coisas sejam feitas da forma certa."

Isso no meu mundo:

Esta atividade ajuda as crianças a entenderem a importância de ter uma rotina diária organizada e saudável. Ao organizar suas atividades do dia como um "mapa" ou "caminho", as crianças conseguem perceber quais ações precisam ser feitas antes de outras e por que isso é importante. Por exemplo, escovar os dentes antes de tomar o café da manhã é um hábito saudável. Com isso, elas aprendem a distinguir quais hábitos contribuem para um dia mais saudável e divertido e quais não são recomendados. Essa organização também mostra como planejar e realizar atividades de forma prática ajuda a fazer o dia a dia funcionar melhor, como um "passeio bem planejado".

Avaliação:

A avaliação desta atividade será realizada de maneira participativa e processual, envolvendo as crianças em reflexões sobre suas próprias criações e as dos colegas. O objetivo é verificar a compreensão do conceito de grafos, dependências entre ações e a relação dessas ideias com o ambiente computacional.

1. Avaliação Individual: Reflexão sobre os Próprios Grafos

- Peça a cada criança que explique seu grafo de rotina, destacando a ordem das atividades e o motivo pelo qual escolheu determinada sequência.
- Utilize questões para estimular a reflexão, como:
 - "Por que você colocou esta ação antes de outra?"
 - "Você acha que poderia mudar a ordem? Por quê?"
 - "Se essa atividade fosse feita fora de ordem, o que aconteceria?"
- Observe se a criança consegue identificar dependências e explicar de maneira lógica as conexões entre as ações em seu grafo.

2. Avaliação Coletiva: Troca de Experiências e Análise entre Grupos

- Organize uma atividade em que as crianças troquem seus grafos com outros grupos ou colegas.
- Oriente cada grupo a analisar o grafo recebido, fazendo perguntas como:
 - "Essa ordem faz sentido? Por quê?"
 - "Vocês mudariam alguma coisa? O que e por quê?"
 - "Vocês identificaram alguma ação que poderia estar conectada de outra forma?"
- Relacione o feedback dado por cada grupo ao ambiente computacional, dizendo: "Assim como vocês estão ajustando esses grafos, nos computadores, os programadores verificam e corrigem as conexões entre tarefas para garantir que tudo funcione."

3. Avaliação Formativa: Revisão e Ajustes dos Próprios Grafos

- Peça às crianças que revisem seus grafos após receberem o feedback dos colegas. Incentive-as a fazer melhorias ou experimentar diferentes conexões.
- Use questões para estimular a melhoria, como:
 - "O que vocês aprenderam ao analisar o grafo de outro grupo?"
 - "Vocês mudaram algo no seu grafo? Por quê?"

4. Avaliação Final: Apresentação e Conexão com a Computação

- Conduza uma roda de conversa para que as crianças compartilhem o que aprenderam durante a análise e revisão.
- Questione como as ideias trabalhadas se relacionam com o uso dos computadores. Exemplos de perguntas:
 - "Por que é importante organizar as tarefas em uma ordem certa?"
 - "Nos computadores, o que acontece se as tarefas não estiverem conectadas da forma correta?"
- Avalie se as crianças conseguem identificar dependências e explicar como as ações conectadas formam um todo funcional.

Recursos de apoio ao professor:

Fernando Emilio Puntel. Grafos em 12 Minutos! Vértices, Arestas, Grau e Muito Mais!. YouTube, 2025. Disponível em: <<https://www.youtube.com/watch?v=4W8bTrDmpck>>. Acesso em: 06/04/2026.

Referências:

CORMEN, Thomas H.; LEISERSON, Charles E.; RIVEST, Ronald L.; STEIN, Clifford. *Introduction to Algorithms*. 3. ed. Cambridge: MIT Press, 2009.

SEDGEWICK, Robert; WAYNE, Kevin. *Algorithms*. 4. ed. Boston: Addison-Wesley, 2011.

Plano de Atividade

Tema	Processamento de Dados
Título	Eu posso ser um programador incrível!
Conhecimento	Algoritmos e Programação
Faixa Etária	4 e 5 anos
Duração	4 horas ¹

Conhecimento em Computação:

Programação é o processo de construir algoritmos, isto é, sequências lógicas e ordenadas de passos que permitem a resolução de problemas ou a realização de tarefas por um computador. Um algoritmo deve ser claro, preciso, finito e livre de ambiguidades, de modo que seja compreendido e executado pelo computador de forma confiável (Cormen et al., 2022). Esses aspectos fundamentais garantem que as instruções sejam interpretadas corretamente e levem ao resultado esperado.

A programação é realizada por meio de linguagens de programação, que são ferramentas formais usadas para comunicar essas instruções ao computador. De acordo com Knuth (1997), "programar é a arte de expressar soluções eficientes para problemas através de uma linguagem que o computador consiga interpretar". Exemplos dessas linguagens incluem Python, Java e Scratch, sendo esta última amplamente utilizada em ambientes educacionais para introduzir conceitos de programação de forma visual e interativa.

Os computadores, por sua natureza, são dispositivos que executam operações de acordo com uma sequência lógica de comandos. Entretanto, para que isso seja possível, as instruções fornecidas devem ser exatas, detalhadas e organizadas em etapas claras. Qualquer imprecisão no algoritmo pode levar a erros na execução, o que reforça a importância de projetar instruções bem estruturadas.

Por exemplo, um algoritmo detalhado para escovar os dentes poderia ser descrito assim:

1. Vá até o local onde a escova de dentes está guardada.
2. Pegue a escova de dentes com uma das mãos.
3. Pegue o tubo de pasta de dentes com a outra mão.
4. Abra a tampa do tubo de pasta de dentes girando-a no sentido anti-horário (ou removendo-a caso seja de encaixe).
5. Pressione o tubo de pasta para aplicar uma quantidade equivalente ao tamanho de uma ervilha nas cerdas da escova.
6. Feche a tampa do tubo de pasta de dentes e guarde-o no local apropriado.
7. Abra a torneira.

¹ Esta duração é uma estimativa de tempo e pode ser flexibilizada de acordo com a demanda da turma.

8. Coloque a escova de dentes sob a água corrente por 2 a 3 segundos para molhar as cerdas.
9. Feche a torneira.
10. Coloque a escova de dentes na boca e escove os dentes superiores, movendo a escova para frente e para trás em movimentos curtos, por aproximadamente 30 segundos.
11. Escove os dentes inferiores, repetindo os movimentos curtos, por mais 30 segundos.
12. Escove as superfícies internas dos dentes superiores e inferiores com movimentos verticais.
13. Escove a língua, movendo a escova suavemente de trás para frente.
14. Abra a torneira novamente e enxague a boca com água.
15. Enxágue a escova de dentes sob a água corrente para remover qualquer resíduo de pasta.
16. Feche a torneira.
17. Guarde a escova de dentes no local apropriado.

Este exemplo demonstra como um algoritmo deve ser detalhado, descrevendo cada passo necessário de maneira clara e lógica, sem pressupor ações implícitas.

Para ensinar computação, é fundamental compreender que os computadores não "pensam" ou "interpretam" como humanos; eles apenas executam instruções exatas conforme programadas. Isso significa que qualquer imprecisão, como um passo mal definido ou fora de ordem, pode levar a erros no resultado.

Características fundamentais de um algoritmo:

- **Finitude:** Deve ter um número limitado de passos e terminar em algum ponto.
- **Clareza:** Cada passo deve ser descrito de forma precisa e inequívoca.
- **Ordem:** As instruções devem seguir uma sequência lógica.
- **Entrada e saída:** Um algoritmo pode receber dados de entrada e deve produzir um resultado.

Ao apresentar a programação às crianças, não estamos apenas ensinando como "dar ordens" ao computador, mas também promovendo habilidades importantes, como a resolução de problemas, a criatividade e a capacidade de organizar pensamentos de maneira lógica. Ensinar as crianças a escrever algoritmos claros e precisos ajuda a desenvolver essas competências essenciais.

Objetivo:

O objetivo desta atividade é ajudar as crianças a conhecer mais sobre a profissão de programador, explorando como as pessoas usam a programação para criar soluções e controlar diferentes situações do dia a dia. A atividade também incentivará as crianças a levantar hipóteses sobre por que é importante realizar programações, além de estimular a criatividade, ao permitir que cada criança crie suas próprias sequências e ações. Além disso, a atividade ajudará a desenvolver a coordenação motora, ao desenhar ou montar representações físicas de suas ideias, e promoverá interações sociais, com atividades em grupo onde as crianças podem trocar ideias e colaborar. Por fim, a atividade buscará estimular o raciocínio lógico, ensinando as crianças a organizar ações em uma sequência e a pensar de forma ordenada e estratégica.

Habilidades do Século XXI:

- **Criatividade e Inovação:** A criança desenvolverá criatividade durante a criação dos sinais/códigos a serem utilizados.

Eixos e Habilidades da BNCC:

- **“ESCUTA, FALA, PENSAMENTO E IMAGINAÇÃO” (EI03EF01):** Expressar ideias, desejos e sentimentos sobre suas vivências, por meio da linguagem oral e escrita (escrita espontânea), de fotos, desenhos e outras formas de expressão.
- **“CORPO, GESTOS E MOVIMENTOS” (EI03CG05):** Coordenar suas habilidades manuais no atendimento adequado a seus interesses e necessidades em situações diversas.

Eixos e Habilidades da BNCC Computação - Educação Infantil:

- **“PENSAMENTO COMPUTACIONAL” (EI03CO02):** Expressar as etapas para a realização de uma tarefa de forma clara e ordenada.
- **“PENSAMENTO COMPUTACIONAL” (EI03CO03):** Experienciar a execução de algoritmos brincando com objetos (des)plugados.
- **“PENSAMENTO COMPUTACIONAL” (EI03CO04):** Criar e representar algoritmos para resolver problemas.

Materiais necessários para a atividade:

- Cartolina ou Eva's
- Formas Geométricas impressas (Círculo, triângulo, quadrado e retângulo)
- Tesoura
- Livro “Ada Lovelace, a condessa Curiosa”

Desenvolvimento da atividade:

1. Introdução ao Conceito de Programação

- Leia o livro Ada Lovelace (ver Referências), a Condessa Curiosa, que apresenta de forma lúdica a história de Ada Lovelace, a primeira pessoa a criar uma ideia de programação, inspirando as crianças.
- Explique, com suas próprias palavras, que programar é dar instruções claras e organizadas a um computador ou robô. Relacione o conceito com exemplos do cotidiano, como "dar instruções para alguém encontrar um objeto perdido" ou "seguir uma receita de bolo".
- Utilize a história de Ada para contextualizar o surgimento da programação e enfatize como ela abriu caminho para a criação de jogos, aplicativos e outras tecnologias.

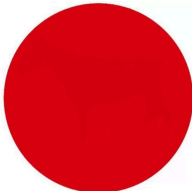
2. Escolha dos Materiais e Formação dos Grupos

- Divida as crianças em dois grupos. Permita que cada grupo escolha a cor de EVA que deseja usar e entregue formas geométricas para serem recortadas, como círculos, quadrados e triângulos.
- Mostre exemplos de formas geométricas recortadas já prontas e explique que cada forma representará uma ação ou comando. Por exemplo: "O círculo pode significar 'pular' e o quadrado pode significar 'bater palmas'".
- Explique que essas formas e ações funcionarão como um "código" que o outro grupo deverá interpretar e executar.

3. Prototipagem e Criação dos Comandos

- Oriente cada grupo a decidir quais ações criar e como organizar suas formas geométricas para formar uma sequência lógica.
- Explique que eles estão construindo uma "receita de ações" e incentive a criatividade ao escolher comandos.
- Destaque que organizar as formas de maneira clara e lógica ajuda a evitar confusões e garante que o outro grupo consiga seguir as instruções.

Dica: Desenhe no quadro ou lousa as formas geométricas com suas respectivas ações para que o grupo executor possa consultá-las facilmente durante a atividade.

Símbolo	Instrução
	Pular
	Bater palmas

Dica: Caso as sequências criadas pelos grupos não sejam claras, o professor deve intervir, utilizando termos adequados e sugerindo ajustes pontuais, como "Repense esta sequência para que fique mais lógica e fácil de entender".

4. Execução dos Comandos

- Oriente cada grupo a apresentar sua sequência de comandos para o outro grupo.

- Explique que o grupo executor deve seguir as ações na ordem apresentada, interpretando corretamente cada forma e realizando as ações correspondentes.
- Ressalte a importância de seguir os comandos com atenção para que o resultado final seja conforme o esperado.

5. Reflexão e Feedback

- Reúna todos para uma roda de conversa e pergunte:
 - "As instruções estavam claras?"
 - "Foi fácil seguir as ações propostas pelo outro grupo?"
 - "Como poderíamos melhorar as instruções para que ficassem ainda mais fáceis de entender?"
- Incentive as crianças a compartilhar o que acharam divertido e desafiador na atividade.
- Explique que essa etapa é importante para refletir sobre a clareza das instruções e a lógica das ações, conectando com o conceito de iteração e melhoria presente na programação.

Dica: Use exemplos visuais durante a roda de conversa, como desenhos ou esquemas das sequências criadas, para reforçar os pontos discutidos.

Isso no meu mundo:

Na nossa vida, estamos sempre seguindo e dando comandos. Quando brincamos, por exemplo, precisamos ouvir o que o amigo diz para seguir a brincadeira, como pular quando ele manda ou bater palmas quando ele pede. Assim como fizemos na atividade, onde criamos comandos para os colegas seguirem, no nosso dia a dia também precisamos entender e seguir instruções. Seja ao arrumar a mochila para a escola ou ao colocar os brinquedos de volta na caixa, sempre há uma ordem para fazer as coisas e regras para cumprir. Essa atividade nos ajuda a pensar sobre como organizar e seguir essas instruções, facilitando nossas tarefas e nos ajudando a comunicar claramente o que queremos que os outros façam.

Avaliação:

A avaliação desta atividade será realizada em duas etapas complementares:

1. Observação da Professora

- Durante a criação dos códigos e a execução das sequências, a professora observará os seguintes pontos:
 - **Sequência Lógica:** As crianças foram capazes de organizar os comandos de forma lógica e coerente?
 - **Clareza das Instruções:** As crianças conseguiram criar comandos claros, que o outro grupo conseguiu interpretar e executar corretamente?

- **Explicação dos Comandos:** As crianças conseguem explicar o que cada forma geométrica representa e como o comando deve ser seguido?
- **Colaboração em Grupo:** Houve participação ativa de todos os membros do grupo nas decisões e na execução da atividade?

2. Autoavaliação das Crianças

- Ao final da atividade, as crianças serão convidadas a participar de uma roda de conversa para avaliar o processo e compartilhar suas percepções. Algumas perguntas que podem ser feitas:
 - O que você mais gostou de fazer nesta atividade?
 - O que achou mais fácil ou mais difícil de entender?
 - Você acha que os comandos que criamos estavam claros? Por quê?
 - O que poderíamos fazer diferente na próxima vez para melhorar?
- A professora pode registrar as respostas das crianças para identificar aspectos que funcionaram bem e pontos que podem ser aprimorados em atividades futuras.

Essa abordagem permite que as crianças reflitam sobre o processo e se sintam parte integrante da avaliação, valorizando sua perspectiva e promovendo o desenvolvimento de habilidades de metacognição. Além disso, as observações da professora e o feedback das crianças serão utilizados para ajustar e melhorar atividades futuras.

Recursos de apoio ao professor:

Bate papo: Educação. O que é Algoritmo? - Lógica de programação para crianças #PensamentoComputacional. YouTube, 2019. Disponível em: <<https://www.youtube.com/watch?v=IsSHOeBPwU8>>. Acesso em: 06/04/2026.

Diolinux. O que é "o tal do Algoritmo"? - Lógica e Programação. YouTube, 2020. Disponível em: <<https://www.youtube.com/watch?v=z1XTcKKRbKM>>. Acesso em: 06/04/2026.

Referências:

BIM, Sílvia Amélia. Ada Lovelace a Condessa Curiosa. Editora Inverso, 2021.

CORMEN, T. H.; LEISERSON, C. E.; RIVEST, R. L.; STEIN, C. *Algoritmos: Teoria e Prática*. 3ª ed. São Paulo: Editora Campus, 2022.

KNUTH, D. E. *The Art of Computer Programming: Fundamental Algorithms*. 3ª ed. Boston: Addison-Wesley, 1997.

Plano de Atividade

Tema	Transmissão de dados
Título	Televisando ideias - Repórteres em ação
Conhecimento	Trabalhando com as vivências práticas da comunicação e transmissão de informações
Faixa Etária	4 a 5 anos
Duração	5 aulas ¹

Conhecimento em Computação:

A comunicação sem fio é um exemplo de como tecnologias computacionais transformam a transmissão de informações. No contexto deste plano de atividade, é importante aprofundar conceitos fundamentais de computação relacionados à comunicação sem fio, incluindo redes de computadores, transmissão broadcast e o funcionamento de dispositivos como controles remotos e roteadores Wi-Fi.

Redes de computadores são estruturas que interligam dispositivos para a troca de dados. Uma rede de computadores permite a comunicação entre dispositivos de forma eficiente e organizada, independentemente de sua localização física (Tanenbaum e Wetherall, 2011). Nesse contexto, a comunicação sem fio utiliza ondas de rádio ou sinais infravermelhos para transmitir dados sem a necessidade de conexões físicas, como cabos.

A transmissão broadcast, por exemplo, é um método no qual uma mensagem é enviada de um único transmissor para múltiplos receptores. Esse conceito está presente na transmissão televisiva, onde um sinal é enviado a várias TVs simultaneamente, e em redes Wi-Fi, que distribuem dados para múltiplos dispositivos conectados.

Para ilustrar, o controle remoto utiliza um sinal infravermelho para enviar comandos para a televisão. Quando um botão é pressionado, um circuito interno no controle gera um sinal codificado que viaja até o receptor da TV. Esse receptor decodifica o sinal e executa a ação correspondente, como aumentar o volume ou trocar de canal.

Tecnologias modernas, como o Wi-Fi, funcionam de maneira semelhante, mas utilizam ondas de rádio em vez de sinais infravermelhos. Segundo Stallings (2020), "o Wi-Fi é uma tecnologia que permite a transmissão de dados em alta velocidade através do ar, conectando dispositivos em uma rede local sem a necessidade de cabos". Esse processo envolve a troca de pacotes de dados entre dispositivos e pontos de acesso, demonstrando como as redes de computadores e protocolos computacionais possibilitam a comunicação eficiente.

Para este plano de aula, o professor deve destacar esses conceitos de comunicação sem fio de forma acessível, conectando-os às tecnologias do cotidiano das crianças, como controles

¹ Esta duração é uma estimativa de tempo e pode ser flexibilizado de acordo com a demanda da turma.

remotos, televisões e redes Wi-Fi. Isso permitirá que as crianças compreendam os processos computacionais que possibilitam a transmissão de informações, ao mesmo tempo que desenvolvem habilidades de comunicação, pensamento lógico e sequenciamento.

Objetivo:

O objetivo desta atividade é proporcionar às crianças o domínio dos conceitos de informação tecnológica dos meios de comunicação, com destaque para a TV, de forma que sejam capazes de colocarem-se no papel de criadores de conteúdo digital.

Habilidades do Século XXI:

- **Criatividade e Inovação:** As habilidades de criatividade e inovação poderão ser trabalhadas desde a troca de ideias inicial, criação do protótipo utilizando material reciclável, até o desenvolvimento do canal de televisão.

Eixos e Habilidades da BNCC:

- **“CORPO, GESTOS E MOVIMENTOS” (EI03CG01):** Criar com o corpo formas diversificadas de expressão de sentimentos, sensações e emoções, tanto nas situações do cotidiano quanto em brincadeiras, dança, teatro, música.
- **“CORPO, GESTOS E MOVIMENTOS” (EI03CG02):** Demonstrar controle e adequação do uso de seu corpo em brincadeiras e jogos, escuta e reconto de histórias, atividades artísticas, entre outras possibilidades.
- **“CORPO, GESTOS E MOVIMENTOS” (EI03CG03):** Criar movimentos, gestos, olhares e mímicas em brincadeiras, jogos e atividades artísticas como dança, teatro e música.
- **“CORPO, GESTOS E MOVIMENTOS” (EI03CG05):** Coordenar suas habilidades manuais no atendimento adequado a seus interesses e necessidades em situações diversas.
- **“ESCUTA, FALA, PENSAMENTO E IMAGINAÇÃO” (EI03EF01):** Expressar ideias, desejos e sentimentos sobre suas vivências, por meio da linguagem oral e escrita (escrita espontânea), de fotos, desenhos e outras formas de expressão.
- **“ESCUTA, FALA, PENSAMENTO E IMAGINAÇÃO” (EI03EF04):** Recontar histórias ouvidas e planejar coletivamente roteiros de vídeos e de encenações, definindo os contextos, os personagens e a estrutura da história.
- **“ESCUTA, FALA, PENSAMENTO E IMAGINAÇÃO” (EI03EF06):** Produzir suas próprias histórias orais e escritas (escrita espontânea), em situações com função social significativa.
- **“ESPAÇOS, TEMPOS, QUANTIDADES, RELAÇÕES E TRANSFORMAÇÕES” (EI03ET02):** Observar e descrever mudanças em diferentes materiais, resultantes de ações sobre eles, em experimentos envolvendo fenômenos naturais e artificiais.

Eixos e Habilidades da BNCC Computação - Educação Infantil:

- **“PENSAMENTO COMPUTACIONAL” (EI03CO06):** Compreender decisões em dois estados (verdadeiro ou falso).
- **“MUNDO DIGITAL” (EI03CO08):** Compreender o conceito de interfaces para comunicação com objetos (des)plugados.
- **“MUNDO DIGITAL” (EI03CO09):** Identificar dispositivos computacionais e as diferentes formas de interação.

Materiais necessários para a atividade:

Obrigatório:

- Caixa de papelão
- Tintas
- Canetas hidrográficas
- Lápis de cor
- Fitas adesivas
- Tesoura
- Cola
- Papéis coloridos variados
- Tampa de garrafa pet

Opcional:

- Lâmpada (celular, laser, qualquer forma de emissão de luz que simule controle remoto)
- Computador com acesso à internet
- Projetor
- Aparelho de TV para exposição

Desenvolvimento da atividade:

1. Atividade Diagnóstica - Levantamento de Hipóteses

- Realize uma roda de conversa com as crianças para levantar hipóteses sobre o funcionamento da televisão e como as imagens chegam até ela. Pergunte: "Como você acha que a imagem vai de um lugar para outro?" ou "Você acha que a TV precisa de fios para funcionar?".
- Use as respostas das crianças para introduzir a ideia de transmissão de informações, preparando-as para compreender conceitos como sequenciamento lógico e comunicação sem fio.

- Explique que esse momento inicial serve para explorar o conhecimento prévio das crianças, estimular a curiosidade e criar uma base para os conceitos que serão trabalhados.

2. Roda de Conversa - Evolução da TV e Comunicação Sem Fio

- Apresente a evolução dos aparelhos eletrônicos, com foco na TV, e mostre o vídeo "De onde vem a TV?". Disponível em: [De Onde Vem a TV? #Episódio 2](#).
- Explique que a transmissão de informações pode acontecer de maneira sem fio, como no caso do controle remoto que utiliza sinal infravermelho e no Wi-Fi, que usa ondas de rádio.
- Relacione essas explicações às tecnologias que as crianças já conhecem, ajudando-as a compreender como dispositivos interagem sem a necessidade de cabos.

3. Demonstração Prática - Controle Remoto e Comunicação Sem Fio

- Utilize um controle remoto e uma TV para demonstrar como funciona a comunicação sem fio. Mostre que, ao apertar um botão no controle (input), a TV responde (output).
- Permita que as crianças experimentem diferentes botões para observar como os comandos funcionam e são transmitidos pelo sinal infravermelho.
- Explique que o controle remoto envia sinais codificados que a TV interpreta para executar ações específicas.

4. Atividade Lúdica de "Comandos Sem Fio"

- Organize uma atividade em que uma criança seja o "controle remoto" e outra a "TV". O "controle remoto" usará gestos ou cartões coloridos para enviar comandos, como "pular", "girar" ou "bater palmas".
- Explique que essa atividade simula como as instruções podem ser enviadas sem fios, mostrando a relação entre o comando enviado e a ação executada.
- Ressalte que essa dinâmica ajuda a consolidar o conceito de transmissão de informações sem fio de forma prática e divertida.

5. Mão na Massa - Construção do Protótipo do Aparelho de TV e Controle Remoto

- Divida as crianças em pequenos grupos e peça para que construam um protótipo de TV e controle remoto usando materiais recicláveis, como caixas de papelão, papéis coloridos e botões de brinquedo.
- Oriente os grupos a definir os "comandos" do controle remoto, como "trocar de canal" ou "aumentar volume", relacionando cada botão (input) à resposta da TV (output).
- Explique que essa etapa desenvolve a compreensão do conceito de entrada e saída de informações, além de estimular a criatividade e o trabalho em equipe.

6. Organização dos Grupos e Criação de Conteúdos dos Canais

- Instrua cada grupo a criar seu próprio "canal de TV", produzindo conteúdos como histórias, previsões do tempo ou pequenas reportagens.
- Explique que cada criança terá um papel específico, como apresentador, diretor ou operador de controle remoto, enfatizando a importância de colaboração e sequenciamento lógico.
- Destaque que essa etapa conecta a prática de comunicação com o conceito de coordenação entre diferentes partes de um processo.

7. Exploração dos Dispositivos Sem Fio no Ambiente

- Incentive as crianças a explorar a sala de aula e a escola para identificar dispositivos que utilizam comunicação sem fio, como roteadores de Wi-Fi, celulares e controles remotos.
- Explique que esses dispositivos utilizam tecnologias como infravermelho ou ondas de rádio para transmitir informações sem a necessidade de cabos.
- Relacione essa exploração com a aplicação prática dos conceitos apresentados, reforçando a presença dessas tecnologias no cotidiano.

8. Apresentação dos Canais de TV para a Comunidade Escolar

- Organize uma apresentação em que cada grupo mostre seu "canal de TV" para a comunidade escolar, utilizando o protótipo construído.
- Instrua os grupos a explicar como criaram os comandos e como a TV responde às diferentes entradas.
- Ressalte que essa atividade permite às crianças demonstrar sua compreensão dos conceitos trabalhados, ao mesmo tempo que desenvolve habilidades de comunicação e apresentação.

9. Reflexão e Feedback

- Realize uma roda de conversa com perguntas como:
 - "Como vocês se sentiram ao criar comandos sem fio?"
 - "O que acharam mais interessante sobre como as informações viajam sem fio?"
- Registre as respostas das crianças e promova uma discussão coletiva sobre as experiências vividas.
- Explique que essa etapa ajuda a consolidar o aprendizado, reforçando a importância da colaboração, do sequenciamento lógico e da clareza na comunicação.

Isso no meu mundo:

A comunicação sem fio faz parte do nosso dia a dia e está presente em muitos momentos. Quando usamos um controle remoto para mudar o canal da TV ou conectamos um tablet ao Wi-Fi para assistir a vídeos, estamos usando tecnologias que transmitem informações sem

precisar de fios. Nesta atividade, aprendemos como esses sinais "viajam pelo ar" para fazer as coisas funcionarem, como mudar de canal ou ligar a TV. Entender como essas tecnologias funcionam nos ajuda a perceber como a informação chega até nós e como podemos controlar os dispositivos do nosso dia a dia, como uma TV ou um tablet. Além disso, isso nos ajuda a pensar de forma organizada, planejando quais ações devem acontecer primeiro e o que vem depois, assim como fizemos ao criar nossos próprios comandos.

Avaliação:

Nesta atividade, é proposta uma avaliação a partir de um conjunto de perguntas que deve ser realizada para as crianças.

- Como o controle remoto consegue mudar o canal da TV, mesmo que não tenha um fio conectado a ela?
- Podemos mudar a ordem dos comandos no controle remoto, como aumentar o volume antes de ligar a TV? Isso funciona? Por quê?
- Você pode me mostrar como o controle remoto envia um comando para a TV, como "ligar" ou "aumentar o volume"? O que acontece depois que apertamos o botão?
- Se quisermos mudar de canal, qual botão devemos apertar primeiro? O que acontece depois?

Essa abordagem permite que as crianças reflitam sobre o processo e se sintam parte integrante da avaliação, valorizando sua perspectiva e promovendo o desenvolvimento de habilidades de metacognição.

Recursos de apoio ao professor:

Manual do Mundo. Entenda o WI-FI de uma VEZ por TODAS!. YouTube, 2021. Disponível em: <<https://www.youtube.com/watch?v=V2XW8nxNjcc>>. Acesso em: 06/04/2026.

Professor André Fernandes. Dica do Dedé - Rede Sem Fio. YouTube, 2016. Disponível em: <<https://www.youtube.com/watch?v=xXzRKgZbKW8>>. Acesso em: 06/04/2026.

Referências:

STALLINGS, William. *Wireless Communications & Networks*. 2ª ed. Boston: Pearson, 2020.

TANENBAUM, Andrew S.; WETHERALL, David J. *Redes de Computadores*. 5ª ed. São Paulo: Pearson, 2011.

Plano de Atividade

Tema	Uso consciente da tecnologia
Título	Descarte Consciente
Conhecimento	Descarte de lixo eletrônico
Faixa Etária	4 e 5 anos
Duração	3 horas ¹

Conhecimento em Computação:

Os computadores e dispositivos eletrônicos são compostos por diferentes materiais, muitos dos quais possuem propriedades específicas que os tornam ideais para funções computacionais. Por exemplo, o cobre é amplamente utilizado em circuitos e fios devido à sua alta condutividade elétrica (Ashby et al., 2005). Já o níquel, presente em baterias recarregáveis, é essencial para o armazenamento de energia. Esses materiais são extraídos da natureza e passam por processos industriais complexos antes de serem utilizados em componentes eletrônicos.

Dentro de um computador, os principais componentes incluem a placa-mãe, processadores, memória RAM, discos rígidos ou SSDs, fontes de energia e periféricos como teclado e mouse. Cada um desses elementos contém materiais como silício, presente em semicondutores, além de metais como alumínio, ouro e prata, usados em pequenas quantidades para conexões críticas devido à sua alta resistência à corrosão e excelente condutividade.

Além disso, componentes como baterias e monitores LCD contêm substâncias químicas que requerem descarte adequado. As baterias, por exemplo, podem conter chumbo e cádmio, elementos altamente tóxicos que, quando descartados de forma inadequada, podem contaminar o solo e os cursos d'água. Monitores antigos (CRT) possuem fósforo e vidro com chumbo, ambos prejudiciais ao meio ambiente (Kang e Schoenung, 2005).

A fabricação de dispositivos eletrônicos também gera impactos significativos. A extração de materiais, como o lítio para baterias, pode causar danos ecológicos em regiões de mineração, incluindo a contaminação de rios e a degradação do solo. Por isso, além de entender como os computadores são feitos, é importante discutir o ciclo de vida dos dispositivos e o impacto ambiental do lixo eletrônico.

¹ Esta duração é uma estimativa de tempo e pode ser flexibilizado de acordo com a demanda da turma.

Quando descartados de maneira inadequada, os materiais eletrônicos podem liberar substâncias tóxicas, causando danos à saúde humana e ao meio ambiente. Por outro lado, práticas de reciclagem e reutilização podem minimizar esses efeitos. Por exemplo, o cobre retirado de placas de circuito pode ser derretido e reutilizado em novas aplicações industriais, reduzindo a necessidade de extração de matéria-prima.

Ao ensinar esses conceitos, o professor pode conectar a fabricação dos dispositivos ao descarte consciente, explicando às crianças que os computadores são feitos de materiais valiosos que podem ser reutilizados. Para facilitar, é possível usar exemplos práticos: “Este cabo tem cobre dentro, um material que vem da natureza e ajuda a conduzir energia. Se jogarmos no lixo comum, ele pode acabar em um lugar onde prejudica o meio ambiente. Mas, se reciclarmos, ele pode ser usado em outro dispositivo.”

Esses conhecimentos ajudam o professor a transmitir informações mais detalhadas às crianças e a conscientizá-las sobre a importância de cuidar do meio ambiente. Assim, além de entenderem o papel da tecnologia em suas vidas, elas desenvolvem um senso crítico sobre a sustentabilidade e a responsabilidade no uso e descarte de dispositivos eletrônicos.

Objetivo:

O objetivo desta atividade é introduzir o conceito de descarte consciente dos componentes eletrônicos, ensinando às crianças a importância de fazer o descarte correto para reduzir o impacto ambiental. Elas vão aprender sobre o lixo eletrônico e como ele se diferencia do lixo comum, compreendendo por que o descarte inadequado pode ser prejudicial ao meio ambiente. Além disso, queremos estimular a reflexão sobre o impacto ambiental dos dispositivos tecnológicos, incentivando as crianças a adotarem práticas de reciclagem e reutilização de materiais. Durante a atividade, as crianças também irão desenvolver habilidades de colaboração e trabalho em grupo, pensando em soluções sustentáveis e compreendendo como suas ações podem contribuir para um futuro mais seguro e saudável para todos. Dessa forma, buscamos fomentar o pensamento crítico e promover uma maior conscientização sobre como a tecnologia e a sustentabilidade precisam andar de mãos dadas.

Habilidades do Século XXI:

- **Pensamento crítico e resolução de problemas:** a criança irá aprender sobre a necessidade de um descarte diferente para o lixo eletrônico.

Eixos e Habilidades da BNCC:

- **“O EU, O OUTRO E O NÓS” (EI03EO02):** Agir de maneira independente, com confiança em suas capacidades, reconhecendo suas conquistas e limitações.
- **“ESCUTA, FALA, PENSAMENTO E IMAGINAÇÃO” (EI03EF03):** Escolher e folhear livros, procurando orientar-se por temas e ilustrações e tentando identificar palavras conhecidas.

- **“ESCUTA, FALA, PENSAMENTO E IMAGINAÇÃO” (EI03EF06):** Produzir suas próprias histórias orais e escritas (escrita espontânea), em situações com função social significativa.
- **“ESCUTA, FALA, PENSAMENTO E IMAGINAÇÃO” (EI03EF08):** Selecionar livros e textos de gêneros conhecidos para a leitura de um adulto e/ou para sua própria leitura (partindo de seu repertório sobre esses textos, como a recuperação pela memória, pela leitura das ilustrações etc.).
- **“ESPAÇOS, TEMPOS, QUANTIDADES, RELAÇÕES E TRANSFORMAÇÕES” (EI03ET02):** Observar e descrever mudanças em diferentes materiais, resultantes de ações sobre eles, em experimentos envolvendo fenômenos naturais e artificiais.

Eixos e Habilidades da BNCC Computação - Educação Infantil:

- **“CULTURA DIGITAL” (EI03CO10):** Utilizar tecnologia digital de maneira segura, consciente e respeitosa.

Material necessário para a atividade:

- Componentes eletrônicos como: placas de circuito, cabos, pilhas, teclado, mouse, chips, ventoinha do computador e baterias
- Caixa de papelão, tintas, pincéis, tesoura, adesivos e fitas para que as crianças possam criar uma miniatura da caixa de descarte
- Livro "O Livro que Não Tinha Fim"
- Responsabilidade com o descarte de lixo eletrônico por parte da escola

Desenvolvimento da atividade:

1. Leitura e Exploração Inicial

- Comece a atividade com a leitura do livro O Livro que Não Tinha Fim (ver Referências). Leia o livro em voz alta para as crianças, mostrando as ilustrações e fazendo pausas para perguntas e reflexões.
- Após a leitura, relacione a ideia do “ciclo que não termina” com o ciclo de vida dos componentes eletrônicos. Explique que, assim como os materiais do livro continuavam, os componentes dos dispositivos eletrônicos podem ser reutilizados ou reciclados para ajudar o meio ambiente.
- Pergunte: "Vocês acham que um computador velho pode ter partes que ainda são úteis? O que acontece se essas partes forem jogadas no lixo comum?"

2. Exploração dos Componentes Eletrônicos

- Mostre às crianças componentes eletrônicos seguros para manuseio, como placas de circuito, cabos e baterias (sem danos visíveis). Explique para que cada componente serve:

- Placas de circuito: “São como estradas onde a energia e as informações passam para fazer o computador funcionar.”
- Cabos: “Servem para conectar diferentes partes do computador ou carregar energia.”
- Baterias: “Guardam energia para que o dispositivo funcione sem estar ligado na tomada.”
- Explique que esses componentes contêm materiais como cobre e níquel, que vêm da natureza, e que descartá-los no lixo comum pode causar poluição no solo e na água.
- **Dica para o professor: Onde conseguir os materiais?**
 - **Famílias das crianças:** Solicite que tragam componentes eletrônicos antigos que não estão mais em uso, como teclados, mouses, cabos ou celulares quebrados.
 - **Centros de reciclagem:** Entre em contato com cooperativas de reciclagem que lidam com e-lixo, pedindo doações de materiais descartados e seguros.
 - **Escolas ou universidades:** Algumas instituições possuem laboratórios ou departamentos que podem fornecer peças obsoletas para atividades pedagógicas.
 - **Lojas de manutenção eletrônica:** Pequenas oficinas geralmente acumulam peças descartadas que podem ser cedidas para atividades educativas.

3. Reflexão: Impactos do Descarte Inadequado

- Pergunte às crianças o que acham que pode acontecer se os componentes forem jogados no lixo comum. Mostre imagens ou vídeos curtos sobre poluição ambiental causada por lixo eletrônico.
- Use exemplos simples, como: “Se uma bateria vaza no chão, ela pode estragar o solo e prejudicar as plantas e os animais que vivem ali.”

4. Criação da História: O Ciclo de Vida de um Componente Eletrônico

- Oriente as crianças a criar uma história baseada em um componente eletrônico. Elas podem escolher entre:
 - **Fantástico:** Criar uma narrativa onde o componente tem vida e conta sua própria história, desde sua fabricação até o descarte consciente.
 - **Funcional:** Explicar o papel do componente no dispositivo, o que ele faz e como deve ser descartado corretamente.
- Ajude as crianças a estruturar a história, fornecendo exemplos:
 - “Eu sou uma bateria! Fui feita para guardar energia, mas, se não for descartada corretamente, posso causar muitos problemas ao meio ambiente.”
 - “Sou uma placa de circuito que conecta diferentes partes de um computador. Quando sou reciclada, posso ser usada em outro dispositivo.”

5. Ideação e Prototipagem - Caixa de Descarte de Lixo Eletrônico

- Divida as crianças em grupos para criar protótipos de caixas de descarte de lixo eletrônico.
- Ajude os grupos a incluir mensagens educativas, como “Não jogue no lixo comum!” ou “Recicle para proteger o planeta!”.
- Mostre exemplos reais de caixas de descarte para inspirar os grupos.

6. Atividade Visual - Cartaz de Boas Práticas

- Crie um cartaz coletivo com boas práticas para o descarte de lixo eletrônico. Inclua desenhos, mensagens simples e ilustrações sobre o impacto ambiental do descarte inadequado.

6. Reflexão Final - Jogo de Perguntas e Respostas

- Conduza um jogo de perguntas para revisar os conceitos aprendidos:
 - “Por que não podemos jogar baterias no lixo comum?”
 - “O que acontece com o meio ambiente quando descartamos eletrônicos de forma errada?”
 - “Como podemos ajudar a cuidar do planeta com a reciclagem?”
- Finalize reforçando que o descarte consciente é uma forma de cuidar do planeta e que cada criança pode fazer a diferença.

Isso no meu mundo:

Aprender sobre descarte consciente nos ajuda a entender como podemos cuidar melhor do meio ambiente e dos materiais que usamos todos os dias, incluindo componentes eletrônicos. Diferentes objetos podem ser feitos e refeitos a partir de um mesmo material, e muitos dos dispositivos que usamos, como computadores e celulares, possuem peças que precisam ser descartadas de maneira correta. O lixo eletrônico, como placas, baterias e cabos, não pode ser jogado no lixo comum, pois pode prejudicar o meio ambiente. Nesta atividade, as crianças compreendem como a reciclagem e o descarte consciente são importantes, desenvolvendo um senso crítico e cidadania, além de aprenderem como esses conceitos estão ligados ao mundo da computação. Isso nos mostra que a tecnologia e o meio ambiente podem estar conectados e que todos nós temos um papel em garantir um uso mais responsável e sustentável dos recursos.

Avaliação:

Pesquisa obtida por cada aluno como forma de registro, além de perguntas propostas pelo professor, como por exemplo:

1. O que vocês entenderam por reciclagem?
2. Qual o material reciclável, do livro, mais encontrado em um computador?
3. Existe diferença entre o lixo reciclável comum e o lixo eletrônico (E-lixo)?
4. Qual a importância do descarte correto dos diferentes tipos de lixo?
5. Vocês possuem algum lixo eletrônico em casa? Se sim, quais?

Recursos de apoio ao professor:

Ciência todo dia. Esse é o PIOR tipo de lixo que existe. YouTube, 2024. Disponível em: <<https://www.youtube.com/watch?v=NNvvZjVSp9M>>. Acesso em: 06/04/2026.

Manual do Mundo. Descobrimos como ELETROELETRÔNICOS são RECICLADOS! #Boravê. YouTube, 2024. Disponível em: <<https://www.youtube.com/watch?v=zGA6YDzGCWo>>. Acesso em: 06/04/2026.

Referências:

ASHBY, Michael F.; SHERCLIFF, Hugh; CEBON, David. *Materials: Engineering, Science, Processing and Design*. Oxford: Butterworth-Heinemann, 2005.

INSTITUTO ECOFUTURO. *O livro que não tinha fim*. São Paulo: Fundação Educar DPaschoal, 2006. Disponível em: <http://www.educardpaschoal.org.br/web/files/files/O%20livro%20que%20nao%20tinha%20fim.pdf>. Acesso em: 15 jan. 2025.

KANG, Hyunmyung; SCHOENUNG, Julie M. *Electronic waste recycling: A review of U.S. infrastructure and technology options*. *Resources, Conservation and Recycling*, v. 45, n. 4, p. 368-400, 2005.

Plano de Atividade

Tema	Hardware
Título	Criando o meu computador
Conhecimento	Componentes do computador
Faixa Etária	4 e 5 anos
Duração	4 horas ¹

Conhecimento em Computação:

Um computador é uma máquina composta por componentes físicos (hardware) e lógicos (software) que trabalham juntos para executar tarefas específicas. No hardware, os principais componentes incluem a Unidade Central de Processamento (CPU), o monitor, o teclado e o mouse. A CPU, muitas vezes chamada de "cérebro" do computador, é responsável por processar e executar as instruções fornecidas pelo software, convertendo-as em ações concretas. O processamento de instruções é o coração do funcionamento computacional, sendo essencial para a execução de qualquer tarefa (Knuth, 1997). O monitor exibe os resultados dessas ações, enquanto o teclado e o mouse são dispositivos de entrada, permitindo que os usuários enviem comandos e informações ao computador.

Além dos computadores tradicionais, dispositivos como tablets e celulares também são máquinas computacionais, mas com características que diferem em sua forma e interface. Tablets e celulares possuem telas sensíveis ao toque (touchscreens), que combinam funções de entrada e saída. A tela atua como um monitor, exibindo informações visuais, e também como um dispositivo de entrada, substituindo o teclado físico e o mouse por teclados virtuais e gestos de toque. Esses dispositivos, assim como os computadores tradicionais, possuem uma CPU que realiza o processamento das informações e executa os comandos fornecidos pelo usuário. A integração entre unidades de entrada, processamento e saída forma a base dos sistemas computacionais modernos (Von Neumann, 1945).

Embora as diferenças de formato sejam evidentes, a lógica de funcionamento é semelhante entre computadores, tablets e celulares. Em todos eles, as tarefas seguem o mesmo ciclo básico:

- **Entrada de Dados:** Comandos fornecidos por dispositivos de entrada, como teclado, mouse ou touchscreen.
- **Processamento:** Realizado pela CPU, onde os dados são interpretados e processados.

¹ Esta duração é uma estimativa de tempo e pode ser flexibilizada de acordo com a demanda da turma.

- **Saída de Dados:** Resultado exibido em dispositivos como o monitor ou a tela sensível ao toque.

A representação de dados neste ciclo ocorre de forma binária, com 0s e 1s servindo como base para todas as operações. Essa abordagem é fundamental para que máquinas computacionais realizem operações lógicas e aritméticas de maneira eficiente (Turing, 1936). Por exemplo, em um computador tradicional, a entrada pode ser feita pelo teclado (digitando um texto), o processamento é realizado pela CPU, e o monitor exibe o texto digitado. Em um tablet, o teclado virtual substitui o teclado físico, mas a entrada e o processamento seguem o mesmo princípio.

Objetivo:

O objetivo desta atividade é possibilitar o entendimento de como os diferentes componentes de um computador funcionam juntos para realizar tarefas do dia a dia, como digitar, clicar e visualizar informações na tela. Elas aprenderão a identificar os principais componentes, como a CPU, o monitor, o teclado e o mouse, e entender suas funções de forma simples e visual, considerando diferentes dispositivos. Além disso, a atividade visa desenvolver a capacidade de cuidar desses componentes, ensinando práticas para preservar o hardware, como manusear com cuidado e evitar danos. Com isso, busca-se estimular o pensamento crítico e a compreensão visual, para que as crianças possam distinguir o papel de cada parte do computador e compreender como elas se conectam para formar um sistema funcional.

Habilidades do Século XXI:

- **Pensamento crítico e resolução de problemas:** as crianças vão trabalhar o pensamento crítico conforme aprendem sobre o funcionamento de cada componente e o que fazer com cada um.

Eixos e Habilidades da BNCC:

- **“ESCUTA, FALA, PENSAMENTO E IMAGINAÇÃO” (EI03EF03):** Escolher e folhear livros, procurando orientar-se por temas e ilustrações e tentando identificar palavras conhecidas.
- **“ESCUTA, FALA, PENSAMENTO E IMAGINAÇÃO” (EI03EF04):** Recontar histórias ouvidas e planejar coletivamente roteiros de vídeos e de encenações, definindo os contextos, os personagens, a estrutura da história.
- **“EU, O OUTRO E NÓS” (EI03EO04):** Comunicar suas ideias e sentimentos a pessoas e grupos diversos.
- **“ESPAÇOS, TEMPOS, QUANTIDADES, RELAÇÕES E TRANSFORMAÇÕES” (EI03ET01):** Estabelecer relações de comparação entre objetos, observando suas propriedades.

Eixos e Habilidades da BNCC Computação - Educação Infantil:

- **“MUNDO DIGITAL” (EI03CO08):** Compreender o conceito de interfaces para comunicação com objetos (des)plugados.
- **“MUNDO DIGITAL” (EI03CO09):** Identificar dispositivos computacionais e as diferentes formas de interação.

Material necessário para a atividade:

- Materiais Recicláveis: Caixas de papelão, tampas de garrafa, canudos, pedaços de papel
- Componentes de Computador Antigos: Placas de circuito, cabos, mouses, partes de teclado (seguras para manuseio)
- Materiais de Desenho: Folhas de papel, lápis de cor, canetinhas, tinta guache
- Fitas adesivas ou fita isolante
- Cola

Desenvolvimento da atividade:

1. Identificação do Problema (Roda de Conversa Inicial)

- Pergunte às crianças se elas já viram computadores, tablets ou celulares e como imaginam que esses dispositivos funcionam.
- Mostre imagens ou exemplos reais dos dispositivos (como um notebook, um tablet e um celular) para ilustrar as diferenças e semelhanças entre eles.
- Explique que todos esses dispositivos têm componentes que realizam funções parecidas, como entrada (teclado, toque na tela), processamento (CPU) e saída (tela, alto-falantes).
- Estimule as crianças a levantar hipóteses com questões como:
 - "O que faz o computador ou o tablet funcionar?"
 - "Como você acha que conseguimos ver um desenho na tela?"

2. Ideação - Criando Soluções

- Entregue folhas de papel e lápis de cor para que cada criança desenhe como imagina que funciona um computador, um tablet ou um celular.
- Peça que representem as partes principais, como a tela, o teclado, os botões ou a CPU, destacando as funções de cada uma.
- Forme grupos para que compartilhem os desenhos e discutam como as partes dos dispositivos podem se conectar para realizar tarefas.
- Oriente os grupos a pensar em quais componentes são comuns entre computadores, tablets e celulares, e como eles diferem.

3. Prototipagem - Construção do dispositivo

- Distribua materiais recicláveis como caixas de papelão, tampas de garrafa, canudos e papéis para que os grupos construam protótipos de dispositivos à escolha deles: computador, tablet ou celular.
- Disponibilize, se possível, componentes seguros de computadores antigos (como cabos e pequenas placas de circuito) para enriquecer os protótipos e estimular a curiosidade.
- Oriente os grupos a criar um "teclado" usando tampas de garrafa para computadores ou simular um "teclado virtual" em tablets e celulares. Incentive-os a pensar em detalhes, como botões, ícones ou até mesmo a representação da bateria.
- Ajude os grupos a identificar quais materiais são mais adequados para cada parte do protótipo e como organizar os componentes para que o dispositivo seja funcional.

4. Teste e Refinamento

- Cada grupo deve apresentar seu protótipo para a turma, explicando como ele funciona, quais são seus componentes e como eles se conectam.
- Após cada apresentação, incentive os colegas a fazer perguntas ou dar sugestões. Exemplos de perguntas:
 - "Como funciona a tela do seu tablet ou celular?"
 - "Onde está o teclado e por que ele está aí?"
- Ajude os grupos a aplicar o feedback recebido para melhorar seus protótipos, ajustando detalhes ou adicionando novos elementos.

5. Conclusão - Reflexão sobre o Processo de Design

- Realize uma roda de conversa para consolidar o aprendizado, perguntando:
 - "O que aprendemos sobre como esses dispositivos funcionam?"
 - "O que eles têm em comum e o que é diferente?"
 - "Por que é importante conhecer essas partes e cuidar delas?"
- Reforce a ideia de que os diferentes dispositivos – computadores, tablets e celulares – funcionam com base em princípios semelhantes, adaptados para diferentes usos.
- Proponha que as crianças contem como poderiam usar seus protótipos no dia a dia, relacionando o aprendizado ao mundo real.

Isso no meu mundo:

Entender como um computador funciona nos ajuda a perceber que cada componente tem uma função específica e importante, assim como diferentes objetos que usamos no dia a dia. O monitor, o teclado e o mouse são como partes de um grande time, onde cada um faz sua parte para alcançar um objetivo, assim como em um jogo ou uma brincadeira em grupo. Quando sabemos qual componente usar para cada atividade, como clicar, escrever ou desenhar na tela, conseguimos entender melhor como o computador nos ajuda em várias coisas. Aprender sobre essas partes também nos ensina a cuidar delas, como fazemos com nossos brinquedos favoritos, garantindo que elas continuem funcionando bem por muito tempo. Assim, o

aprendizado sobre o computador e seus componentes se conecta com nosso cotidiano, mostrando a importância de entender e preservar o que usamos todos os dias.

Avaliação:

A avaliação será realizada ao final da atividade, focando na compreensão dos conceitos de hardware e na relação entre os componentes do computador. Para isso, o professor utilizará as seguintes estratégias:

1. Apresentação do Protótipo:

Cada grupo apresentará seu protótipo do computador, explicando como cada componente (teclado, monitor, CPU, etc.) contribui para o funcionamento geral do computador. O professor avaliará se as crianças conseguem descrever as funções dos diferentes componentes e como eles se conectam para que o computador realize suas funções.

2. Perguntas Reflexivas:

Após a apresentação, o professor fará algumas perguntas individuais para avaliar o nível de compreensão das crianças sobre o conhecimento em computação:

- "Qual parte do computador é responsável por processar as informações?"
- "Como o monitor e o teclado trabalham juntos para que possamos usar o computador?"
- "Por que precisamos cuidar dos componentes do computador?"

As respostas a essas perguntas ajudarão a avaliar se as crianças compreenderam os conceitos básicos de função e interconexão dos componentes.

Recursos de apoio ao professor:

Eu TI Ensino. Informática Básica: Principais hardwares do computador! Conheça os componentes do computador!. YouTube, 2020. Disponível em: <<https://www.youtube.com/watch?v=pFTgWgb5wiM>>. Acesso em: 06/04/2026.

DuarttHub. Todas as Peças de Computador Explicadas em 8 Minutos. YouTube, 2025. Disponível em: <<https://www.youtube.com/watch?v=ZSIrMa7JYc8>>. Acesso em: 06/04/2026.

Manual do mundo. O que tem DENTRO do NOTEBOOK?. YouTube, 2021. Disponível em: <https://www.youtube.com/watch?v=BB_5IPDn72o>. Acesso em: 06/04/2026.

Referências:

KNUTH, Donald E. *The Art of Computer Programming*. 3. ed. Boston: Addison-Wesley, 1997. v. 1. 672 p.

TURING, Alan M. *On Computable Numbers, with an Application to the Entscheidungsproblem*. Proceedings of the London Mathematical Society, v. 2, n. 42, p. 230–265, 1936.

VON NEUMANN, John. *First Draft of a Report on the EDVAC*. Pennsylvania: Moore School of Electrical Engineering, 1945.

Plano de Atividade

Tema	Processamento de dados
Título	Criando histórias com códigos
Conhecimento	Numeração Binária
Faixa Etária	4 e 5 anos
Duração	2 horas ¹

Conhecimento em Computação:

A numeração binária é o sistema base utilizado pelos computadores para processar e armazenar informações. Diferentemente do sistema decimal, que utiliza dez símbolos (de 0 a 9), o sistema binário opera com apenas dois símbolos: 0 e 1. Essa simplicidade permite que os computadores representem dados e executem instruções de maneira eficiente e confiável (Tanenbaum, 2011).

No contexto computacional, os números binários são usados para codificar comandos, dados e instruções. Um bit, que é a menor unidade de informação em computação, pode assumir o valor de 0 ou 1. Combinações de bits formam bytes e palavras, que podem representar números, caracteres, imagens e outros tipos de informações. Por exemplo, enquanto no sistema decimal contamos de 0 a 9 antes de "virar" para 10, no sistema binário contamos de 0 a 1 antes de "virar" para 10, que equivale a 2 no decimal (Cormen et al., 2022).

Abaixo, uma tabela que exemplifica como números decimais são convertidos para o sistema binário. Essa tabela pode ser utilizada como recurso visual para introduzir o conceito de conversão de sistemas numéricos.

¹ Esta duração é uma estimativa de tempo e pode ser flexibilizada de acordo com a demanda da turma.

Decimal	Binário
0	0
1	1
2	10
3	11
4	100
5	101
6	110
7	111
8	1000
9	1001
10	1010

A relação entre 0 e 1 e as ações dos computadores pode ser entendida como uma analogia à eletrônica subjacente: o número 1 pode representar um circuito ligado (tensão presente) e o número 0, um circuito desligado (ausência de tensão). Essa representação física é essencial para o funcionamento dos dispositivos computacionais (Turing, 1936).

Além disso, destacar a relação entre sistemas de numeração e sua conversão é fundamental para a compreensão prática dos conceitos. Por exemplo, o número 10 no sistema binário é equivalente ao número 2 no sistema decimal. Essa tradução entre sistemas é fundamental para o entendimento de como os computadores convertem informações humanas em linguagem computacional (Stallings, 2020).

A numeração binária não é apenas uma forma de contagem, mas também a base do pensamento computacional. Ao utilizar o binário, os computadores traduzem informações complexas em sequências simples e organizadas, demonstrando como um sistema aparentemente básico pode resolver problemas sofisticados.

Objetivo:

O objetivo dessa atividade é trabalhar o conceito de numeração binária por meio da produção de um conto.

Habilidades do Século XXI:

- **Criatividade e Inovação:** Espera-se que a criança desenvolva criatividade durante a criação da história. As habilidades de criatividade e inovação poderão ser trabalhadas na criação de novos glossários para a criação de novas situações ou histórias.

Eixos e Habilidades da BNCC:

- **“O EU, O OUTRO E O NÓS” (EI03EO03):** Ampliar as relações interpessoais, desenvolvendo atitudes de participação e cooperação.(EI03CO06): Compreender decisões em dois estados (verdadeiro ou falso).
- **“CORPO, GESTOS E MOVIMENTOS” (EI03CG02):** Demonstrar controle e adequação do uso de seu corpo em brincadeiras e jogos, escuta e reconto de histórias, atividades artísticas, entre outras possibilidades.
- **“TRAÇOS, SONS, CORES E FORMAS” (EI03TS02):** Expressar-se livremente por meio de desenho, pintura, colagem, dobradura e escultura, criando produções bidimensionais e tridimensionais.
- **“ESPAÇOS, TEMPOS, QUANTIDADES, RELAÇÕES E TRANSFORMAÇÕES” (EI03ET01):** Estabelecer relações de comparação entre objetos, observando suas propriedades.

Eixos e Habilidades da BNCC Computação - Educação Infantil:

- **“PENSAMENTO COMPUTACIONAL” (EI03CO06):** Compreender decisões em dois estados (verdadeiro ou falso).
- **“MUNDO DIGITAL” (EI03CO07):** Reconhecer dispositivos eletrônicos (e não-eletrônicos), identificando quando estão ligados ou desligados (abertos ou fechados).

Material necessário para a atividade:

- Glossário: Sequência de imagens para ser usado de exemplo
- Tabela com quatro espaços em branco, numeradas sequencialmente em binário, para que a criança possa construir a sequência da história a partir da leitura do glossário
- Folha sulfite ou cartolinas para a criação dos elementos de design
- Marcadores e lápis de cor para desenhar
- Lanterna para representar os 0s e 1s
- Cola, tesoura e fita adesiva para a prototipagem

Desenvolvimento da atividade:

1. Introdução e Perguntas Norteadoras

- Comece com uma roda de conversa, utilizando perguntas norteadoras para despertar o interesse das crianças sobre como os computadores funcionam e introduzir o conceito de numeração binária. Pergunte, por exemplo:
 - "Como você acha que o computador entende os comandos que a gente dá?"
 - "Você sabia que os computadores falam uma língua diferente da nossa? Eles usam só dois números, 0 e 1!"
 - "Por que será que eles só usam esses dois números?"

- Explique o conceito de numeração binária de forma lúdica, utilizando exemplos visuais, como uma lanterna acesa (1) e apagada (0) para representar os números binários.
- Ressalte que a numeração binária é a linguagem que os computadores usam para processar informações de maneira simples e eficiente.

2. Exemplo de Sequência Lógica

- Mostre um exemplo prático para demonstrar a importância da sequência lógica em uma história. Use o glossário como referência:
 - "001: A árvore do parque estava cheia de maçãs"
 - "010: Luna pegou uma maçã"
 - "011: Foi para a escola."
 - "100: A maçã foi dada para a professora."
- Explique que algumas ações dependem de outras. Por exemplo, "A maçã foi dada para a professora" só pode acontecer depois de "Foi para a escola".
- Reforce que a sequência lógica é importante para que a história faça sentido, assim como os computadores seguem uma ordem para executar comandos.

3. Introdução da Tabela Binária

- Separe as crianças em grupos de 5.
- Entregue para grupo uma tabela com quatro espaços numerados em binário (001 a 100).
- Explique que cada número binário representa uma ação, e as crianças precisarão preencher os espaços com as partes da história em uma ordem que faça sentido.

4. Prototipagem - Construindo as Peças da História

- Instrua as crianças a pensar em uma história simples, com uma sequência de ações que dependam umas das outras. Por exemplo:
 - "001: Acordo e escovo os dentes."
 - "010: Tomo o café da manhã."
 - "011: Brinco no jardim."
 - "100: Volto para casa."
- Oriente as crianças a desenhar cada parte da história em fichas e, em seguida, organizá-las na tabela binária na ordem correta.

4. Dinâmica de Validação

- Reúna todos para uma roda de conversa e peça para que cada grupo explique sua história, seguindo a sequência da tabela.
- Os demais colegas devem verificar se a história faz sentido e se a sequência lógica foi respeitada.
- Incentive os colegas a darem feedback sobre a clareza e a organização das histórias.

5. Reflexão Final

- Conduza uma discussão com perguntas como:
 - "O que aconteceu quando a sequência da história não fazia sentido?"
 - "Como foi organizar a história usando os números binários?"
 - "Foi fácil para os seus colegas entenderem a sua história? Por que sim ou por que não?"
 - "O que você faria diferente se pudesse criar outro código?"
- Explique que entender e respeitar a ordem das ações é essencial tanto para criar histórias quanto para programar computadores.
- As crianças terão a chance de iterar e melhorar seus designs, pensando em como poderiam tornar suas representações mais claras e fáceis de entender.

6. Conexão com a Realidade Computacional

- Relacione o processo de criação das histórias com a forma como os computadores processam informações.
- Explique que, assim como as crianças organizaram suas histórias, os computadores seguem sequências lógicas para realizar tarefas e que essa organização é o que permite que eles funcionem corretamente.

Isso no meu mundo:

Aproximar a realidade da criança, com o funcionamento de um computador. Dessa forma, compreender que da mesma maneira que nos comunicamos com diferentes tipos de linguagens, o computador também utiliza de uma linguagem (numeração binária) para executar os comandos solicitados.

Avaliação:

A avaliação desta atividade será realizada em duas etapas complementares: observação da professora e autoavaliação das crianças.

1. Observação da Professora

- Durante a criação das histórias e a organização na tabela binária, a professora observará os seguintes pontos:
 - **Sequência Lógica:** As crianças foram capazes de organizar os elementos da história na tabela binária de forma coerente, respeitando a ordem lógica das ações?
 - **Clareza na Criação dos Elementos:** Os elementos da história criados pelas crianças são claros e fáceis de identificar?
 - **Preenchimento da Tabela:** As crianças compreenderam como utilizar os números binários na tabela para sequenciar suas histórias corretamente?
 - **Colaboração em Grupo:** Houve participação ativa de todos os membros dos grupos na criação e organização das histórias?

- **Interpretação e Validação:** As crianças conseguiram explicar suas histórias de forma que os colegas ou professoras pudessem compreendê-las, utilizando o glossário e a tabela como suporte?

2. Atividade Prática com Verificação Imediata

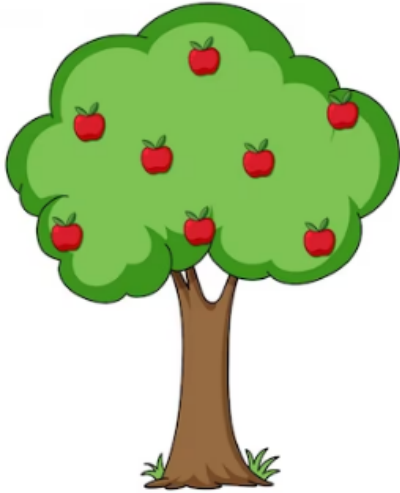
- A professora coloca números binários na lousa e as crianças devem indicar o número correspondente em decimal.
- Para verificar a compreensão, ela pode questionar as crianças sobre a sequência, pedindo que expliquem como chegaram à resposta.
- Caso alguma criança se confunda, a professora pode intervir com perguntas investigativas, como:
 - "Será que este número corresponde ao cartão certo?"
 - "Vamos checar a sequência de numeração novamente?"

3. Autoavaliação das Crianças

- Ao final da atividade, as crianças participarão de uma roda de conversa para avaliar o processo e refletir sobre sua experiência. Algumas perguntas que podem ser feitas:
 - "O que você mais gostou de fazer nesta atividade?"
 - "Foi fácil criar sua história usando os números binários? Por quê?"
 - "Você conseguiu colocar as ações na ordem certa na tabela? Teve alguma parte que foi mais difícil?"
 - "Se pudesse fazer a atividade novamente, o que mudaria na sua história ou na forma como organizou os elementos?"
- A professora pode registrar as respostas das crianças para identificar aspectos positivos e dificuldades enfrentadas durante a atividade. Esse feedback será útil para ajustar futuras implementações.

Esse processo une elementos de verificação prática, colaboração e reflexão, promovendo aprendizado ativo e centrado nas crianças.

Glossário:



A árvore do parque estava cheia de maçãs.



Luna pegou uma maçã.



Foi para a escola.



A maçã foi dada para a professora.

Tabela com a numeração binária:

1

10

11

100

Recursos de apoio ao professor:

Eu TI Ensino. Entenda o sistema binário e como ele funciona. (Informática Básica). YouTube, 2020. Disponível em: <<https://www.youtube.com/watch?v=q3xLvOsqhpo>>. Acesso em: 06/04/2026.

Eu TI Ensino. Conversão de bases numéricas: Binário x Decimal. (Informática Básica). YouTube, 2020. Disponível em: <<https://www.youtube.com/watch?v=VcNSBwQjVnQ>>. Acesso em: 06/04/2026.

Referências:

CORMEN, Thomas H.; LEISERSON, Charles E.; RIVEST, Ronald L.; STEIN, Clifford. *Algoritmos: Teoria e Prática*. 3ª ed. São Paulo: Editora Campus, 2022.

STALLINGS, William. *Computer Organization and Architecture*. 10ª ed. Boston: Pearson, 2020.

TANENBAUM, Andrew S.; WETHERALL, David J. *Redes de Computadores*. 5ª ed. São Paulo: Pearson, 2011.

Plano de Atividade

Tema	Segurança da informação
Título	Ambiente virtual - Segurança para além das telas
Conhecimento	Privacidade e segurança de dados
Faixa Etária	4 a 5 anos
Duração	4 aulas ¹

Conhecimento em Computação:

Privacidade e segurança de dados são pilares fundamentais na computação, especialmente quando se trata da proteção de crianças no ambiente digital. Privacidade refere-se ao controle sobre informações pessoais, enquanto a segurança da informação envolve práticas e ferramentas para proteger esses dados contra acessos não autorizados ou usos mal-intencionados (Stallings, 2017). Esses conceitos são essenciais para prevenir riscos que variam desde fraudes e vazamentos de informações até situações graves, como abuso infantil online.

No contexto digital, crianças podem estar vulneráveis a interações perigosas, especialmente em redes sociais, jogos online e aplicativos de mensagens. Ataques como phishing podem ser usados para enganar crianças a fornecer informações pessoais, como endereços, nomes completos ou dados de familiares. Esses dados, se caírem nas mãos erradas, podem ser utilizados para abordagens mal-intencionadas, como tentativas de contato direto ou chantagem emocional. Reconhecer e evitar esses ataques é uma habilidade fundamental que pode ser ensinada por meio de práticas como verificar a origem de mensagens e nunca compartilhar informações sem a supervisão de um adulto.

Os ambientes digitais também podem ser explorados por indivíduos mal-intencionados para o abuso infantil online, uma forma de crime que utiliza plataformas digitais para aliciamento, exploração ou compartilhamento indevido de imagens de crianças. Embora o tema seja sensível, é essencial que professores compreendam sua relação com privacidade e segurança de dados, capacitando-se para instruir crianças sobre como identificar situações suspeitas. Por exemplo, mensagens de desconhecidos pedindo fotos ou informações pessoais devem ser imediatamente reportadas a um adulto responsável.

Na computação, mecanismos como criptografia e autenticação de múltiplos fatores são usados para proteger informações e dificultar o acesso não autorizado a contas e dispositivos.

¹ Esta duração é uma estimativa de tempo e pode ser flexibilizada de acordo com a demanda da turma.

Esses conceitos podem ser adaptados para o público infantil, enfatizando que senhas fortes e a consulta a um adulto antes de compartilhar qualquer informação são práticas indispensáveis para garantir a segurança. Além disso, o uso de configurações de privacidade em redes sociais e aplicativos permite limitar quem pode visualizar ou interagir com os perfis das crianças, reduzindo a exposição a interações potencialmente perigosas.

A conscientização sobre a pegada digital é outro aspecto crucial. O rastro deixado por ações online, como postagens em redes sociais ou histórico de navegação, pode ser explorado por terceiros para monitorar ou manipular as atividades das crianças. Orientar sobre os cuidados ao compartilhar informações pessoais ou fotos, destacando que uma vez postadas na internet podem se tornar permanentes, ajuda a prevenir problemas futuros.

Por fim, a segurança infantil online também envolve educação sobre comportamentos suspeitos. Professores podem apresentar exemplos práticos, como:

- Mensagens de estranhos solicitando amizade ou informações.
- Links prometendo prêmios ou jogos gratuitos, que podem conter malwares ou servir como isca para capturar dados.
- Convites para conversas privadas ou encontros presenciais, que devem ser prontamente reportados.

Além das práticas técnicas, é necessário enfatizar a importância do diálogo entre crianças e adultos. O ensino de computação pode incluir simulações de situações reais, onde as crianças aprendam a identificar riscos e responder de forma segura, sempre buscando ajuda de um responsável.

A abordagem de privacidade e segurança de dados no ensino de computação não apenas protege crianças de riscos online, mas também promove a construção de um ambiente digital mais ético e consciente, conectando a tecnologia com práticas responsáveis.

Objetivo:

Compreender a importância do uso seguro de equipamentos em ambiente virtual, preservando a privacidade e segurança de dados, construindo mecanismos de defesa e proteção contra o abuso sexual infantil.

Habilidades do Século XXI:

- **Pensamento crítico e resolução de problemas:** Espera-se que a criança construa, a partir das atividades desenvolvidas, postura crítica referente aos conteúdos e relações e interações disponíveis na internet.

Eixos e Habilidades da BNCC:

- **“ESPAÇOS, TEMPOS, QUANTIDADES, RELAÇÕES E TRANSFORMAÇÕES” (EI03ET03):** Identificar e selecionar fontes de

Este plano foi inspirado no plano de atividades criado pelos participantes da Atividade Curricular de Integração Ensino, Pesquisa e Extensão (ACIEPE) “Educação em Computação para crianças de 4 e 5 anos: preparando professores para a formação de usuários ativos de tecnologia”

informações, para responder a questões sobre a natureza, seus fenômenos, sua conservação.

Eixos e Habilidades da BNCC Computação - Educação Infantil:

- **“CULTURA DIGITAL” (EI03CO10):** Utilizar tecnologia digital de maneira segura, consciente e respeitosa.

Material necessário para a atividade:

- Livro “A menina das cores”
- Imagens de exemplos de informações pessoais (foto, número de telefone, endereço)
- Computador ou tablet seguro para demonstração do ambiente virtual
- Papéis, canetinhas, lápis de cor para os desenhos e protótipos
- Materiais para confecção de cartazes e panfletos: folhas de papel grandes, adesivos, tinta, etc.

Desenvolvimento da atividade:

1: Introdução ao Conceito de Privacidade e Segurança Online

- Comece a aula com a leitura do livro A Menina das Cores (ver Referências). Leia em voz alta, mostrando as ilustrações e incentivando as crianças a se conectarem com a história.
- Relacione a história da personagem com o conceito de privacidade. Diga: “Assim como a menina do livro guardava suas cores para protegê-las, nós também precisamos proteger informações importantes, como nossas fotos, nomes e endereços.”
- Pergunte: "O que aconteceria se alguém tentasse pegar as cores da menina sem a permissão dela? Isso seria certo ou errado? Por quê?"
- Apresente imagens de dados pessoais, como fotos e endereços, e discuta quais devem ser protegidos. Relacione com o tema de abuso infantil dizendo: “Algumas pessoas podem pedir informações para fazer coisas erradas. Por isso, nunca devemos compartilhar essas informações sem falar com um adulto de confiança.”
- Explique que, na internet, existem pessoas boas, mas também há quem queira enganar ou machucar. Reforce que as crianças devem sempre contar para um adulto se algo estranho acontecer.

2: Exploração do Ambiente Virtual

- Mostre às crianças um site infantil seguro e destaque os elementos de segurança, como o cadeado na barra de endereço. Explique: “Esse cadeado é como um sinal de proteção. Ele nos diz que o site é seguro para navegar.”
- Apresente exemplos de mensagens ou links suspeitos, como “Clique aqui para ganhar um prêmio!” e pergunte: “Vocês acham que isso é seguro? Por que não devemos clicar sem perguntar a um adulto?”

- Aborde o abuso infantil: Diga: “Às vezes, alguém pode enviar mensagens pedindo fotos ou informações pessoais. Isso é muito perigoso e deve ser contado para um adulto imediatamente. Se alguém pedir para manter isso em segredo, é ainda mais importante contar para um responsável.”
- Pergunte às crianças como reagiriam em diferentes situações, como: “O que vocês fariam se recebessem uma mensagem de alguém pedindo para falar em particular ou mandar uma foto?” Ensine-as a identificar e evitar essas interações perigosas.

Dica: Um exemplo de site infantil seguro é o **Clubinho Salva-Vidas** (<https://clubinhosalvavidas.com.br>), desenvolvido para promover a conscientização de crianças sobre temas como segurança e cidadania de maneira lúdica e educativa

3: Projeto de Espaço Virtual Seguro

- Forme pequenos grupos e peça para cada um desenhar como seria um espaço virtual seguro. Oriente: “Pensem em elementos que protejam as pessoas nesse espaço, como cadeados, guardiões ou avisos dizendo ‘não compartilhe informações pessoais’.”
- Inclua o tema de abuso infantil: Peça que os grupos pensem em maneiras de proteger crianças contra pessoas que querem machucar, incluindo alertas como “Nunca fale com estranhos sem contar a um adulto” ou “Aqui ninguém pode pedir informações pessoais.”
- Cada grupo deve mostrar seu desenho à turma e explicar como os elementos criados ajudam a proteger as pessoas no ambiente digital.

4: Criação de Materiais de Prevenção e Apresentação

- Peça às crianças que criem cartazes e panfletos com mensagens de conscientização sobre segurança online. Sugira incluir frases como:
 - “Nunca compartilhe informações com estranhos.”
 - “Se algo estranho acontecer, fale com um adulto de confiança.”
 - “Cuidado com mensagens pedindo fotos ou informações pessoais.”
- Diga que esses materiais serão expostos na escola para ensinar outras crianças e adultos sobre como se proteger na internet.
- Organize uma apresentação onde as crianças expliquem o que aprenderam, conectando os cartazes às situações de proteção contra abusos.

5. Reflexão Final

- Conduza um jogo de perguntas para revisar os conceitos aprendidos:
 - “Se alguém pedir para você guardar um segredo que parece errado, o que você faz?”
 - “Por que nunca devemos compartilhar informações sem falar com um adulto?”
 - “Como sabemos se um site é seguro?”

- Finalize reforçando que proteger informações na internet é essencial para evitar que pessoas mal-intencionadas possam causar mal, especialmente a crianças. Reforce a ideia de que sempre podem contar com um adulto de confiança para ajudá-las.

Isso no meu mundo:

Na nossa vida, estamos sempre nos conectando com outras pessoas, seja em casa, na escola ou até pela internet. Assim como temos regras para manter nossas coisas seguras no mundo real, também precisamos cuidar das nossas informações quando estamos online. Com esta atividade, as crianças vão aprender que existem certas informações que são muito importantes e devem ser protegidas, como nosso nome, endereço e fotos. Entender sobre privacidade e segurança de dados no mundo virtual é essencial para garantir que, mesmo navegando na internet, as crianças estejam seguras, assim como estão no ambiente familiar. Isso significa aprender a não compartilhar informações sem a supervisão de um adulto, saber identificar situações que podem ser perigosas e usar a internet de uma forma mais consciente e cuidadosa.

Avaliação:

A avaliação será realizada após a conclusão das atividades, utilizando diferentes métodos para verificar a compreensão dos conceitos de privacidade e segurança da informação. O professor pode aplicar as seguintes estratégias:

- Avalie a capacidade das crianças de explicar o que criaram nos cartazes e panfletos. Observe se as crianças conseguem descrever as informações pessoais que não devem ser compartilhadas e quais são os cuidados necessários para navegar na internet de forma segura.
- Realize perguntas individuais para verificar se as crianças compreenderam os conceitos:
 - "Se alguém na internet pedir o seu endereço, o que você deve fazer?",
 - "Por que é importante contar para um adulto antes de compartilhar alguma informação online?"
- Crie situações hipotéticas, como: "E se você estiver jogando e aparecer uma mensagem pedindo para clicar em um link, o que você faria?". Isso ajudará a entender como as crianças aplicariam o aprendizado na prática.

Recursos de apoio ao professor:

Smile and Learn - Português. Privacidade online para crianças - Proteção e segurança na internet para crianças. YouTube, 2020. Disponível em: <<https://www.youtube.com/watch?v=IRYbq9EMyNM>>. Acesso em: 06/04/2026.

Manual do mundo. O QUE INTERNET SABE sobre VOCÊ (e você NEM IMAGINA). YouTube, 2023. Disponível em: <<https://www.youtube.com/watch?v=VjgtiyTGzHk>>. Acesso em: 06/04/2026.

Referências:

CÂNDIDO, Rita. *A Menina das Cores* / Rita Cândido. São Carlos: Editora Scienza, 2021.

MITCHELL, Brian. *Web Security for Network and System Administrators*. Boston: Cengage Learning, 2009.

SCHNEIER, Bruce. *Applied Cryptography: Protocols, Algorithms, and Source Code in C*. 2. ed. New York: Wiley, 1996.

SOLOVE, Daniel J. *The Digital Person: Technology and Privacy in the Information Age*. New York: NYU Press, 2004.

STALLINGS, William. *Cryptography and Network Security: Principles and Practice*. 7. ed. Upper Saddle River: Pearson, 2017.

Plano de Atividade

Tema	Processamento de dados
Título	Labirinto do sons
Conhecimento	Entrada - Processamento - Saída de dados
Faixa Etária	4 a 5 anos
Duração	4 horas ¹

Conhecimento em Computação:

O processamento de dados é o núcleo do funcionamento de qualquer sistema computacional. Em sua essência, um computador funciona como uma máquina que processa informações utilizando um sistema binário, onde todos os dados e comandos são representados por 0s e 1s. Essa codificação binária é a base para todas as operações, desde cálculos matemáticos até a exibição de imagens e vídeos. Alan Turing, em sua teoria sobre máquinas computacionais, demonstrou como o sistema binário é suficiente para executar qualquer operação lógica e aritmética (Turing, 1936).

Para realizar o processamento, o computador segue um ciclo básico dividido em três etapas principais:

- **Entrada (Input):** Dados ou instruções são fornecidos ao computador por meio de dispositivos como teclado, mouse, sensores ou outros meios. Esses dados podem ser números, texto, comandos ou sinais digitais.
- **Processamento:** A Unidade Central de Processamento (CPU) interpreta as instruções recebidas, realiza cálculos e toma decisões com base nos dados de entrada. A CPU executa essas tarefas de acordo com uma sequência de instruções pré-definidas, organizadas em programas ou algoritmos. Essa abordagem modular foi formalizada na arquitetura de von Neumann, que estrutura os sistemas em unidades de entrada, processamento, memória e saída (Von Neumann, 1945).
- **Saída (Output):** Os resultados do processamento são apresentados ao usuário por meio de dispositivos de saída, como monitores, impressoras ou alto-falantes. Esses resultados podem variar de um simples texto em uma tela até respostas complexas em sistemas interativos.

O papel do processamento de dados é transformar as entradas em saídas úteis e compreensíveis. Isso envolve operações como filtragem, análise, classificação e apresentação

¹ Esta duração é uma estimativa de tempo e pode ser flexibilizada de acordo com a demanda da turma.

de dados, todas realizadas por meio de algoritmos. Donald Knuth define algoritmos como "sequências precisas de instruções destinadas à resolução de problemas computacionais", destacando que a clareza e a precisão dessas instruções são cruciais para o funcionamento correto do sistema (Knuth, 1997).

Adicionalmente, é fundamental compreender que os dados e os comandos são conceitos distintos:

- **Dados:** Representam as informações fornecidas, como números, texto ou imagens.
- **Comandos:** São as instruções que determinam como os dados devem ser processados.

Por exemplo, ao somar dois números, os números são os dados, enquanto a instrução "somar" é o comando que guia o processamento. Essa distinção é essencial para entender como os computadores operam e realizam tarefas complexas a partir de operações básicas.

Objetivo:

O objetivo desta atividade é possibilitar a compreensão de como funciona o processamento de dados em um computador, que envolve três etapas: entrada, processamento e saída. Assim como usamos diferentes tipos de linguagem para nos comunicar, os computadores também utilizam uma linguagem especial para entender o que devem fazer.

Habilidades do Século XXI:

- **Criatividade e Inovação:** Espera-se que a criança desenvolva criatividade durante a criação do jogo de labirinto.

Eixos e Habilidades da BNCC:

- **“TRAÇOS, SONS, CORES E FORMAS” (EI03TS01):** Utilizar sons produzidos por materiais, objetos e instrumentos musicais durante brincadeiras de faz de conta, encenações, criações musicais, festas.
- **“CORPO, GESTOS E MOVIMENTOS” (EI03CG05):** Coordenar suas habilidades manuais no atendimento adequado a seus interesses e necessidades em situações diversas.

Eixos e Habilidades da BNCC Computação - Educação Infantil:

- **“PENSAMENTO COMPUTACIONAL” (EI03CO03):** Experimentar a execução de algoritmos brincando com objetos (des)plugados.
- **“PENSAMENTO COMPUTACIONAL” (EI03O0C4):** Criar e representar algoritmos para resolver problemas.

Material necessário para a atividade:

- Fita Adesiva
- Cones, Caixas ou Outros Objetos Pequenos
- Venda para os Olhos
- Papéis e Lápis de Cor ou Marcadores
- Instrumentos ou Objetos para Criar Sons (opcional)

Desenvolvimento da atividade:

1. Introdução ao Conceito de Processamento de Dados

- Explique às crianças, de maneira simples, que o computador funciona transformando informações. Ele recebe algo que chamamos de "entrada", faz um trabalho com essa informação, que chamamos de "processamento", e depois entrega um resultado, chamado de "saída".
- Mostre exemplos cotidianos para facilitar a compreensão, como uma máquina de suco: colocamos frutas (entrada), a máquina espreme e mistura (processamento), e o suco pronto sai (saída).
- Ressalte que, no computador, a "entrada" pode vir de um teclado ou mouse, o "processamento" acontece dentro da CPU, e a "saída" pode ser algo que vemos na tela ou ouvimos nos alto-falantes.
- Faça perguntas para estimular a curiosidade, como:
 - "Quem sabe me dizer como o computador 'pensa' para mostrar algo na tela?"
 - "O que acontece quando clicamos em algo com o mouse?"

2. Divisão em Grupos:

- Divida a turma em dois grupos e explique que cada grupo criará uma linguagem de comunicação baseada em sons, sem utilizar palavras.
- Diga que essa atividade é para mostrar como computadores usam códigos para entender e realizar tarefas.

3. Criação da Linguagem:

- Peça que cada grupo discuta e escolha sons para representar comandos como "andar para frente", "virar à esquerda" ou "virar à direita". Lembre às crianças que os comandos serão utilizados para guiar uma outra criança por um labirinto.
- Auxilie os grupos a criar uma lista organizada com os sons e seus significados, garantindo que todos entendam.
- Diga que esses sons serão usados para "conversar" com um amigo, como fazemos com computadores ao usar linguagens de programação.

4. Preparação do Labirinto:

- Desenhe um labirinto no chão com fita adesiva, criando um caminho com obstáculos.
- Peça a um dos grupos que posicione os obstáculos, certificando-se de que o caminho seja desafiador, mas possível de ser completado.

5. Execução da Atividade - Entrada, Processamento e Saída:

- Selecione duas crianças por grupo: uma será o "robô vendado" e outra será o "programador", que dará os comandos sonoros.
- Informe que os sons criados pelo grupo serão os "dados de entrada", o "robô" irá processar esses sons para decidir como agir, e o resultado será alcançar o final do labirinto.
- Observe se os comandos são claros e ajude, caso necessário, a ajustar a comunicação.

6. Revisão e Iteração:

- Se o "robô" encontrar dificuldades, peça ao grupo que revise sua linguagem de comandos.
- Mostre que ajustes e correções fazem parte do aprendizado e do trabalho com sistemas computacionais.

7. Reflexão Final:

- Conduza uma roda de conversa com perguntas como:
 - "O que aprendemos sobre como dar instruções claras?"
 - "Por que é importante revisar e ajustar os comandos?"
- Reforce que computadores só funcionam corretamente quando recebem comandos precisos e que o processamento de dados é como organizar informações para obter resultados úteis.

Isso no meu mundo:

Quando brincamos de labirinto, aprendemos que, assim como precisamos de instruções claras para ajudar nosso colega vendado a chegar ao final do caminho, os computadores também precisam de comandos precisos para fazer qualquer coisa. Eles não entendem nossa língua da mesma forma que nós, então usamos uma linguagem especial que o computador consegue entender, chamada de código. Da mesma forma que na atividade, em que alguém dava instruções (entrada), e o amigo vendado seguia as orientações para encontrar a saída (processamento e saída), os computadores funcionam de forma parecida. Eles recebem informações, processam essas informações e, então, mostram um resultado. Assim, podemos ver que, mesmo nas brincadeiras do nosso dia a dia, usamos processos muito parecidos com os dos computadores — como quando alguém nos dá instruções sobre onde ir e o que fazer!

Avaliação:

Após a realização da atividade, o professor fará algumas perguntas para ajudar as crianças a refletirem sobre o processo e para avaliar o entendimento dos conceitos:

- Como vocês pensaram na criação dos sons (código)?
- O que poderia acontecer se a criança recebesse os comandos de forma correta? E se recebesse de forma errada?
- O que acontece se algum comando tem mais de um significado? Como isso afetaria a navegação pelo labirinto?
- Qual seria o menor número de sons necessários para que o código fosse funcional?

Recursos de apoio ao professor:

CV - Informática. Informática: Entrada, Processamento e Saída (E-P-S) - Lógica de Programação e Dispositivos I/O. YouTube, 2025. Disponível em: <<https://www.youtube.com/watch?v=6whIS5h4re0>>. Acesso em: 06/04/2026.

Referências:

KNUTH, Donald E. *The Art of Computer Programming*. 3. ed. Boston: Addison-Wesley, 1997. v. 1. 672 p.

TURING, Alan M. *On Computable Numbers, with an Application to the Entscheidungsproblem*. Proceedings of the London Mathematical Society, v. 2, n. 42, p. 230–265, 1936.

VON NEUMANN, John. *First Draft of a Report on the EDVAC*. Pennsylvania: Moore School of Electrical Engineering, 1945.

Plano de Atividade

Tema	Segurança da informação
Título	Trilha dos protetores da internet
Conhecimento	Uso seguro da Internet
Faixa Etária	4 e 5 anos
Duração	8 horas ¹

Conhecimento em computação:

A segurança da informação é uma área essencial da computação, voltada para a proteção de dados contra acessos não autorizados, alterações indevidas e destruição maliciosa ou acidental. Baseia-se em três princípios fundamentais: confidencialidade, integridade e disponibilidade. A confidencialidade garante que somente pessoas autorizadas tenham acesso às informações, protegendo dados sensíveis de olhares curiosos ou mal-intencionados (Stallings, 2017). A integridade assegura que as informações permaneçam inalteradas, exceto por quem tem permissão para modificá-las, enquanto a disponibilidade garante que os dados estejam acessíveis sempre que forem necessários, independentemente de falhas ou ataques.

No ambiente digital, onde informações são constantemente compartilhadas e armazenadas, ameaças como phishing, malwares e ataques de engenharia social são frequentes. O phishing, por exemplo, é uma estratégia em que golpistas se passam por organizações confiáveis, como bancos ou serviços populares, para induzir as pessoas a compartilhar informações confidenciais, como senhas ou números de cartões de crédito (Mitnick e Simon, 2011). Já os malwares, que incluem vírus e ransomware, são softwares projetados para roubar dados ou causar danos aos sistemas, muitas vezes disfarçados em arquivos ou aplicativos aparentemente inofensivos (Pfleeger e Pfleeger, 2015). A engenharia social, por sua vez, utiliza a manipulação psicológica para convencer as vítimas a revelar informações sensíveis, explorando a confiança ou a distração.

Proteger-se dessas ameaças envolve a adoção de boas práticas, que combinam tecnologia e comportamento consciente. Por exemplo, o uso de senhas fortes é uma medida simples, mas eficaz. Essas senhas devem conter uma combinação de letras maiúsculas e minúsculas, números e símbolos, e evitar informações óbvias, como datas de nascimento ou sequências numéricas simples (Stallings, 2017). A implementação de autenticação de dois fatores (2FA)

¹ Esta duração é uma estimativa de tempo e pode ser flexibilizada de acordo com a demanda da turma.

é outra camada de proteção que pode fazer a diferença, exigindo um segundo nível de autenticação, como um código enviado para o celular ou e-mail do usuário, para confirmar sua identidade. Além disso, é crucial estar atento ao clicar em links ou baixar arquivos, especialmente de fontes desconhecidas, pois muitas vezes esses podem ser vetores de ataque.

Manter sistemas e aplicativos sempre atualizados é igualmente importante, pois as atualizações frequentemente corrigem falhas de segurança que poderiam ser exploradas por invasores. Por fim, a educação é uma das ferramentas mais poderosas para garantir a segurança da informação. Entender como identificar sinais de perigo, como e-mails fraudulentos ou mensagens suspeitas, ajuda a evitar situações de risco. Saber reconhecer a estrutura de um ataque de phishing, como erros de ortografia em mensagens ou links que levam a páginas estranhas, é fundamental para navegar de forma segura no ambiente digital (Mitnick e Simon, 2011).

Esses conceitos, embora aparentemente técnicos, são acessíveis e podem ser aplicados de forma prática no dia a dia, promovendo a conscientização e formando hábitos que protegem tanto as informações pessoais quanto o bem-estar digital de cada usuário.

Objetivos:

O objetivo desta atividade é promover a compreensão e discussão sobre o uso consciente, ético e seguro da internet e das redes sociais, incentivando as crianças a adotarem práticas responsáveis ao utilizar ferramentas digitais. Além disso, a atividade busca explicar os principais perigos do uso inadequado da internet, ajudando as crianças a reconhecê-los de forma prática e acessível, por meio de rodas de conversa e jogos interativos. Dessa forma, as crianças terão a oportunidade de aprender a navegar com segurança e confiança no ambiente digital.

Habilidades do Século XXI:

- **Criatividade e Inovação:** Espera-se que a criança desenvolva criatividade durante as discussões e criações de cenários. As habilidades de criatividade e inovação poderão ser trabalhadas também durante a criação do jogo de tabuleiro e suas regras.

Eixos e Habilidades da BNCC:

- **“O EU, O OUTRO E O NÓS” (EI03EO04):** Comunicar suas ideias e sentimentos a pessoas e grupos diversos.
- **“TRAÇOS, SONS, CORES E FORMAS” (EI03TS02):** Expressar-se livremente por meio de desenho, pintura, colagem, dobradura e escultura, criando produções bidimensionais e tridimensionais.
- **“ESCUTA, FALA, PENSAMENTO E IMAGINAÇÃO (EI03EF04):** Recontar histórias ouvidas e planejar coletivamente roteiros de vídeos e de encenações, definindo os contextos, os personagens, a estrutura da história.

Eixos e Habilidades da BNCC Computação - Educação Infantil:

- **“CULTURA DIGITAL” (EI03CO10):** Utilizar tecnologia digital de maneira segura, consciente e respeitosa.

Material necessário para a atividade:

- Modelos pré-desenhados de tabuleiros
- Papelão
- Papel sulfite
- Guache
- Caneta/lápis
- Cola

Desenvolvimento da atividade:

1. Identificação do Problema (Roda de Conversa Inicial)

- Inicie uma roda de conversa, perguntando às crianças o que elas sabem sobre a internet. Pergunte, por exemplo:
 - "O que vocês gostam de fazer online?"
 - "Vocês acham que tudo na internet é seguro?"
 - "O que vocês acham que significa estar seguro na internet?"
- Explique de forma simples que na internet existem coisas legais, como jogos e vídeos, mas também perigos, como mensagens de estranhos ou links suspeitos. Use exemplos cotidianos para tornar o tema mais acessível, como "cuidar de sua senha é como guardar uma chave importante".
- Diga que aprenderemos juntos como ser “Protetores da Internet”, ajudando a criar um ambiente digital seguro e divertido.

2. Leitura da HQ e Discussão sobre Malwares:

- Apresente a HQ da Turma da Mônica sobre segurança online, disponível [neste link](#). Leia a história em grupo, incentivando as crianças a observar as situações enfrentadas pelos personagens.
- Ao longo da leitura, destaque pontos importantes, como o que significa proteger uma senha, evitar links desconhecidos e pedir ajuda a um adulto ao encontrar algo estranho na internet.
- Faça perguntas durante e após a leitura, como: "Por que o personagem teve problemas ao clicar no link?" ou "Como ele conseguiu resolver o problema?". Isso ajuda a conectar a narrativa com os conceitos de segurança digital.

3. Ideação - Levantamento de Soluções

- Crie uma extensão da narrativa do HQ, onde as crianças são convidadas a se tornarem personagens da história. Use fantoches, desenhos ou dramatizações para enriquecer a experiência.
- Apresente desafios fictícios que as crianças devem resolver, como identificar links suspeitos ou criar uma senha segura para proteger um tesouro virtual.
- Mostre exemplos visuais, como um e-mail falso ou um link perigoso, para que elas identifiquem os sinais de alerta.

4. Criação do Jogo de Tabuleiro: Explorando a Segurança na Internet

- Mostre um exemplo de tabuleiro básico com casas coloridas que representam ações seguras (azuis) e ações perigosas (vermelhas). Explique como o jogo ensinará segurança online de forma divertida.
- Divida as crianças em pequenos grupos e forneça modelos pré-desenhados de tabuleiros com espaços para completar com desafios e boas práticas, baseados nos conceitos aprendidos.
- Dê exemplos concretos para incluir no jogo, como:
 - Casas seguras: "Você usou uma senha forte. Avance duas casas."
 - Casas de perigo: "Você clicou em um link suspeito. Volte três casas."
 - Perguntas para avançar: "O que é uma senha forte?" ou "O que você deve fazer ao receber uma mensagem de um estranho?"
- Oriente que cada grupo inclua ações claras e simples no jogo, ajustando conforme o nível de compreensão das crianças.

5. Jogando e Aprendendo

- Guie as crianças para jogarem o tabuleiro, explicando as regras de forma clara. Cada criança pode ser uma peça ou representar um personagem digital.
- Reforce os conceitos de segurança a cada jogada, explicando o motivo por trás das recompensas e penalidades no jogo. Por exemplo: "Você avançou porque sua senha protegeu suas informações."

6. Produção Final: Cartaz de Segurança Online

- Peça às crianças que criem um cartaz coletivo ao final da atividade, com desenhos e frases sobre o que aprenderam no jogo e na leitura da HQ.
- Inclua mensagens como "Cuidado com mensagens de estranhos", "Não clique em links desconhecidos" e "Use senhas fortes para se proteger".
- Use o cartaz como parte de uma campanha de conscientização na escola, para que outras crianças aprendam sobre segurança na internet.

7. Reflexão Final e Sistematização

- Conduza uma roda de conversa final para discutir o que foi aprendido. Pergunte, por exemplo:
 - "O que vocês fariam diferente na internet agora?"
 - "Por que é importante proteger nossos dados?"
- Conecte as práticas aprendidas no dia a dia, mostrando como cada criança pode se tornar um "Protetor da Internet".

Isso no meu mundo:

Nesta atividade, entendemos que a internet pode ser um lugar cheio de coisas legais e úteis, mas também precisamos ter cuidado. Assim como aprendemos a olhar para os dois lados antes de atravessar a rua, precisamos tomar precauções ao navegar online. Aprender sobre segurança na internet nos ajuda a perceber quando algo não está certo, como mensagens suspeitas ou pedidos para compartilhar nossas informações pessoais. Isso nos faz entender que, mesmo no mundo digital, é importante cuidar do que fazemos e proteger nossos dados, garantindo que nossa experiência na internet seja segura e divertida. Assim, conseguimos aplicar tudo isso em nosso dia a dia, seja ao usar o celular para jogar, conversar com amigos, ou acessar sites.

Avaliação:

As crianças criarão um cartaz coletivo com as boas práticas de segurança online e sentimentos relacionados à perda de dados pessoais. O cartaz será usado como forma de avaliar se as crianças compreendem as consequências e as boas práticas relacionadas à segurança na internet.

Ao final da atividade, o professor fará algumas perguntas simples, como:

- "O que podemos fazer para garantir nossa segurança na internet?"
- "Por que não devemos compartilhar nossas senhas com qualquer pessoa?"

As respostas ajudarão a avaliar se as crianças entenderam os conceitos principais sobre uso seguro da internet.

Recursos de apoio ao professor:

LearnFree em Português. Segurança na Internet: Sete conselhos para prevenir riscos nas redes sociais. YouTube, 2016. Disponível em: <<https://www.youtube.com/watch?v=QFdkggG34wo>>. Acesso em: 06/04/2026.

DuarttHub. Todos os Vírus de Computador Explicados em 8 minutos. YouTube, 2025. Disponível em: <https://www.youtube.com/watch?v=ASJ8QeWPd_o>. Acesso em: 06/04/2026.

Referências:

MITNICK, Kevin; SIMON, William L. *The Art of Deception: Controlling the Human Element of Security*. New York: Wiley, 2011.

PFLEEGER, Charles P.; PFLEEGER, Shari L. *Security in Computing*. 5. ed. Upper Saddle River: Prentice Hall, 2015.

SOUZA, Mauricio de; MAURICIO DE SOUSA PRODUÇÕES. *Seja incrível na internet*. São Paulo: Mauricio de Sousa Produções, 2022. Disponível em: <https://turmadamonica.uol.com.br/revistasespeciais/?ed=seja-incrivel-na-internet>. Acesso em: 15 jan. 2025.

STALLINGS, William. *Cryptography and Network Security: Principles and Practice*. 7. ed. Upper Saddle River: Pearson, 2017.

Plano de Atividade

Tema	Uso consciente de tecnologia
Título	Como lidamos com os vídeos que assistimos na internet?
Conhecimento	Tempo de tela
Faixa Etária	4 e 5 anos
Duração	2 horas ¹

Conhecimento em Computação:

A computação está integrada à vida cotidiana por meio de telas que mediam interações em dispositivos como celulares, tablets, televisores e computadores. Essas interfaces visuais são projetadas para facilitar o uso de sistemas computacionais e garantir uma experiência amigável ao usuário (Shneiderman et al., 2016). Contudo, o uso excessivo de telas pode causar impactos negativos, como fadiga ocular, sedentarismo e prejuízos ao desenvolvimento motor e social, especialmente em crianças (Anderson e Subrahmanyam, 2017).

O conceito de tempo saudável de tela busca equilibrar o uso dessas tecnologias com outras atividades essenciais, como brincar, interagir com pessoas e praticar exercícios físicos. Embora telas sejam ferramentas valiosas para aprendizado e entretenimento, seu uso deve ser planejado para evitar efeitos prejudiciais. No contexto do ensino de computação, é fundamental problematizar a relação das crianças com as telas, mostrando que a computação não se limita ao uso passivo de dispositivos, mas envolve a criação, análise e implementação de tecnologias com responsabilidade.

A computação proporciona acesso a recursos digitais, mas também oferece oportunidades para integrar atividades práticas e corporais no ensino. Por exemplo, ao ensinar algoritmos, os professores podem utilizar brincadeiras que simulem sequências lógicas, incentivando as crianças a realizar movimentos físicos para representar etapas de um programa. Essa abordagem promove a compreensão conceitual enquanto reduz o tempo sedentário, reforçando a ideia de aprendizado ativo e integrado.

Além disso, o ensino de computação deve abordar o impacto das telas no desenvolvimento humano e social. O design de interfaces acessíveis, como lembretes para pausas e modos de exibição que reduzem a fadiga visual, exemplifica como a computação pode mitigar os efeitos do uso prolongado de dispositivos (Shneiderman et al., 2016). Integrar esses conceitos às aulas ajuda as crianças a compreenderem que a computação pode contribuir para um estilo de vida mais equilibrado e saudável.

¹ Esta duração é uma estimativa de tempo e pode ser flexibilizada de acordo com a demanda da turma.

Por outro lado, estudos indicam que o excesso de tempo de tela está associado ao aumento do sedentarismo e à redução das interações sociais (Anderson e Subrahmanyam, 2017). Dessa forma, é essencial promover um uso consciente das tecnologias, destacando que o aprendizado computacional não substitui atividades essenciais ao desenvolvimento global, como brincadeiras ao ar livre e interações interpessoais.

Ao ensinar computação, os professores podem incentivar discussões sobre o impacto das telas no cotidiano e envolver as crianças em projetos que explorem o design de soluções tecnológicas que promovam hábitos saudáveis. Por exemplo, as crianças podem criar protótipos de aplicativos que incentivam pausas regulares ou mensagens que estimulem atividades físicas. Essas atividades reforçam a noção de que a computação não é apenas uma área técnica, mas também uma disciplina comprometida com o bem-estar humano.

O ensino de computação, portanto, deve equilibrar a inserção das telas com a valorização de atividades práticas, promovendo uma integração responsável entre tecnologia e desenvolvimento humano. Essa abordagem garante que as crianças compreendam não apenas como usar as tecnologias, mas também como projetá-las de forma ética e sustentável, alinhando aprendizado computacional com saúde e bem-estar.

Objetivo:

Possibilitar que a criança compreenda o quão problemático é ficar muito tempo usando uma tela, a fim de sugerir novas ideias de proporção de tempo.

Habilidades do Século XXI:

- **Pensamento Crítico e resolução de problemas:** a criança irá analisar o tempo do vídeo sugerido e considerar uma nova maneira de recriar o mesmo vídeo, evidenciando tempo de qualidade na transmissão de informações.

Eixos e Habilidades da BNCC:

- **“O EU, O OUTRO E O NÓS” (EI03EO03):** Ampliar as relações interpessoais, desenvolvendo atitudes de participação e cooperação.
- **“O EU, O OUTRO E O NÓS” (EI03EO04):** Comunicar suas ideias e sentimentos a pessoas e grupos diversos.
- **“TRAÇOS, SONS, CORES E FORMAS” (EI03TS03):** Reconhecer as qualidades do som (intensidade, duração, altura e timbre), utilizando-as em suas produções sonoras e ao ouvir músicas e sons.
- **“ESCUTA, FALA, PENSAMENTO E IMAGINAÇÃO” (EI03EF04):** Recontar histórias ouvidas e planejar coletivamente roteiros de vídeos e de encenações, definindo os contextos, os personagens, a estrutura da história.
- **“ESPAÇOS, TEMPOS, QUANTIDADES, RELAÇÕES E TRANSFORMAÇÕES” (EI03ET01):** Estabelecer relações de comparação entre objetos, observando suas propriedades.

Eixos e Habilidades da BNCC Computação - Educação Infantil:

- **“CULTURA DIGITAL” (EI03CO10):** Utilizar tecnologia digital de maneira segura, consciente e respeitosa.
- **“CULTURA DIGITAL” (EI03CO11):** Adotar hábitos saudáveis de uso de artefatos computacionais, seguindo recomendações de órgãos de saúde competentes.

Material necessário para a atividade:

- Mídias digitais (celular, computador, câmera filmadora, projetor multimídia, internet)
- Lousa e giz

Desenvolvimento da atividade:

1: Introdução ao Uso de Telas

- Inicie uma roda de conversa para explorar o uso de telas pelas crianças. Pergunte:
 - “Quais dispositivos vocês usam no dia a dia, como celular, tablet ou TV?”
 - “O que vocês mais gostam de fazer nesses dispositivos?”
 - “Quanto tempo vocês acham que passam usando telas?”
- Explique o conceito de tempo saudável de tela: “É importante equilibrar o uso de telas com outras atividades, como brincar ao ar livre, conversar com a família e descansar. Assim, as telas nos ajudam a aprender e nos divertir sem prejudicar nossa saúde.”
- Mostre um exemplo de cronograma equilibrado para o dia de uma criança:
 - **Manhã:** Café da manhã, brincar ao ar livre, assistir a um vídeo educativo (30 minutos).
 - **Tarde:** Atividades escolares, brincar com brinquedos, assistir a um desenho (20 minutos).
 - **Noite:** Jantar em família, leitura de um livro, dormir cedo.
- Explique que o objetivo do cronograma é ajudar a organizar o tempo para aproveitar o dia com várias atividades diferentes.

2: Assistindo ao Vídeo e Atividades Alternativas

- Mostre um vídeo curto (aproximadamente 5 minutos). Sugestão: Vídeo curto sobre animais da floresta ou profissões, como Canal "Teca na TV".
- Peça que as crianças realizem outra atividade enquanto assistem ao vídeo, como desenhar ou brincar com objetos simples.
- Pergunte:
 - “Foi fácil ou difícil fazer outra atividade enquanto assistiam ao vídeo?”
 - “O que vocês sentiram ao dividir a atenção entre duas coisas?”
- Relacione a experiência ao uso saudável de telas: “Às vezes, é melhor focar em uma única atividade para aprender ou aproveitar melhor o que estamos fazendo.”

Dica: Um canal no YouTube que oferece conteúdo educativo e adequado para crianças pequenas é o Canal "Mundo Bitá" (<https://www.youtube.com/@MundoBita/videos>).

3: Comparação entre Vídeos Longos e Curtos

- Apresente dois vídeos sobre o mesmo tema (ex.: animais), sendo um mais longo e outro mais curto.
- Sugestão de vídeos:
 - Vídeo curto: “Animais da floresta” (5 minutos).
 - Vídeo longo: Documentário infantil sobre animais (15-20 minutos).
 - Exemplos disponíveis no YouTube Kids ou canais educativos confiáveis.
- Antes de assistir, pergunte:
 - “Vocês acham que vídeos mais curtos ou mais longos nos ensinam mais?”
 - “O que muda quando assistimos vídeos de durações diferentes?”
- Após assistir aos vídeos, peça que as crianças reflitam sobre o uso do tempo:
 - “O que vocês aprenderam com o vídeo curto?”
 - “E com o vídeo longo?”
 - “O tempo do vídeo influenciou como vocês usaram o resto do dia?”
- Diga que vídeos curtos podem ser úteis para aprender algo rapidamente e liberar tempo para outras atividades, enquanto vídeos longos são bons quando queremos aprofundar o conhecimento sobre um tema.

4: Projeto Colaborativo - Planejando um Vídeo Ideal

- Organize as crianças em pequenos grupos e peça que criem o roteiro para um vídeo curto. Oriente:
 - “Escolham um tema simples, como cuidar de plantas, brincar no parque ou contar uma história divertida.”
- Pergunte ao grupo:
 - “Como podemos ensinar ou mostrar algo em poucos minutos?”
 - “Quais imagens ou cenas são mais importantes para o vídeo?”

Dica: Mostre exemplos de storyboards simples para ajudar as crianças a organizar suas ideias com desenhos ou anotações.

5: Reflexão e Conexão com o Cotidiano

- Finalize a atividade com uma roda de conversa. Pergunte:
 - “O que vocês aprenderam sobre como usar o tempo de tela de forma saudável?”
 - “Como podemos usar o que aprendemos para organizar nosso dia?”
- Peça às crianças que desenhem como equilibrariam o uso de telas com outras atividades, como brincar, conversar ou se movimentar.

- Reforce que telas são ferramentas valiosas, mas é importante usá-las de forma equilibrada, aproveitando também o tempo para interagir e brincar.

Isso no meu mundo:

No nosso dia a dia, estamos sempre cercados por telas, como a televisão, o celular e o tablet. Elas fazem parte das nossas brincadeiras, das nossas conversas e até do nosso aprendizado. Mas, assim como em outras áreas da nossa vida, é importante saber a hora de usar e a hora de dar uma pausa. Nesta atividade, vamos ajudar as crianças a entender que o tempo de tela deve ser equilibrado. Assim como a gente precisa de uma boa alimentação e de tempo para se exercitar, também precisamos usar as telas de forma que não afete nossa saúde e nos permita fazer outras atividades importantes, como brincar ao ar livre, conversar com a família ou desenhar. Entender esse equilíbrio é essencial para garantir que as telas sejam uma parte positiva e saudável do nosso dia.

Avaliação:

Após recriar os vídeos, as crianças seriam avaliadas através da produção de desenhos.

Cada criança receberá uma folha de papel dividida em duas partes. De um lado, elas desenharão uma prática saudável de uso de tela, como assistir a um desenho por um curto período e depois brincar ao ar livre. Do outro lado, desenharão uma prática não saudável, como ficar muito tempo em frente à TV sem realizar outras atividades. Esses desenhos permitirão que o professor avalie a compreensão das crianças sobre o equilíbrio no uso da tecnologia.

Após concluírem os desenhos, as crianças participarão de uma roda de conversa para compartilhar o que desenharam. Cada criança explicará seu desenho, promovendo a reflexão sobre as práticas saudáveis e não saudáveis. Essa discussão ajudará a reforçar os conceitos aprendidos e permitirá que o professor esclareça qualquer confusão que surgir.

Durante a discussão, o professor fará algumas perguntas para verificar se as crianças entenderam o conceito de tempo saudável de tela e como isso se aplica ao seu cotidiano:

- "Quando é saudável usar o celular ou o tablet?"
- "O que mais podemos fazer ao invés de assistir à TV por muito tempo?"

Essas perguntas ajudarão a avaliar se as crianças conseguem relacionar o que aprenderam com situações do dia a dia.

Recursos de apoio ao professor:

Explicatricks. Celular e crianças: uso de telas YouTube, 2024. Disponível em: <<https://www.youtube.com/watch?v=kNcVSlr9ars>>. Acesso em: 06/04/2026.

Referências:

ANDERSON, Craig A.; SUBRAHMANYAM, Kaveri. *Digital Screen Time and Youth: Benefits, Risks, and Policy Recommendations*. Journal of Children and Media, v. 11, n. 4, p. 367-372, 2017.

PAPERT, Seymour. *Mindstorms: Children, Computers, and Powerful Ideas*. New York: Basic Books, 1980.

SHNEIDERMAN, Ben; PLAISANT, Catherine; COHEN, Max; JACOBS, Steven. *Designing the User Interface: Strategies for Effective Human-Computer Interaction*. 6. ed. Boston: Pearson, 2016.

Instrumentos de avaliação

O grupo considerou muitas ideias?

- () As crianças consideraram uma ideia.
- () As crianças consideraram algumas ideias.
- () As crianças consideraram muitas ideias.

O grupo considerou muitos tipos de ideias?

- () Os alunos consideraram um tipo de ideia.
- () Os alunos consideraram alguns tipos de ideias.
- () Os alunos consideraram muitos tipos de ideias.

O grupo desenvolveu ideias novas?

- () As crianças desenvolveram uma ideia comum que muitas outras crianças teriam sugerido e/ou replicaram uma ideia existente.
- () As crianças desenvolveram uma ideia interessante que várias outras crianças teriam sugerido e/ou acrescentaram minimamente a uma ideia existente.
- () As crianças desenvolveram uma ideia incomum que poucas outras crianças teriam sugerido e/ou de maneira substancial construíram sobre uma ideia existente de forma incomum.

O grupo detalhou as ideias?

- () As crianças adicionaram poucos detalhes e melhorias às ideias deles.
- () As crianças adicionaram alguns detalhes e melhorias às ideias deles.
- () As crianças adicionaram muitos detalhes e melhorias às ideias deles.

O grupo propôs ideias úteis?

- () As crianças propuseram ideias que podem atender às necessidades do usuário final em determinadas condições.
- () As crianças propuseram ideias que atenderiam às necessidades do usuário final.
- () As crianças propuseram ideias que atenderiam às necessidades do usuário final e agregariam significativamente valor às vidas delas.

Instrumentos de avaliação

O grupo resumizou tópicos ou argumentos?

- ☐ As crianças não organizaram as informações, o que levou a um entendimento inadequado.
- ☐ As crianças, de maneira inconsistente, demonstraram habilidade para organizar as informações, o que levou a um entendimento inadequado.
- ☐ As crianças, de maneira consistente, demonstraram habilidade para organizar as informações, o que levou a um entendimento adequado.

O grupo considerou suposições anteriores?

- ☐ As suposições foram definidas, mas não explicadas como tendo significado para a posição.
- ☐ As suposições foram definidas e vinculadas às ideias do tópico, mas não foram claramente explicadas ou elaboradas.
- ☐ As suposições foram definidas e vinculadas às ideias do tópico; as crianças puderam elaborar suposições e discutir implicações.

O grupo comunica ponto de vista?

- ☐ As crianças não identificam posição própria sobre o assunto.
- ☐ As crianças identificam posição própria sobre o assunto, obtendo apoio da experiência.
- ☐ As crianças identificam posição própria sobre o assunto, obtendo apoio da experiência e de informações não disponíveis em fontes designadas.

O grupo fornece evidências de pesquisa?

- ☐ Nenhuma evidência fornecida para apoiar o argumento.
- ☐ Aceita evidências pelo seu valor nominal, mesmo que sejam incorretas, inadequadas ou deturpadas para apoiar o argumento.
- ☐ As informações são coletadas de fontes apropriadas e confiáveis para dar suporte ao argumento.

O grupo analisou dados?

- ☐ Nenhuma análise de um tópico. As crianças apenas listaram ou definiram conceitos do tópico.
- ☐ As crianças demonstraram capacidade de analisar e fazer interpretações dos tópicos.
- ☐ As crianças demonstraram capacidade de analisar e elaborar interpretações dos tópicos

O grupo considera perspectivas e posições?

- () Nenhuma identificação de outras perspectivas e posições.
- () Identifica outras perspectivas e posições.
- () Identifica e avalia outras perspectivas e posições.

O grupo tirou implicações?

- () As crianças não conseguem explicar ou testemunhar o impacto de novas informações.
- () As crianças conseguem explicar ou testemunhar o impacto de novas informações.
- () As crianças explicam o impacto de aprender novas informações, fazem previsões e geram novas ideias.

O grupo avalia conclusões?

- () Nenhuma reflexão da evolução da ideia no desenvolvimento do argumento.
- () Reflexão limitada da evolução da ideia no desenvolvimento do argumento.
- () Ampla reflexão sobre a evolução da ideia no desenvolvimento do argumento.



Referências:

SHIVELY, K.; STITH, K. M.; RUBENSTEIN, L. D. Measuring what matters: Assessing creativity, critical thinking, and the design process. *Gifted Child Today*, SAGE Publications Sage CA: Los Angeles, CA, v. 41, n. 3, p. 149–158, 2018.

APPENDIX G

Design activity plans

Activity design plan

Theme	Data processing
Title	Sound Maze
Knowledge	Input - Processing - Data Output
Age Range	4 and 5 years old
Duration	4 hours ¹

Computer Knowledge:

Data processing is the core of any computing system. At its core, a computer functions as a machine that processes information using a binary system, where all data and commands are represented by the digits 0 and 1. This binary coding is the basis for all operations, from mathematical calculations to displaying images and videos. Alan Turing, in his theory of computing machines, demonstrated how the binary system is sufficient to perform any logical and arithmetic operation (Turing, 1936).

To perform processing, the computer follows a basic cycle divided into three main steps:

- **Input:** Data or instructions are provided to the computer through devices such as a keyboard, mouse, sensors, or other means. This data can be numbers, text, commands, or digital signals.
- **Processing:** The Central Processing Unit (CPU) interprets received instructions, performs calculations, and makes decisions based on input data. The CPU performs these tasks according to a sequence of predefined instructions, organized into programs or algorithms. This modular approach was formalized in the von Neumann architecture, which structures systems into input, processing, memory, and output units (Von Neumann, 1945).
- **Output:** The results of processing are presented to the user through output devices such as monitors, printers, or speakers. These results can range from simple text on a screen to complex responses in interactive systems.

The role of data processing is to transform inputs into useful and understandable outputs. This involves operations such as filtering, analyzing, sorting, and presenting data, all performed through algorithms. Donald Knuth defines algorithms as "precise sequences of instructions designed to solve computational problems," emphasizing that the clarity and precision of these instructions are crucial to the proper functioning of the system (Knuth, 1997).

¹This duration is an estimate of time and can be flexible according to the class demand.

Additionally, it is crucial to understand that data and commands are distinct concepts:

- **Data:** Represents the information provided, such as numbers, text, or images.
- **Commands:** These are the instructions that determine how the data should be processed.

For example, when adding two numbers, the numbers are the data, while the "add" instruction is the command that guides the processing. This distinction is essential to understanding how computers operate and perform complex tasks based on basic operations.

Objective:

The goal of this activity is to provide an understanding of how data processing works in a computer, which involves three stages: input, processing, and output. Just as we use different types of language to communicate, computers also use a special language to understand what they should do.

21st Century Skills:

- **Creativity and Innovation:** The child is expected to develop creativity while creating the maze game.

BNCC Axes and Skills:

- **“TRACES, SOUNDS, COLORS, AND SHAPES” (EI03TS01):** Use sounds produced by materials, objects, and musical instruments during pretend play, performances, musical creations, and parties.
- **“BODY, GESTURES AND MOVEMENTS” (EI03CG05):** Coordinate your manual skills to meet your interests and needs in different situations.

BNCC Computing Axes and Skills - Early Childhood Education:

- **“COMPUTATIONAL THINKING” (EI03CO03):** Experience the execution of algorithms by playing with (un)plugged objects.
- **“COMPUTATIONAL THINKING” (EI03CO04):** Create and represent algorithms to solve problems.

Materials needed for the activity:

- Duct Tape
- Cones, Boxes, or Other Small Objects
- Blindfold
- Paper, Crayons, or Markers
- Instruments or Objects to Make Sounds (optional)

This plan was inspired by the activity plan created by the participants of the Curricular Activity for the Integration of Teaching, Research and Extension (ACIEPE) “Computer Education for 4 and 5 year old children: training teachers to become active users of technology”.

Activity development:

1. Introduction to the Concept of Data Processing

- Explain to children, simply, that a computer works by transforming information. It receives something we call "input," performs work on that information, which we call "processing," and then delivers a result, called "output."
- Show everyday examples to facilitate understanding, such as a juice machine: we put fruits (input), the machine squeezes and mixes (processing), and the ready juice comes out (output).
- Point out that on a computer, "input" can come from a keyboard or mouse, "processing" happens inside the CPU, and "output" can be something we see on the screen or hear through the speakers.
- Ask questions to stimulate curiosity, such as:
 - "Can anyone tell me how the computer 'thinks' to display something on the screen?"
 - "What happens when we click something with the mouse?"

2. Division into Groups:

- Divide the class into two groups and explain that each group will create a communication language based on sounds, without using words.
- Explain that this activity is to show how computers use code to understand and perform tasks.

3. Language Creation:

- Have each group discuss and choose sounds to represent commands such as "walk forward," "turn left," or "turn right." Remind the children that the commands will be used to guide another child through a maze.
- Help groups create an organized list of sounds and their meanings, ensuring everyone understands.
- Explain that these sounds will be used to "talk" to a friend, like we do with computers when using programming languages.

4. Preparing the Maze:

- Draw a maze on the floor with masking tape, creating a path with obstacles.
- Ask one of the groups to position the obstacles, making sure the path is challenging but possible to complete.

5. Activity Execution - Input, Processing and Output:

- Select two children per group: one will be the "blindfolded robot" and the other will be the "programmer," who will give the sound commands.

This plan was inspired by the activity plan created by the participants of the Curricular Activity for the Integration of Teaching, Research and Extension (ACIEPE) "Computer Education for 4 and 5 year old children: training teachers to become active users of technology".

- Inform that the sounds created by the group will be the "input data", the "robot" will process these sounds to decide how to act, and the result will be reaching the end of the maze.
- Observe whether the commands are clear and help, if necessary, to adjust the communication.

6. Review and Iteration:

- If the "robot" encounters difficulties, ask the group to review their command language.
- Demonstrate that adjustments and corrections are part of learning and working with computer systems.

7. Final Reflection:

- Lead a discussion with questions like:
 - "What have we learned about giving clear instructions?"
 - "Why is it important to review and adjust commands?"
- Reinforce that computers only function correctly when given precise commands and that data processing is like organizing information to obtain useful results.

This in my world:

When we play maze games, we learn that, just as we need clear instructions to help our blindfolded friend reach the end of the path, computers also need precise commands to do anything. They don't understand our language the way we do, so we use a special language that the computer can understand, called code. Just like in the activity, where someone gave instructions (input), and the blindfolded friend followed the instructions to find the exit (processing and output), computers work similarly. They receive information, process it, and then display a result. Thus, we can see that, even in our everyday games, we use processes very similar to those of computers, like when someone gives us instructions on where to go and what to do!

Assessment:

After completing the activity, the teacher will ask some questions to help the children reflect on the process and to assess their understanding of the concepts:

- How did you think about creating the sounds (code)?
- What would happen if the child received the commands correctly? What if they received them incorrectly?
- What happens if a command has more than one meaning? How would this affect navigation through the maze?
- What would be the smallest number of sounds needed for the code to work?

Resources to support teachers:

CV - Informática. Informática: Entrada, Processamento e Saída (E-P-S) - Lógica de Programação e Dispositivos I/O. YouTube, 2025. Available at: <<https://www.youtube.com/watch?v=6whIS5h4re0>>. Access in: 06/04/2026.

References:

KNUTH, Donald E. *The Art of Computer Programming*. 3. ed. Boston: Addison-Wesley, 1997. v. 1. 672 p.

TURING, Alan M. *On Computable Numbers, with an Application to the Entscheidungsproblem*. Proceedings of the London Mathematical Society, v. 2, n. 42, p. 230–265, 1936.

VON NEUMANN, John. *First Draft of a Report on the EDVAC*. Pennsylvania: Moore School of Electrical Engineering, 1945.

Activity design plan

Theme	Data processing
Title	I can be an amazing programmer!
Knowledge	Algorithms and Programming
Age Range	4 and 5 years old
Duration	4 hours ¹

Computer Knowledge:

Programming is the process of building algorithms. Algorithms are logical, ordered sequences of steps that allow a computer to solve problems or perform tasks. An algorithm must be clear, precise, finite, and free of ambiguities, so that it can be understood and executed by the computer reliably (Cormen et al., 2022). These fundamental aspects ensure that instructions are interpreted correctly and lead to the expected result.

Programming is done through programming languages, which are formal tools used to communicate these instructions to the computer. According to Knuth (1997), "programming is the art of expressing efficient solutions to problems through a language that the computer can interpret". Examples of such languages include Python, Java, and Scratch. Scratch is a visual, block-based programming language widely used in educational settings to introduce programming concepts in a visually engaging and interactive manner.

Computers, by their nature, are devices that perform operations according to a logical sequence of commands. However, for this to be possible, the instructions provided must be accurate, detailed, and organized into clear, step-by-step instructions. Any inaccuracy in the algorithm can lead to errors in execution, which reinforces the importance of designing well-structured instructions.

For example, a detailed algorithm for brushing teeth could be described like this:

1. Go to where the toothbrush is stored.
2. Hold the toothbrush in one hand.
3. Take the tube of toothpaste with your other hand.
4. Open the cap of the toothpaste tube by turning it counterclockwise (or removing it if it is a snap-on cap).
5. Squeeze the toothpaste tube to apply a pea-sized amount to the bristles of the toothbrush.
6. Close the cap on the toothpaste tube and store it in the appropriate place.
7. Open the tap.
8. Place the toothbrush under running water for 2 to 3 seconds to wet the bristles.

¹This duration is an estimate of time and can be flexible according to the class demand.

9. Close the tap.
10. Place the toothbrush in your mouth and brush your upper teeth, moving the brush back and forth in short strokes, for approximately 30 seconds.
11. Brush your lower teeth, repeating the short strokes, for another 30 seconds.
12. Brush the inside surfaces of your upper and lower teeth using vertical strokes.
13. Brush your tongue, moving the brush gently from back to front.
14. Turn the tap back on and rinse your mouth with water.
15. Rinse the toothbrush under running water to remove any toothpaste residue.
16. Close the tap.
17. Store your toothbrush in the appropriate place.

This example demonstrates how an algorithm should be detailed, describing each necessary step clearly and logically, without assuming implicit actions.

To teach computing, it is essential to understand that computers do not "think" or "interpret" like humans; they simply execute exact instructions as programmed. This means that any inaccuracy, such as a poorly defined or out-of-order step, can lead to errors in the result.

Fundamental characteristics of an algorithm:

- **Finiteness:** It must have a limited number of steps and end at some point.
- **Clarity:** Each step must be described precisely and unambiguously.
- **Order:** Instructions must follow a logical sequence.
- **Input and output:** An algorithm can receive input data and must produce a result.

By introducing children to programming, we are not only teaching them how to "give orders" to the computer, but also fostering important skills such as problem-solving, creativity, and the ability to organize thoughts logically. Teaching children to write clear, precise algorithms helps develop these essential skills.

Objective:

The goal of this activity is to help children learn more about the programming profession, exploring how people use programming to create solutions and control different everyday situations. The activity will also encourage children to come up with hypotheses about why programming is important, as well as stimulate creativity by allowing each child to create their own sequences and actions. In addition, the activity will help develop motor coordination when drawing or assembling physical representations of their ideas, and will promote social interactions, with group activities where children can exchange ideas and collaborate. Finally, the activity will seek to stimulate logical reasoning, teaching children to organize actions in a sequence and to think in an orderly and strategic way.

21st Century Skills:

- **Creativity and Innovation:** The child will develop creativity while creating the signs/codes to be used.

BNCC Axes and Skills:

- **“LISTENING, SPEAKING, THINKING AND IMAGINATION” (EI03EF01):** Express ideas, desires, and feelings about your experiences, through oral and written language (spontaneous writing), photos, drawings, and other forms of expression.
- **“BODY, GESTURES AND MOVEMENTS” (EI03CG05):** Coordinate your manual skills to adequately meet your interests and needs in different situations.

BNCC Computing Axes and Skills - Early Childhood Education:

- **“COMPUTATIONAL THINKING” (EI03CO02):** Express the steps to perform a task in a clear and orderly manner.
- **“COMPUTATIONAL THINKING” (EI03CO03):** Experience the execution of algorithms by playing with (un)plugged objects.
- **“COMPUTATIONAL THINKING” (EI03CO04):** Create and represent algorithms to solve problems.

Materials needed for the activity:

- Cardboard or Eva's
- Printed Geometric Shapes (Circle, Triangle, Square and Rectangle)
- Scissors
- Book “Ada Lovelace, the Curious Countess”

Activity development:

1. Introduction to Programming Concepts

- Read the book Ada Lovelace (see References), the Curious Countess, which presents playfully the story of Ada Lovelace, the first person to create a programming idea, inspiring children.
- Explain, in your own words, that programming is giving clear and organized instructions to a computer or robot. Relate the concept to everyday examples, such as "giving instructions to someone to find a lost object" or "following a cake recipe."
- Use Ada's story to contextualize the emergence of programming and emphasize how it paved the way for the creation of games, apps, and other technologies.

2. Choosing Materials and Forming Groups

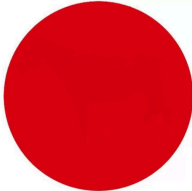
- Divide the children into two groups. Allow each group to choose the color of foam they want to use and give them geometric shapes to cut out, such as circles, squares, and triangles.

- Show examples of ready-made cut-out geometric shapes and explain that each shape will represent an action or command. For example: “The circle could mean ‘jump’ and the square could mean ‘clap’.”
- Explain that these shapes and actions will function as a "code" that the other group must interpret and execute.

3. Prototyping and Creating Commands

- Guide each group to decide which actions to create and how to arrange their geometric shapes to form a logical sequence.
- Explain that they are building an “action recipe” and encourage creativity when choosing commands.
- Highlight that organizing the shapes clearly and logically helps avoid confusion and ensures that the other group can follow the instructions.

Tip: Draw the geometric shapes with their respective actions on the board or chalkboard so that the group performing the activity can easily consult them during the activity.

Simbol	Instruction
	Jump
	Clap

Tip: If the sequences created by the groups are not clear, the teacher should intervene, using appropriate terms and suggesting specific adjustments, such as "Rethink this sequence so that it is more logical and easier to understand".

4. Executing Commands

- Instruct each group to present their sequence of commands to the other group.
- Explain that the executing group must follow the actions in the order presented, correctly interpreting each form and carrying out the corresponding actions.
- Emphasize the importance of following the commands carefully so that the final result is as expected.

This plan was inspired by the activity plan created by the participants of the Curricular Activity for the Integration of Teaching, Research and Extension (ACIEPE) “Computer Education for 4 and 5 year old children: training teachers to become active users of technology”.

5. Reflection and Feedback

- Gather everyone together for a discussion circle and ask:
 - "Were the instructions clear?"
 - "Was it easy to follow the actions proposed by the other group?"
 - "How could we improve the instructions to make them even easier to understand?"
- Encourage children to share what they found fun and challenging about the activity.
- Explain that this step is crucial for reflecting on the clarity of instructions and the logic of actions, as it connects with the concept of iteration and improvement inherent in programming.

Tip: Use visual examples during the conversation circle, such as drawings or diagrams of the sequences created, to reinforce the points discussed.

This in my world:

In our lives, we are always following and giving commands. When we play, for example, we need to listen to what our friend says to continue the game, such as jumping when they tell us to or clapping when they ask us to. Just as we did in the activity, where we created commands for our colleagues to follow, in our daily lives, we also need to understand and follow instructions. Whether it's packing your backpack for school or putting your toys back in the box, there's always an order to do things and rules to follow. This activity helps us think about how to organize and follow these instructions, making our tasks easier and helping us communicate what we want others to do.

Assessment:

The evaluation of this activity will be carried out in two complementary stages:

1. Teacher's Observation

- During the creation of codes and the execution of sequences, the teacher will observe the following points:
 - **Logical Sequence:** Were the children able to organize the commands logically and coherently?
 - **Clarity of Instructions:** Were the children able to create clear commands that the other group was able to interpret and execute correctly?
 - **Explanation of Commands:** Can children explain what each geometric shape represents and how the command should be followed?
 - **Group Collaboration:** Was there active participation by all group members in the decisions and execution of the activity?

2. Children's Self-Assessment

- At the end of the activity, children will be invited to participate in a conversation to evaluate the process and share their perceptions. Some questions that can be asked:

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- What did you enjoy most about doing this activity?
 - What did you find easiest or hardest to understand?
 - Do you think the commands we created were clear? Why?
 - What could we do differently next time to improve?
- The teacher can record the children's responses to identify aspects that worked well and points that can be improved in future activities.

This approach allows children to reflect on the process and feel part of the assessment, valuing their perspective and promoting the development of metacognition skills. In addition, the teacher's observations and the children's feedback will be used to adjust and improve future activities.

Resources to support teachers:

Bate papo: Educação. O que é Algoritmo? - Lógica de programação para crianças #PensamentoComputacional. YouTube, 2019. Available at:

<<https://www.youtube.com/watch?v=IsSHOeBPwU8>>. Access in: 06/04/2026.

Diolinux. O que é "o tal do Algoritmo"? - Lógica e Programação. YouTube, 2020. Available at: <<https://www.youtube.com/watch?v=z1XTcKKRbKM>>. Access in: 06/04/2026.

References:

AMÉLIA, Sílvia. *Ada Lovelace, a condessa curiosa*. São Paulo: Ciranda Cultural, 2017.

CORMEN, T. H.; LEISERSON, C. E.; RIVEST, R. L.; STEIN, C. *Algoritmos: Teoria e Prática*. 3ª ed. São Paulo: Editora Campus, 2022.

KNUTH, D. E. *The Art of Computer Programming: Fundamental Algorithms*. 3ª ed. Boston: Addison-Wesley, 1997.

Activity design plan

Theme	Data processing
Title	Creating stories with codes
Knowledge	Binary Numbering
Age Range	4 and 5 years old
Duration	2 hours ¹

Computer Knowledge:

Binary numbering is the basic system used by computers to process and store information. Unlike the decimal system, which uses ten symbols (0 through 9), the binary system operates with only two symbols: 0 and 1. This simplicity allows computers to represent data and execute instructions efficiently and reliably (Tanenbaum, 2011).

In computing, binary numbers are used to encode commands, data, and instructions. A bit, which is the smallest unit of information in computing, can assume the value of either 0 or 1. Combinations of bits form bytes and words, which can represent numbers, characters, images, and other types of information. For example, while in the decimal system we count from 0 to 9 before "rolling" to 10, in the binary system we count from 0 to 1 before "rolling" to 10, which is equivalent to 2 in decimal (Cormen et al., 2022).

Below is a table illustrating the conversion of decimal numbers to the binary system. This table can be used as a visual aid to introduce the concept of number system conversion.

¹ This duration is an estimate of time and can be flexible according to the class demand.

Decimal	Binary
0	0
1	1
2	10
3	11
4	100
5	101
6	110
7	111
8	1000
9	1001
10	1010

The relationship between 0 and 1 and the actions of computers can be understood as an analogy to the underlying electronics: the number 1 can represent an on circuit (voltage present) and the number 0, an off circuit (no voltage). This physical representation is essential for the functioning of computing devices (Turing, 1936).

Furthermore, highlighting the relationship between number systems and their conversion is crucial for a practical understanding of the concepts. For example, the number 10 in the binary system is equivalent to the number 2 in the decimal system. This translation between systems is crucial for understanding how computers convert human information into computational language (Stallings, 2020).

Binary numbering is not just a form of counting, but also the foundation of computational thinking. By using binary, computers translate complex information into simple, organized sequences, demonstrating how a seemingly basic system can solve sophisticated problems.

Objective:

The objective of this activity is to work on the concept of binary numbering through the production of a story.

21st Century Skills:

- **Creativity and Innovation:** Children are expected to develop creativity while creating the story. Creativity and innovation skills can be developed by creating new glossaries for new situations or stories.

This plan was inspired by the activity plan created by the participants of the Curricular Activity for the Integration of Teaching, Research and Extension (ACIEPE) "Computer Education for 4 and 5 year old children: training teachers to become active users of technology".

BNCC Axes and Skills:

- **“THE SELF, THE OTHER AND THE US” (EI03EO03):** Expand interpersonal relationships, developing attitudes of participation and cooperation.
- **“BODY, GESTURES AND MOVEMENTS” (EI03CG02):** Demonstrate control and appropriate use of your body in games and play, listening to and retelling stories, and artistic activities, among other possibilities.
- **“TRACES, SOUNDS, COLORS AND SHAPES” (EI03TS02):** Express yourself freely through drawing, painting, collage, folding, and sculpture, creating two-dimensional and three-dimensional productions.
- **“SPACES, TIMES, QUANTITIES, RELATIONS AND TRANSFORMATIONS” (EI03ET01):** Establish comparison relationships between objects, observing their properties.

Eixos e Habilidades da BNCC Computação - Educação Infantil:

- **“COMPUTATIONAL THINKING” (EI03CO06):** Understanding decisions in two states (true or false).
- **“DIGITAL WORLD” (EI03CO07):** Recognize electronic (and non-electronic) devices, identifying when they are on or off (open or closed).

Materials needed for the activity:

- Glossary: Image sequence to be used as an example
- Table with four blank spaces, numbered sequentially in binary, so the child can construct the story sequence based on the glossary
- Sticky paper or poster board for creating design elements
- Markers and colored pencils for drawing
- Flashlight to represent the 0s and 1s
- Glue, scissors, and tape for prototyping

Activity development:

1. Introduction and Guiding Questions

- Start with a conversation, using guiding questions to spark children's interest in how computers work and introduce the concept of binary numbering. Ask, for example:
 - "How do you think the computer understands the commands we give it?"
 - "Did you know that computers speak a different language than we do? They only use two numbers, 0 and 1!"
 - "Why do they only use those two numbers?"
- Explain the concept of binary numbering playfully, using visual examples, such as a flashlight on (1) and off (0) to represent binary numbers.

This plan was inspired by the activity plan created by the participants of the Curricular Activity for the Integration of Teaching, Research and Extension (ACIEPE) “Computer Education for 4 and 5 year old children: training teachers to become active users of technology”.

- Emphasize that binary numbering is the language that computers use to process information simply and efficiently.

2. Example of Logical Sequence

- Provide a practical example to demonstrate the importance of logical sequence in a story. Use the glossary as a reference:
 - "001: The tree in the park was full of apples."
 - "010: Luna picked an apple."
 - "011: Went to school."
 - "100: The apple was given to the teacher."
- Explain that some actions depend on others. For example, "The apple was given to the teacher" can only happen after "She went to school."
- Reinforce that the logical sequence is important for the story to make sense, just as computers follow an order to execute commands.

3. Introduction to Binary Table

- Separate the children into groups of 5.
- Give the group a table with four spaces numbered in binary (001 to 100).
- Explain that each binary number represents an action, and the children will need to fill in the blanks with the parts of the story in an order that makes sense.

4. Prototyping - Building the Pieces of History

- Instruct children to think of a simple story with a sequence of actions that build on each other. For example:
 - "001: I wake up and brush my teeth."
 - "010: I have breakfast."
 - "011: I play in the garden."
 - "100: I come home."
- Instruct children to draw each part of the story on index cards and then arrange them on the binary table in the correct order.

4. Validation Dynamics

- Gather everyone together for a discussion circle and ask each group to explain their story, following the sequence in the table.
- The other colleagues must check whether the story makes sense and whether the logical sequence was respected.
- Encourage colleagues to provide feedback on the clarity and organization of stories.

5. Final Reflection

- Lead a discussion with questions like:

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- "What happened when the story sequence didn't make sense?"
- "What was it like organizing the story using binary numbers?"
- "Was it easy for your colleagues to understand your story? Why or why not?"
- "What would you do differently if you could create a different code?"
- Explain that understanding and respecting the order of actions is essential for both creating stories and programming computers.
- Children will have the chance to iterate and improve their designs, thinking about how they could make their representations clearer and easier to understand.

6. Connection with Computational Reality

- Relate the story creation process to the way computers process information.
- Explain that, just as the children organized their stories, computers follow logical sequences to perform tasks, and that this organization is what allows them to function correctly.

This in my world:

Bringing children closer to reality by understanding how a computer works. This helps them understand that, just as we communicate using different languages, computers also use a language (binary numbering) to execute requested commands.

Assessment:

The evaluation of this activity will be carried out in two complementary stages: observation by the teacher and self-assessment by the children.

1. Teacher's Observation

- When creating stories and organizing them in the binary table, the teacher will observe the following points:
 - **Logical Sequence:** Were the children able to organize the story elements in the binary table coherently, respecting the logical order of actions?
 - **Clarity in Creating the Elements:** Are the story elements created by the children clear and easy to identify?
 - **Completing the Table:** Did the children understand how to use the binary numbers in the table to sequence their stories correctly?
 - **Group Collaboration:** Was there active participation from all group members in creating and organizing the stories?
 - **Interpretation and Validation:** Were the children able to explain their stories in a way that their peers or teachers could understand, using the glossary and the table as support?

2. Practical Activity with Immediate Verification

- The teacher puts binary numbers on the board, and the children must indicate the corresponding number in decimal.

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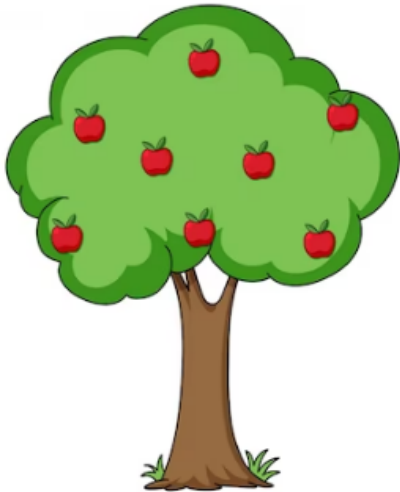
- To check understanding, she can question the children about the sequence, asking them to explain how they arrived at the answer.
- If any child becomes confused, the teacher can intervene with probing questions, such as:
 - "Does this number correspond to the right card?"
 - "Shall we check the numbering sequence again?"

3. Children's Self-Assessment

- At the end of the activity, children will participate in a discussion to evaluate the process and reflect on their experience. Some questions that can be asked:
 - "What did you enjoy most about this activity?"
 - "Was it easy to create your story using binary numbers? Why?"
 - "Were you able to put the actions in the correct order in the table? Was there a more difficult part?"
 - "If you could do the activity again, what would you change about your story or the way you organized the elements?"
- The teacher can record the children's responses to identify positive aspects and challenges encountered during the activity. This feedback will be useful for adjusting future implementations.

This process combines elements of practical verification, collaboration, and reflection, promoting active, child-centered learning.

Glossary:



This plan was inspired by the activity plan created by the participants of the Curricular Activity for the Integration of Teaching, Research and Extension (ACIEPE) “Computer Education for 4 and 5 year old children: training teachers to become active users of technology”.

Table with binary numbering:

1	10
11	100

Resources to support teachers:

Eu TI Ensino. Entenda o sistema binário e como ele funciona. (Informática Básica). YouTube, 2020. Available at: <<https://www.youtube.com/watch?v=q3xLvOsqhpo>>. Access in: 06/04/2026.

Eu TI Ensino. Conversão de bases numéricas: Binário x Decimal. (Informática Básica). YouTube, 2020. Available at: <<https://www.youtube.com/watch?v=VcNSBwQjVnQ>>. Access in: 06/04/2026.

References:

CORMEN, Thomas H.; LEISERSON, Charles E.; RIVEST, Ronald L.; STEIN, Clifford. *Algoritmos: Teoria e Prática*. 3ª ed. São Paulo: Editora Campus, 2022.

STALLINGS, William. *Computer Organization and Architecture*. 10ª ed. Boston: Pearson, 2020.

TANENBAUM, Andrew S.; WETHERALL, David J. *Redes de Computadores*. 5ª ed. São Paulo: Pearson, 2011.

Activity design plan

Theme	Data transmission
Title	Televising ideas - Reporters in action
Knowledge	Working with practical experiences of communication and transmission of information
Age Range	4 and 5 years old
Duration	5 lessons ¹

Computer Knowledge:

Wireless communication is an example of how computer technologies transform the transmission of information. In the context of this activity plan, it is important to delve deeper into fundamental computing concepts related to wireless communication, including computer networks, broadcast transmission, and the operation of devices such as remote controls and Wi-Fi routers.

Computer networks are structures that interconnect devices to exchange data. A computer network allows communication between devices in an efficient and organized manner, regardless of their physical location (Tanenbaum and Wetherall, 2011). In this context, wireless communication uses radio waves or infrared signals to transmit data without the need for physical connections, such as cables.

Broadcast transmission, for example, is a method in which a message is sent from a single transmitter to multiple receivers. This concept is present in television broadcasting, where a signal is sent to several TVs simultaneously, and in Wi-Fi networks, which distribute data to multiple connected devices.

To illustrate, the remote control uses an infrared signal to send commands to the television. When a button is pressed, an internal circuit in the control generates a coded signal that travels to the TV receiver. This receiver decodes the signal and performs the corresponding action, such as increasing the volume or changing channels.

Modern technologies like Wi-Fi work similarly but use radio waves instead of infrared signals. According to Stallings (2020), "Wi-Fi is a technology that allows high-speed data transmission through the air, connecting devices in a local network without the need for cables". This process involves the exchange of data packets between devices and access points, demonstrating how computer networks and computational protocols enable efficient communication.

For this lesson plan, the teacher should highlight these wireless communication concepts in an accessible way, connecting them to children's everyday technologies, such as remote

¹This duration is an estimate of time and can be flexible according to the class demand.

controls, televisions, and Wi-Fi networks. This will allow children to understand the computational processes that enable the transmission of information, while also developing communication, logical thinking, and sequencing skills.

Objective:

The objective of this activity is to provide children with a command of the concepts of technological information in the media, with an emphasis on TV, so that they can place themselves in the role of creators of digital content.

21st Century Skills:

- **Creativity and Innovation:** Creativity and innovation skills can be worked on from the initial exchange of ideas, creation of the prototype using recyclable material, to the development of the television channel.

BNCC Axes and Skills:

- **“BODY, GESTURES AND MOVEMENTS” (EI03CG01):** Create with the body diverse forms of expression of feelings, sensations, and emotions, both in everyday situations and in games, dance, theater, and music.
- **“BODY, GESTURES AND MOVEMENTS” (EI03CG02):** Demonstrate control and appropriate use of your body in games and play, listening to and retelling stories, artistic activities, among other possibilities.
- **“BODY, GESTURES AND MOVEMENTS” (EI03CG03):** Create movements, gestures, looks, and mimes in games and artistic activities such as dance, theater, and music.
- **“BODY, GESTURES AND MOVEMENTS” (EI03CG05):** Coordinate your manual skills to meet your interests and needs in different situations.
- **“LISTENING, SPEAKING, THINKING AND IMAGINATION” (EI03EF01):** Express ideas, desires, and feelings about your experiences, through oral and written language (spontaneous writing), photos, drawings, and other forms of expression.
- **“LISTENING, SPEAKING, THINKING AND IMAGINATION” (EI03EF04):** Retell stories heard and collectively plan scripts for videos and performances, defining the contexts, characters, and structure of the story.
- **“LISTENING, SPEAKING, THINKING AND IMAGINATION” (EI03EF06):** Produce your own oral and written stories (spontaneous writing), in situations with a significant social function.
- **“SPACES, TIMES, QUANTITIES, RELATIONS AND TRANSFORMATIONS” (EI03ET02):** Observe and describe changes in different materials, resulting from actions on them, in experiments involving natural and artificial phenomena.

BNCC Computing Axes and Skills - Early Childhood Education:

This plan was inspired by the activity plan created by the participants of the Curricular Activity for the Integration of Teaching, Research and Extension (ACIEPE) “Computer Education for 4 and 5 year old children: training teachers to become active users of technology”.

- **“COMPUTATIONAL THINKING” (EI03CO06):** Understanding decisions in two states (true or false).
- **“DIGITAL WORLD” (EI03CO08):** Understand the concept of interfaces for communication with (un)plugged objects.
- **“DIGITAL WORLD” (EI03CO09):** Identify computing devices and the different forms of interaction.

Materials needed for the activity:

Mandatory::

- Cardboard box
- Paints
- Felt-tip pens
- Colored pencils
- Adhesive tape
- Scissors
- Glue
- Assorted colored paper
- Plastic bottle cap

Optional:

- Lamp (cell phone, laser, any form of light emission that simulates remote control)
- Computer with internet access
- Image projector
- TV set for display

Activity development:

1. Diagnostic Activity - Hypothesis Raising

- Hold a discussion with the children to brainstorm ideas about how television works and how images reach it. Ask, "How do you think the image travels from one place to another?" or "Do you think a TV needs wires to work?"
- Use children's responses to introduce the idea of information transmission, preparing them to understand concepts such as logical sequencing and wireless communication.
- Explain that this initial moment serves to explore the children's prior knowledge, stimulate curiosity, and create a foundation for the concepts that will be worked on.

2. Conversation - Evolution of TV and Wireless Communication

- Present the evolution of electronic devices, focusing on TV, and show the video "Where Does TV Come From?". Available at: [📺 De Onde Vem a TV? #Episódio 2](#) .

- Explain that information transmission can happen wirelessly, as in the case of the remote control, which uses an infrared signal, and Wi-Fi, which uses radio waves.
- Relate these explanations to technologies children are already familiar with, helping them understand how devices interact without the need for cables.

3. Practical Demonstration - Remote Control and Wireless Communication

- Use a remote control and a TV to demonstrate how wireless communication works. Show that when you press a button on the remote (input), the TV responds (output).
- Let children experiment with different buttons to see how the commands work and are transmitted via the infrared signal.
- Explain that the remote control sends coded signals that the TV interprets to perform specific actions.

4. "Wireless Controls" Fun Activity

- Organize an activity where one child is the "remote control" and the other the "TV". The "remote control" will use gestures or colored cards to send commands, such as "jump", "spin", or "clap".
- Explain that this activity simulates how instructions can be sent wirelessly, showing the relationship between the command sent and the action performed.
- Emphasize that this dynamic helps to consolidate the concept of wireless information transmission in a practical and fun way.

5. Hands-on - Building the TV Set and Remote Control Prototype

- Divide the children into small groups and have them build a prototype TV and remote control using recycled materials, such as cardboard boxes, colored paper, and toy buttons.
- Instruct the groups to define the remote control "commands", such as "change channel" or "increase volume", relating each button (input) to the TV's response (output).
- Explain that this step develops understanding of the concept of information input and output, in addition to stimulating creativity and teamwork.

6. Organizing Groups and Creating Channel Content

- Instruct each group to create their own "TV channel," producing content such as stories, weather forecasts, or short reports.
- Explain that each child will have a specific role, such as presenter, director, or remote control operator, emphasizing the importance of collaboration and logical sequencing.
- Highlight that this step connects the practice of communication with the concept of coordination between different parts of a process.

This plan was inspired by the activity plan created by the participants of the Curricular Activity for the Integration of Teaching, Research and Extension (ACIEPE) "Computer Education for 4 and 5 year old children: training teachers to become active users of technology".

7. Exploring Wireless Devices in the Environment

- Encourage children to explore their classroom and school to identify devices that use wireless communication, such as Wi-Fi routers, cell phones, and remote controls.
- Explain that these devices use technologies such as infrared or radio waves to transmit information without the need for cables.
- Relate this exploration to the practical application of the concepts presented, reinforcing the presence of these technologies in everyday life.

8. Presentation of TV Channels to the School Community

- Organize a presentation in which each group shows their "TV channel" to the school community, using the prototype they built.
- Instruct the groups to explain how they created the controls and how the TV responds to different inputs.
- Emphasize that this activity allows children to demonstrate their understanding of the concepts being worked on, while also developing communication and presentation skills.

9. Reflection and Feedback

- Discuss with questions like:
 - "How did you feel about creating wireless commands?"
 - "What did you find most interesting about how information travels wirelessly?"
- Record children's responses and encourage a collective discussion about their experiences.
- Explain that this step helps consolidate learning, reinforcing the importance of collaboration, logical sequencing, and clear communication.

This in my world:

Wireless communication is part of our daily lives and is present in many situations. When we use a remote control to change the TV channel or connect a tablet to Wi-Fi to watch videos, we are using technologies that transmit information wirelessly. In this activity, we learn how these signals "travel through the air" to make things work, like changing the channel or turning on the TV. Understanding how these technologies work helps us understand how information reaches us and how we can control everyday devices, such as a TV or tablet. It also helps us think in an organized way, planning which actions should happen first and which come next, just as we did when creating our commands.

Assessment:

In this activity, an assessment is proposed based on a set of questions that must be asked to the children.

This plan was inspired by the activity plan created by the participants of the Curricular Activity for the Integration of Teaching, Research and Extension (ACIEPE) "Computer Education for 4 and 5 year old children: training teachers to become active users of technology".

- How can the remote control change the TV channel even though there is no wire connected to it?
- Can we change the order of commands on the remote, such as increasing the volume before turning on the TV? Does this work? Why?
- Can you show me how the remote sends a command to the TV, like "turn on" or "turn up the volume"? What happens after we press the button?
- If we want to change the channel, which button should we press first? What happens next?

This approach allows children to reflect on the process and feel an integral part of the assessment, valuing their perspective and promoting the development of metacognition skills.

Resources to support teachers:

Manual do Mundo. Entenda o WI-FI de uma VEZ por TODAS!. YouTube, 2021. Available at: <<https://www.youtube.com/watch?v=V2XW8nxNjcc>>. Access in: 06/04/2026.

Professor André Fernandes. Dica do Dedé - Rede Sem Fio. YouTube, 2016. Available at: <<https://www.youtube.com/watch?v=xXzRKgZbKW8>>. Access in: 06/04/2026.

References:

STALLINGS, William. *Wireless Communications & Networks*. 2^a ed. Boston: Pearson, 2020.

TANENBAUM, Andrew S.; WETHERALL, David J. *Redes de Computadores*. 5^a ed. São Paulo: Pearson, 2011.

Activity design plan

Theme	Hardware
Title	Creating my computer
Knowledge	Computer components
Age Range	4 and 5 years old
Duration	4 hours ¹

Computer Knowledge:

A computer is a machine composed of physical (hardware) and logical (software) components that work together to perform specific tasks. In hardware, the main components include the Central Processing Unit (CPU), monitor, keyboard, and mouse. The CPU, often called the "brain" of the computer, is responsible for processing and executing instructions provided by the software, converting them into concrete actions. Instruction processing is the heart of computational functioning, essential for the execution of any task (Knuth, 1997). The monitor displays the results of these actions, while the keyboard and mouse are input devices, allowing users to send commands and information to the computer.

In addition to traditional computers, devices such as tablets and cell phones are also computing machines, but with characteristics that differ in their form and interface. Tablets and cell phones have touchscreens, which combine input and output functions. The screen acts as a monitor, displaying visual information, and also as an input device, replacing the physical keyboard and mouse with virtual keyboards and touch gestures. These devices, like traditional computers, have a CPU that processes information and executes commands provided by the user. The integration of input, processing, and output units forms the basis of modern computing systems (Von Neumann, 1945).

Although the differences in format are evident, the operating logic is similar across computers, tablets, and smartphones. In all of them, tasks follow the same basic cycle:

- **Data Input:** Commands provided by input devices such as keyboard, mouse, or touchscreen.
- **Processing:** Performed by the CPU, where data is interpreted and processed.
- **Data Output:** Result displayed on devices such as a monitor or touchscreen.

Data representation in this cycle occurs in binary form, with 0s and 1s serving as the basis for all operations. This approach is fundamental for computing machines to perform logical and

¹This duration is an estimate of time and can be flexible according to the class demand.

arithmetic operations efficiently (Turing, 1936). For example, on a traditional computer, input can be done via the keyboard (typing text), processing is performed by the CPU, and the monitor displays the typed text. On a tablet, the virtual keyboard replaces the physical keyboard, but input and processing follow the same principle.

Objective:

The goal of this activity is to enable students to understand how the different components of a computer work together to perform everyday tasks, such as typing, clicking, and viewing information on the screen. Children will learn to identify the main components, such as the CPU, monitor, keyboard, and mouse, and understand their functions simply and visually, considering different devices. Furthermore, the activity aims to develop the ability to care for these components, teaching practices to preserve the hardware, such as handling it carefully and avoiding damage. This activity aims to stimulate critical thinking and visual comprehension, so that children can distinguish the role of each computer part and understand how they connect to form a functional system.

21st Century Skills:

- **Critical thinking and problem-solving:** Children will work on critical thinking as they learn about how each component works and what to do with each one.

BNCC Axes and Skills:

- **“LISTENING, SPEAKING, THINKING, AND IMAGINATION” (EI03EF03):** Choose and leaf through books, trying to orient yourself by themes and illustrations, and trying to identify familiar words.
- **“LISTENING, SPEAKING, THINKING, AND IMAGINATION” (EI03EF04):** Retell stories heard and collectively plan scripts for videos and performances, defining the contexts, characters, and structure of the story.
- **“THE SELF, THE OTHER AND THE US” (EI03EO04):** Communicate your ideas and feelings to different people and groups.
- **“SPACES, TIMES, QUANTITIES, RELATIONS AND TRANSFORMATIONS” (EI03ET01):** Establish comparison relationships between objects, observing their properties.

BNCC Computing Axes and Skills - Early Childhood Education:

- **“DIGITAL WORLD” (EI03CO08):** Understand the concept of interfaces for communication with (un)plugged objects.
- **“DIGITAL WORLD” (EI03CO09):** Identify computing devices and the different forms of interaction.

Materials needed for the activity:

- **Recyclable Materials:** Cardboard boxes, bottle caps, straws, pieces of paper

This plan was inspired by the activity plan created by the participants of the Curricular Activity for the Integration of Teaching, Research and Extension (ACIEPE) “Computer Education for 4 and 5 year old children: training teachers to become active users of technology”.

- Old Computer Components: Circuit boards, cables, mice, keyboard parts (safe to handle)
- Drawing Materials: Sheets of paper, colored pencils, markers and gouache paint
- Adhesive tape
- Glue

Activity development:

1. Problem Identification (Initial Conversation)

- Ask children if they have ever seen computers, tablets, or cell phones and how they imagine these devices work.
- Show pictures or real-life examples of devices (such as a laptop, tablet, and cell phone) to illustrate the differences and similarities between them.
- Explain that all of these devices have components that perform similar functions, such as input (keyboard, touch screen), processing (CPU), and output (screen, speakers).
- Encourage children to form hypotheses with questions like:
 - "What makes a computer or tablet work?"
 - "How do you think we can see a drawing on a screen?"

2. Ideation - Creating Solutions

- Provide sheets of paper and colored pencils for each child to draw how they imagine a computer, tablet, or cell phone works.
- Ask them to represent the main parts, such as the screen, keyboard, buttons, or CPU, highlighting the functions of each.
- Form groups to share their drawings and discuss how the parts of the devices can connect to perform tasks.
- Guide groups to think about what components are common between computers, tablets, and cell phones, and how they differ.

3. Prototyping - Building the device

- Distribute recyclable materials such as cardboard boxes, bottle caps, straws, and paper so that groups can build prototypes of devices of their choice: a computer, tablet, or cell phone.
- If possible, provide safe components from old computers (such as cables and small circuit boards) to enrich prototypes and stimulate curiosity.
- Instruct groups to create a "keyboard" using bottle caps for computers or simulate a "virtual keyboard" on tablets and cell phones. Encourage them to think about details, such as buttons, icons, or even a battery representation.
- Help groups identify which materials are best suited for each part of the prototype and how to arrange the components to make the device functional.

This plan was inspired by the activity plan created by the participants of the Curricular Activity for the Integration of Teaching, Research and Extension (ACIEPE) "Computer Education for 4 and 5 year old children: training teachers to become active users of technology".

4. Testing and Refinement

- Each group must present the prototype to the class, explaining how it works, what its components are, and how they connect.
- After each presentation, encourage your colleagues to ask questions or make suggestions. Examples of questions include:
 - "How does your tablet or cell phone screen work?"
 - "Where is the keyboard, and why is it there?"
- Help groups apply the feedback they receive to improve their prototypes by adjusting details or adding new elements.

5. Conclusion - Reflection on the Design Process

- Hold a discussion to consolidate learning, asking:
 - "What have we learned about how these devices work?"
 - "What do they have in common and what's different?"
 - "Why is it important to know and care for these parts?"
- Reinforce the idea that different devices – computers, tablets, and cell phones – operate based on similar principles, adapted for different uses.
- Ask children to share how they could use their prototypes in their daily lives, relating their learning to the real world.

This in my world:

Understanding how a computer works helps us realize that each component has a specific and important function, just like the different objects we use in our daily lives. The monitor, keyboard, and mouse are like parts of a large team, each playing their part to achieve a goal, just like in a game or group play. When we know which component to use for each activity, such as clicking, writing, or drawing on the screen, we can better understand how the computer helps us with various things. Learning about these parts also teaches us how to care for them, just as we do with our favorite toys, ensuring they continue to function well for a long time. Thus, learning about the computer and its components connects with our daily lives, demonstrating the importance of understanding and preserving what we use every day.

Assessment:

The assessment will be conducted at the end of the activity, focusing on understanding hardware concepts and the relationship between computer components. To achieve this, the teacher will use the following strategies:

1. Prototype Presentation:

This plan was inspired by the activity plan created by the participants of the Curricular Activity for the Integration of Teaching, Research and Extension (ACIEPE) "Computer Education for 4 and 5 year old children: training teachers to become active users of technology".

Each group will present the computer prototype, explaining how each component (keyboard, monitor, CPU, etc.) contributes to the computer's overall functionality. The teacher will assess whether the children can describe the functions of the different components and how they connect to make the computer perform its functions.

2. Reflective Questions:

After the presentation, the teacher will ask some individual questions to assess the children's level of understanding of computer knowledge:

- "Which part of the computer is responsible for processing information?"
- "How do the monitor and keyboard work together so we can use the computer?"
- "Why do we need to take care of computer components?"

The answers to these questions will help assess whether children understand the basic concepts of component function and interconnection.

Resources to support teachers:

Eu TI Ensino. Informática Básica: Principais hardwares do computador! Conheça os componentes do computador!. YouTube, 2020. Available at: <<https://www.youtube.com/watch?v=pFTgWgb5wiM>>. Access in: 06/04/2026.

DuarttHub. Todas as Peças de Computador Explicadas em 8 Minutos. YouTube, 2025. Available at: <<https://www.youtube.com/watch?v=ZSlrMa7JYc8>>. Access in: 06/04/2026.

Manual do mundo. O que tem DENTRO do NOTEBOOK?. YouTube, 2021. Available at: <https://www.youtube.com/watch?v=BB_5lPDn72o>. Access in: 06/04/2026.

References:

KNUTH, Donald E. *The Art of Computer Programming*. 3. ed. Boston: Addison-Wesley, 1997. v. 1. 672 p.

TURING, Alan M. *On Computable Numbers, with an Application to the Entscheidungsproblem*. Proceedings of the London Mathematical Society, v. 2, n. 42, p. 230–265, 1936.

VON NEUMANN, John. *First Draft of a Report on the EDVAC*. Pennsylvania: Moore School of Electrical Engineering, 1945.

Activity design plan

Theme	Information security
Title	Virtual environment - Security beyond screens
Knowledge	Data privacy and security
Age Range	4 and 5 years old
Duration	4 aulas ¹

Computer Knowledge:

Privacy and data security are fundamental pillars in computing, especially when it comes to protecting children in the digital environment. Privacy refers to control over personal information, while information security involves practices and tools to protect this data from unauthorized access or malicious use (Stallings, 2017). These concepts are essential to prevent risks ranging from fraud and information leaks to serious situations such as online child abuse.

In the digital world, children can be vulnerable to dangerous interactions, especially on social media, online games, and messaging apps. Attacks like phishing can be used to trick children into providing personal information, such as addresses, full names, or family details. If this data falls into the wrong hands, it can be used for malicious approaches, such as direct contact attempts or emotional blackmail. Recognizing and avoiding these attacks is a fundamental skill that can be taught through practices such as verifying the origin of messages and never sharing information without adult supervision.

Digital environments can also be exploited by malicious individuals for online child abuse, a form of crime that uses digital platforms to groom, exploit, or inappropriately share images of children. Although the topic is sensitive, teachers must understand its relationship with privacy and data security, training themselves to instruct children on how to identify suspicious situations. For example, messages from strangers asking for photos or personal information should be immediately reported to a responsible adult.

In computing, mechanisms such as encryption and multi-factor authentication are used to protect information and prevent unauthorized access to accounts and devices. These concepts can be adapted for children, emphasizing that strong passwords and consulting an adult before sharing any information are essential practices for ensuring security. Furthermore,

¹This duration is an estimate of time and can be flexible according to the class demand.

using privacy settings on social networks and apps allows you to limit who can view or interact with children's profiles, reducing exposure to potentially dangerous interactions.

Awareness of digital footprints is another crucial aspect. The trail left by online actions, such as social media posts or browsing history, can be exploited by third parties to monitor or manipulate children's activities. Guiding children about how to be careful when sharing personal information or photos, emphasizing that once posted online, they can become permanent, helps prevent future problems.

Finally, child online safety also involves educating children about suspicious behavior. Teachers can provide practical examples, such as:

- Messages from strangers requesting friendship or information.
- Links promising prizes or free games may contain malware or serve as bait to capture data.
- Invitations to private conversations or in-person meetings should be reported immediately.

In addition to technical practices, it's important to emphasize the importance of dialogue between children and adults. Computer science instruction can include simulations of real-life situations, where children learn to identify risks and respond safely, always seeking help from a responsible adult.

The privacy and data security approach to computer science education not only protects children from online risks but also promotes the creation of a more ethical and conscious digital environment, connecting technology with responsible practices.

Objective:

Understand the importance of using equipment safely in a virtual environment, preserving privacy and data security, and building defense and protection mechanisms against child sexual abuse.

21st Century Skills:

- **Critical thinking and problem-solving:** It is expected that the child will build, based on the activities developed, a critical stance regarding the content, relationships, and interactions available on the internet.

BNCC Axes and Skills:

- **“SPACES, TIMES, QUANTITIES, RELATIONS AND TRANSFORMATIONS” (EI03ET03):** Identify and select sources of information to answer questions about nature, its phenomena, and its conservation.

BNCC Computing Axes and Skills - Early Childhood Education:

This plan was inspired by the activity plan created by the participants of the Curricular Activity for the Integration of Teaching, Research and Extension (ACIEPE) “Computer Education for 4 and 5 year old children: training teachers to become active users of technology”.

- **“DIGITAL CULTURE” (EI03CO10):** Use digital technology in a safe, conscious, and respectful manner.

Materials needed for the activity:

- Book “The girl of colors”.
- Sample images of personal information (photo, phone number, address).
- A computer or tablet for demonstrating the virtual environment.
- Paper, markers, and colored pencils for drawings and prototypes.
- Materials for making posters and pamphlets: large sheets of paper, stickers, paint, etc.

Activity development:

1: Introduction to the Concept of Online Privacy and Security

- Begin class by reading the book *The Girl with Colors* (see References). Read aloud, pointing out the illustrations and encouraging children to connect with the story.
- Relate the character's story to the concept of privacy. Say: "Just as the girl in the book guarded her colors to protect them, we too need to protect important information, such as our photos, names, and addresses."
- Ask: "What would happen if someone tried to take the girl's colors without her permission? Would that be right or wrong? Why?"
- Present images of personal data, such as photos and addresses, and discuss which ones should be protected. Relate this to the topic of child abuse by saying: "Some people may ask for information to do bad things. Therefore, we should never share this information without talking to a trusted adult."
- Explain that there are good people online, but there are also those who want to deceive or hurt. Reinforce that children should always tell an adult if something strange happens.

2: Exploration of the Virtual Environment

- Show children a safe children's website and highlight the security features, such as the padlock in the address bar. Explain: "This padlock is like a sign of protection. It tells us that the site is safe to browse."
- Show examples of suspicious messages or links, such as "Click here to win a prize!" and ask, "Do you think this is safe? Why shouldn't we click on it without asking an adult?"
- Address child abuse: Say: "Sometimes someone may send messages asking for photos or personal information. This is very dangerous and should be reported to an adult immediately. If someone asks you to keep it a secret, it's even more important to report it to a parent or guardian."
- Ask children how they would react in different situations, such as: "What would you do if you received a message from someone asking to speak privately or send a photo?" Teach them to identify and avoid these dangerous interactions.

This plan was inspired by the activity plan created by the participants of the Curricular Activity for the Integration of Teaching, Research and Extension (ACIEPE) “Computer Education for 4 and 5 year old children: training teachers to become active users of technology”.

Tip: An example of a safe children's website is Clubinho Salva-Vidas (<https://clubinhosalvavidas.com.br>), developed to promote children's awareness of topics such as safety and citizenship in a fun and educational way.

3: Safe Virtual Space Project

- Form small groups and ask each person to draw what a safe virtual space would look like. Guide: "Think about elements that protect people in this space, such as locks, gates, or signs saying 'do not share personal information.'"
- Include the topic of child abuse: Ask groups to brainstorm ways to protect children from people who want to hurt them, including warnings like "Never talk to strangers without telling an adult" or "No one here can ask for personal information."
- Each group should show their drawing to the class and explain how the elements they created help protect people in the digital environment.

4: Creating Prevention and Presentation Materials

- Have children create posters and flyers with online safety awareness messages. Suggest including phrases like:
 - "Never share information with strangers."
 - "If something strange happens, talk to a trusted adult."
 - "Be careful of messages asking for photos or personal information."
- Explain that these materials will be displayed at school to teach other children and adults how to protect themselves online.
- Organize a presentation where children explain what they learned, connecting the posters to abuse protection situations.

5. Final Reflection

- Conduct a quiz game to review the concepts learned:
 - "If someone asks you to keep a secret that feels wrong, what do you do?"
 - "Why should we never share information without talking to an adult?"
 - "How do we know if a website is safe?"
- Conclude by emphasizing that protecting information online is essential to prevent malicious actors from causing harm, especially to children. Reinforce the idea that they can always count on a trusted adult to help them.

This in my world:

In our lives, we're constantly connecting with others, whether at home, at school, or even online. Just as we have rules to keep our things safe in the real world, we also need to protect our information online. With this activity, children will learn that certain information is very important and must be protected, such as their name, address, and photos. Understanding privacy and data security in the virtual world is essential to ensuring that children are as safe as they are in their family environment, even when browsing the internet. This means

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learning not to share information without adult supervision, knowing how to identify potentially dangerous situations, and using the internet more consciously and carefully.

Assessment:

Assessment will be conducted after the activities are completed, using various methods to assess understanding of privacy and information security concepts. The teacher may apply the following strategies:

- Assess children's ability to explain what they created on the posters and flyers. Observe whether they can describe personal information that should not be shared and the precautions needed to navigate the internet safely.
- Ask individual questions to check whether children understand the concepts:
 - "If someone online asks for your address, what should you do?"
 - "Why is it important to tell an adult before sharing information online?"
- Create hypothetical situations, such as: "What if you're playing a game and a message appears asking you to click a link, what would you do?" This will help children understand how they would apply what they've learned in practice.

Resources to support teachers:

Smile and Learn - Português. Privacidade online para crianças - Proteção e segurança na internet para crianças. YouTube, 2020. Available at: <<https://www.youtube.com/watch?v=IRYbq9EMyNM>>. Access in: 06/04/2026.

Manual do mundo. O QUE INTERNET SABE sobre VOCÊ (e você NEM IMAGINA). YouTube, 2023. Available at: <<https://www.youtube.com/watch?v=VjgtiyTGzHk>>. Access in: 06/04/2026.

References:

CÂNDIDO, Rita. *A Menina das Cores* / Rita Cândido. São Carlos: Editora Scienza, 2021.

MITCHELL, Brian. *Web Security for Network and System Administrators*. Boston: Cengage Learning, 2009.

SCHNEIER, Bruce. *Applied Cryptography: Protocols, Algorithms, and Source Code in C*. 2. ed. New York: Wiley, 1996.

SOLOVE, Daniel J. *The Digital Person: Technology and Privacy in the Information Age*. New York: NYU Press, 2004.

STALLINGS, William. *Cryptography and Network Security: Principles and Practice*. 7. ed. Upper Saddle River: Pearson, 2017.

Activity design plan

Theme	Conscious use of technology
Title	Conscious Disposal
Knowledge	Electronic waste disposal
Age Range	4 and 5 years old
Duration	3 hours ¹

Computer Knowledge:

Computers and electronic devices are composed of a variety of materials, many of which have specific properties that make them ideal for computational functions. For example, copper is widely used in circuits and wires due to its high electrical conductivity (Ashby et al., 2005). Nickel, found in rechargeable batteries, is essential for energy storage. These materials are extracted from nature and undergo complex industrial processes before being used in electronic components.

Inside a computer, the main components include the motherboard, processors, RAM, hard drives (SSDs), power supplies, and peripherals such as keyboards and mice. Each of these components contains materials such as silicon (found in semiconductors) and metals such as aluminum, gold, and silver, used in small quantities for critical connections due to their high corrosion resistance and excellent conductivity.

Furthermore, components such as batteries and LCD monitors contain chemicals that require proper disposal. Batteries, for example, can contain lead and cadmium, highly toxic elements that, when disposed of improperly, can contaminate soil and waterways. Older monitors (CRTs) contain phosphors and leaded glass, both of which are harmful to the environment (Kang and Schoenung, 2005).

The manufacturing of electronic devices also generates significant impacts. The extraction of materials, such as lithium for batteries, can cause ecological damage in mining regions, including river contamination and soil degradation. Therefore, in addition to understanding how computers are made, it's important to discuss the life cycle of devices and the environmental impact of e-waste.

When disposed of improperly, electronic materials can release toxic substances, causing harm to human health and the environment. On the other hand, recycling and reuse practices can minimize these effects. For example, copper removed from circuit boards can be melted

¹This duration is an estimate of time and can be flexible according to the class demand.

down and reused in new industrial applications, reducing the need for raw material extraction.

When teaching these concepts, teachers can connect device manufacturing to responsible disposal, explaining to children that computers are made of valuable materials that can be reused. To facilitate this, practical examples can be used: "This cable has copper inside, a naturally occurring material that helps conduct energy. If we throw it in the trash, it could end up in a place where it harms the environment. But if we recycle it, it can be used in another device."

This knowledge helps teachers convey more detailed information to children and raise their awareness of the importance of caring for the environment. This way, in addition to understanding the role of technology in their lives, they develop a critical sense of sustainability and responsible use and disposal of electronic devices.

Objective:

The goal of this activity is to introduce the concept of responsible disposal of electronic components, teaching children the importance of proper disposal to reduce environmental impact. They will learn about electronic waste and how it differs from regular trash, understanding why improper disposal can be harmful to the environment. Furthermore, we aim to encourage reflection on the environmental impact of technological devices, encouraging children to adopt recycling and reuse practices. During the activity, children will also develop collaboration and group work skills, devising sustainable solutions and understanding how their actions can contribute to a safer and healthier future for all. In this way, we aim to foster critical thinking and promote greater awareness of how technology and sustainability must go hand in hand.

21st Century Skills:

- **Critical thinking and problem-solving:** The child will learn about the need for different disposal of electronic waste.

BNCC Axes and Skills:

- **“THE SELF, THE OTHER AND THE US” (EI03EO02):** Act independently, with confidence in your abilities, recognizing your achievements and limitations.
- **“LISTENING, SPEAKING, THINKING AND IMAGINATION” (EI03EF03):** Choose and leaf through books, trying to orient yourself by themes and illustrations, and trying to identify familiar words.
- **“LISTENING, SPEAKING, THINKING AND IMAGINATION” (EI03EF06):** Produce your own oral and written stories (spontaneous writing), in situations with a significant social function.
- **“LISTENING, SPEAKING, THINKING AND IMAGINATION” (EI03EF08):** Select books and texts from known genres for adult reading and/or for your reading

This plan was inspired by the activity plan created by the participants of the Curricular Activity for the Integration of Teaching, Research and Extension (ACIEPE) “Computer Education for 4 and 5 year old children: training teachers to become active users of technology”.

(based on your repertoire of these texts, such as retrieval through memory, reading the illustrations, etc.).

- **“SPACES, TIMES, QUANTITIES, RELATIONS AND TRANSFORMATIONS” (EI03ET02):** Observe and describe changes in different materials, resulting from actions on them, in experiments involving natural and artificial phenomena.

BNCC Computing Axes and Skills - Early Childhood Education:

- **“DIGITAL CULTURE” (EI03CO10):** Use digital technology in a safe, conscious, and respectful manner.

Materials needed for the activity:

- Electronic components such as: circuit boards, cables, batteries, keyboard, mouse, chips, computer fan, and batteries
- Cardboard box, paints, brushes, scissors, stickers, and tape so children can create a miniature version of the disposal box
- Book "The Book That Had No End"
- Responsibility for the disposal of electronic waste by the school

Activity development:

1. Initial Reading and Exploration

- Begin the activity by reading the book *The Book That Never Ended* (see References). Read the book aloud to the children, pointing out the illustrations and pausing for questions and reflection.
- After reading, relate the idea of the "never-ending cycle" to the life cycle of electronic components. Explain that, just as the materials in the book were reusable, electronic device components can be reused or recycled to help the environment.
- Ask: "Do you think an old computer might still have useful parts? What happens if those parts are thrown in the trash?"

2. Exploration of Electronic Components

- Show children safe-to-handle electronic components, such as circuit boards, cables, and batteries (without visible damage). Explain what each component is for:
 - Circuit boards: "They are like highways where energy and information pass to make the computer work."
 - Cables: "They are used to connect different parts of the computer or carry power."
 - Batteries: "They store energy so that the device can operate without being plugged in."

- Explain that these components contain materials such as copper and nickel, which come from nature, and that disposing of them in regular trash can cause soil and water pollution.
- **Teacher Tip: Where can I get the materials?**
 - **Families of children:** Ask them to bring old electronics that are no longer in use, such as keyboards, mouse, cables, or broken cell phones.
 - **Recycling Centers:** Contact recycling cooperatives that handle e-waste and ask for donations of discarded and safe materials.
 - **Schools or universities:** Some institutions have laboratories or departments that can provide obsolete parts for teaching activities.
 - **Electronics repair shops:** Small workshops often accumulate discarded parts that can be donated for educational activities.

3. Reflection: Impacts of Improper Disposal

- Ask children what they think might happen if the components are thrown into the regular trash. Show images or short videos about environmental pollution caused by e-waste.
- Use simple examples, such as: “If a battery leaks into the ground, it can damage the soil and harm the plants and animals that live there.”

4. Story Creation: The Life Cycle of an Electronic Component

- Instruct children to create a story based on an electronic component. They can choose between:
 - **Fanciful:** Create a narrative where the component has life and tells its own story, from its manufacture to its conscious disposal.
 - **Functional:** Explain the role of the component in the device, what it does, and how it should be disposed of correctly.
- Help children structure the story by providing examples:
 - “I’m a battery! I was made to store energy, but if I’m not disposed of properly, I can cause a lot of harm to the environment.”
 - “I’m a circuit board that connects different parts of a computer. When I’m recycled, I can be used in another device.”

5. Ideation and Prototyping - Electronic Waste Disposal Box

- Divide the children into groups to create prototype e-waste disposal boxes.
- Help groups include educational messages, such as “Don’t throw in the trash!” or “Recycle to protect the planet!”
- Show real-life examples of waste bins to inspire groups.

6. Visual Activity - Good Practices Poster

This plan was inspired by the activity plan created by the participants of the Curricular Activity for the Integration of Teaching, Research and Extension (ACIEPE) “Computer Education for 4 and 5 year old children: training teachers to become active users of technology”.

- Create a collective poster with best practices for disposing of electronic waste. Include drawings, simple messages, and illustrations about the environmental impact of improper disposal.

6. Final Reflection - Question and Answer Game

- Conduct a quiz game to review the concepts learned:
 - “Why can’t we throw batteries in the regular trash?”
 - “What happens to the environment when we dispose of electronics incorrectly?”
 - “How can we help take care of the planet by recycling?”
- Conclude by reinforcing that conscious disposal is a way to care for the planet and that every child can make a difference.

This in my world:

Learning about responsible disposal helps us understand how we can better care for the environment and the materials we use every day, including electronic components. Different objects can be made and remade from the same material, and many of the devices we use, such as computers and cell phones, have parts that need to be disposed of properly. Electronic waste, such as boards, batteries, and cables, cannot be thrown into the regular trash, as it can harm the environment. In this activity, children understand the importance of recycling and responsible disposal, develop critical thinking and citizenship skills, and learning how these concepts are linked to the world of computing. This shows us that technology and the environment can be connected and that we all have a role in ensuring a more responsible and sustainable use of resources.

Assessment:

Research obtained by each student as a form of record, in addition to questions proposed by the teacher, such as:

1. What did you understand by recycling?
2. What is the most recyclable material from a book found on a computer?
3. Is there a difference between common recyclable waste and electronic waste (E-waste)?
4. How important is it to dispose of different types of waste correctly?
5. Do you have any electronic waste at home? If so, which ones?

Resources to support teachers:

Ciência todo dia. Esse é o PIOR tipo de lixo que existe. YouTube, 2024. Available at: <<https://www.youtube.com/watch?v=NNvvZjVSp9M>>. Access in: 06/04/2026.

Manual do Mundo. Descobrimos como ELETROELETRÔNICOS são RECICLADOS! #Boravê. YouTube, 2024. Available at: <<https://www.youtube.com/watch?v=zGA6YDzGCWo>>. Access in: 06/04/2026.

References:

ASHBY, Michael F.; SHERCLIFF, Hugh; CEBON, David. *Materials: Engineering, Science, Processing and Design*. Oxford: Butterworth-Heinemann, 2005.

INSTITUTO ECOFUTURO. *O livro que não tinha fim*. São Paulo: Fundação Educar DPaschoal, 2006. Disponível em: <http://www.educardpaschoal.org.br/web/files/files/O%20livro%20que%20nao%20tinha%20fim.pdf>. Acesso em: 15 jan. 2025.

KANG, Hyunmyung; SCHOENUNG, Julie M. *Electronic waste recycling: A review of U.S. infrastructure and technology options. Resources, Conservation and Recycling*, v. 45, n. 4, p. 368-400, 2005.

Activity design plan

Theme	Data processing
Title	Topological routine
Knowledge	Organizational strategies
Age Range	4 and 5 years old
Duration	3 hours ¹

Computer Knowledge:

Graphs are mathematical tools used to organize information and illustrate how different elements are connected. In computing, they are widely used to solve problems involving sequences, relationships, and dependencies, such as route planning, task organization, and even the functioning of social networks (Cormen et al., 2009). A graph is composed of points, called "vertices," and lines connecting them, called "edges." These elements help visually represent the relationship between actions or items.

To make things easier to understand, we can imagine a graph as a "routine map" for a child. Each vertex represents an activity, such as waking up, brushing teeth, having breakfast, or playing. The edges indicate the order in which these activities occur, showing, for example, that we first wake up, then brush our teeth, and only then have breakfast. This organization helps us understand how some actions depend on others to be completed. For example, it's impossible to put on a backpack before finishing putting away school supplies.

In another example, we can imagine a graph that represents the steps involved in getting dressed. Each vertex corresponds to a piece of clothing, and the edges show the logical sequence in which these pieces should be put on. In the figure below, taken from the book *Introduction to Algorithms* (Cormen et al., 2009, p. 467), we can see a graph where the shirt should be put on before the jacket and tie. This example helps illustrate how graphs can be used to organize tasks that depend on a specific sequence.

¹ This duration is an estimate of time and can be flexible according to the class demand.

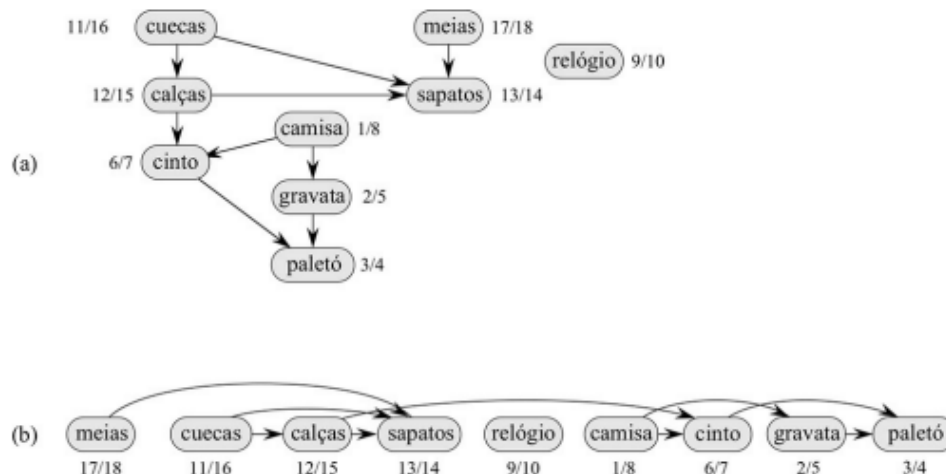


Figura 1: Grafo retirado do livro “Introduction to Algorithms”, versão inglesa, pág, 467.

In computing, a classic example of a graph application is calculating task dependencies. When a program needs to execute multiple actions in order, it can use a graph to ensure each task is performed in the correct sequence. A practical example would be the execution of activities in video games, where each phase can only be accessed after the previous one has been completed.

Furthermore, graphs can be used to plan routes. Consider a mapping application: it uses a graph to represent streets and connections between them, identifying the fastest route between two points. The relationship between graphs and computing is fundamental to many fields, as they are used to model problems and find efficient solutions. A classic example is the use of graphs in computer network optimization, where each vertex represents a device and each edge, a connection. Understanding how these connections work helps ensure data is transmitted quickly and securely (Sedgewick and Wayne, 2011).

This decision-making process is based on the same concepts children can learn when organizing their routines. Through graphs, we can teach children the importance of following an order, understanding connections, and organizing their activities logically.

Objective:

The goal of this activity is to develop critical thinking by evaluating which habits are healthy in their daily routine. Additionally, they will represent these habits in a graph that shows the order in which each action should occur, learning about organization and the sequence of activities.

21st Century Skills:

- **Critical thinking and problem-solving:** In this activity, children must evaluate what is and isn't feasible for a healthy routine, developing critical thinking. Furthermore, children must assimilate the concept of "right and wrong" within their routine and

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distinguish between feasible, unfeasible, or absurd attitudes, involving the concept of problem-solving.

BNCC Axes and Skills:

- **“THE SELF, THE OTHER AND THE US” (EI03EO01):** Demonstrate empathy for others, realizing that people have different feelings, needs, and ways of thinking and acting.
- **“THE SELF, THE OTHER AND THE US” (EI03EO02):** Act independently, with confidence in your abilities, recognizing your achievements and limitations.
- **“THE SELF, THE OTHER AND THE US” (EI03EO03):** Expand interpersonal relationships, developing attitudes of participation and cooperation.
- **“THE SELF, THE OTHER AND THE US” (EI03EO04):** Communicate your ideas and feelings to different people and groups.
- **“BODY, GESTURES AND MOVEMENTS” (EI03CG04):** Adopt self-care habits related to hygiene, food, comfort, and appearance.
- **“BODY, GESTURES AND MOVEMENTS” (EI03CG05):** Coordinate your manual skills to adequately meet your interests and needs in different situations.
- **“TRACES, SOUNDS, COLORS, AND SHAPES” (EI03TS02):** Express yourself freely through drawing, painting, collage, folding, and sculpture, creating two-dimensional and three-dimensional productions.
- **“LISTENING, SPEAKING, THINKING AND IMAGINATION” (EI03EF01):** Express ideas, desires, and feelings about your experiences, through oral and written language (spontaneous writing), photos, drawings, and other forms of expression.
- **“SPACES, TIMES, QUANTITIES, RELATIONS AND TRANSFORMATIONS” (EI03ET07):** Relate numbers to their respective quantities and identify the before, after, and between in a sequence.

BNCC Computing Axes and Skills - Early Childhood Education:

- **“COMPUTATIONAL THINKING” (EI03CO02):** Express the steps to perform a task in a clear and orderly manner.
- **“COMPUTATIONAL THINKING” (EI03CO05):** Compare algorithmic solutions to solve the same problem.

Materials needed for the activity:

- Paper;
- Colored pencils/crayons;

Activity development:

1. Initial Exploration: Routine Talk

This plan was inspired by the activity plan created by the participants of the Curricular Activity for the Integration of Teaching, Research and Extension (ACIEPE) “Computer Education for 4 and 5 year old children: training teachers to become active users of technology”.

- Start a conversation with the children, asking them about their daily routines. For example, ask:
 - "What do you do as soon as you wake up?"
 - "What comes after breakfast?"
 - "How do you get ready for school?"
- Explain that some actions need to be done in a specific order. Say, "For example, to put on your shoes, you need to put on your socks first. Other actions, like drinking juice before or after eating, can vary."
- Relate children's routines to how computers work by saying, "In computing, we also need to organize tasks in a sequence for the system to work properly."

2. Ideation: Design the Routine and Explore Alternatives

- Have children draw their routine on a sheet of paper, representing each action as a simple drawing or symbol.
- Suggest that they think about how the actions connect. Ask, "What happens if we change the order? For example, if you brush your teeth before drinking coffee, does that work? How would it be different?"
- Relate these choices to the computing environment by saying, "On computers, some tasks can be done out of order without problems, but others depend on a certain sequence. For example, you can't print a file before creating it."

3. Prototyping: Creating a Prototype with Concrete Materials

- Distribute cards or blocks so each child can represent their daily activities concretely. Each card can represent a step in the routine.
- Have children arrange the cards on the floor or a table, connecting the steps with arrows that show the order of actions.
- Explain that the connections between the cards are like the connections in a graph. Use examples like: "If you change the order of the cards, what changes? Does it still work?"

4. Sharing and Collaboration: Conversation and Discussion

- Lead a group discussion about the maps you created. Ask:
 - "What actions need to be done in a specific order?"
 - "What actions can be changed in order and still work well?"
- Relate the dependencies you found to the logic of graphs in computing. Explain: "On computers, sometimes one task depends on another. For example, you need to download a game to play it."

5. Collective Construction: Creation of the "Class Routine Map"

- Guide the class in creating a large collective map that represents everyone's routine. Use the board or a large sheet of paper, connecting the actions with arrows.

This plan was inspired by the activity plan created by the participants of the Curricular Activity for the Integration of Teaching, Research and Extension (ACIEPE) "Computer Education for 4 and 5 year old children: training teachers to become active users of technology".

- Show how some actions are directly connected, while others can be done in different ways. Say, "It's like on a computer, where some tasks require a fixed order and others can be more flexible."

6. Iteration and Refinement: Revisit and Improve

- Lead a discussion at the end of the activity, encouraging children to reflect on the sequences and connections. Ask:
 - "Do you think changing the order of some actions could cause problems? In what cases?"
 - "How is this similar to what happens on computers?"
- Conclude by relating the activity to graphs in computing. Say: "The maps you created are like graphs, which we use to organize tasks in computers. They help ensure things are done correctly."

This in my world:

This activity helps children understand the importance of having an organized and healthy daily routine. By organizing their daily activities like a "map" or "path," children can see which actions need to be done before others and why this is important. For example, brushing their teeth before eating breakfast is a healthy habit. This helps them learn to distinguish which habits contribute to a healthier and more enjoyable day and which are not recommended. This organization also shows how planning and carrying out activities in a practical way helps make daily life run more smoothly, like a "well-planned outing."

Assessment:

This activity will be assessed in a participatory and procedural manner, involving children in reflections on their creations and those of their peers. The goal is to assess their understanding of the concept of graphs, dependencies between actions, and the relationship of these ideas to the computational environment.

1. Individual Assessment: Reflection on One's Graphs

- Ask each child to explain their routine graph, highlighting the order of activities and why they chose a particular sequence.
- Use questions to encourage reflection, such as:
 - "Why did you put this action before another?"
 - "Do you think you could change the order? Why?"
 - "If this activity were done out of order, what would happen?"
- Observe whether the child can identify dependencies and logically explain the connections between the actions in their graph.

2. Collective Assessment: Exchange of Experiences and Analysis between Groups

- Organize an activity where children exchange their graphs with other groups or classmates.
- Instruct each group to analyze the graph they received, asking questions such as:

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- "Does this order make sense? Why?"
- "Would you change anything? What and why?"
- "Have you identified any actions that could be connected differently?"
- Relate the feedback given by each group to the computing environment by saying, "Just as you are adjusting these graphs, on computers, programmers check and correct the connections between tasks to ensure everything works."

3. Formative Assessment: Review and Adjustments of Your Graphs

- Ask children to revise their graphs after receiving feedback from their peers. Encourage them to make improvements or experiment with different connections.
- Use questions to encourage improvement, such as:
 - "What did you learn from analyzing another group's graph?"
 - "Did you change anything in your graph? Why?"

4. Final Assessment: Presentation and Connection to Computing

- Lead a discussion so children can share what they learned during the analysis and review.
- Ask how the ideas discussed relate to computer use. Sample questions:
 - "Why is it important to organize tasks in the right order?"
 - "On computers, what happens if tasks aren't connected correctly?"
- Assess whether children can identify dependencies and explain how connected actions form a functional whole.

Resources to support teachers:

Fernando Emilio Puntel. Grafos em 12 Minutos! Vértices, Arestas, Grau e Muito Mais!. YouTube, 2025. Available at: <<https://www.youtube.com/watch?v=4W8bTrDmpck>>. Access in: 06/04/2026.

References:

CORMEN, Thomas H.; LEISERSON, Charles E.; RIVEST, Ronald L.; STEIN, Clifford. *Introduction to Algorithms*. 3. ed. Cambridge: MIT Press, 2009.

SEDGEWICK, Robert; WAYNE, Kevin. *Algorithms*. 4. ed. Boston: Addison-Wesley, 2011.

Activity design plan

Theme	Information security
Title	Trail of the Internet Protectors
Knowledge	Safe Internet Use
Age Range	4 and 5 years old
Duration	8 hours ¹

Computer Knowledge:

Information security is a crucial area of computing, focused on protecting data from unauthorized access, unauthorized alteration, and malicious or accidental destruction. It is based on three fundamental principles: confidentiality, integrity, and availability. Confidentiality ensures that only authorized individuals have access to information, protecting sensitive data from prying or malicious eyes (Stallings, 2017). Integrity ensures that information remains unchanged except by those authorized to modify it, while availability ensures that data is accessible whenever needed, regardless of failures or attacks.

In the digital environment, where information is constantly shared and stored, threats such as phishing, malware, and social engineering attacks are common. Phishing, for example, is a strategy in which scammers pose as trusted organizations, such as banks or popular services, to trick people into sharing confidential information, such as passwords or credit card numbers (Mitnick and Simon, 2011). Malware, which includes viruses and ransomware, is software designed to steal data or cause damage to systems, often disguised as seemingly harmless files or applications (Pfleeger and Pfleeger, 2015). Social engineering, in turn, uses psychological manipulation to convince victims to reveal sensitive information, exploiting trust or distraction.

Protecting yourself from these threats involves adopting best practices that combine technology and conscious behavior. For example, using strong passwords is a simple but effective measure. These passwords should contain a mix of uppercase and lowercase letters, numbers, and symbols, and avoid obvious information such as dates of birth or simple number sequences (Stallings, 2017). Implementing two-factor authentication (2FA) is another layer of protection that can make a difference, requiring a second level of authentication, such as a code sent to the user's cell phone or email, to confirm their identity. Furthermore, it's

¹ This duration is an estimate of time and can be flexible according to the class demand.

crucial to be vigilant when clicking on links or downloading files, especially from unknown sources, as these can often be attack vectors.

Keeping systems and applications up-to-date is equally important. Updates frequently fix security flaws that could be exploited by attackers. Finally, education is one of the most powerful tools for ensuring information security. Understanding how to identify danger signs, such as fraudulent emails or suspicious messages, helps avoid risky situations. Knowing how to recognize the structure of a phishing attack, such as spelling errors in messages or links that lead to strange pages, is essential for safely navigating the digital environment (Mitnick and Simon, 2011).

These concepts, although seemingly technical, are accessible and can be applied practically in everyday life, promoting awareness and forming habits that protect both personal information and the digital well-being of each user.

Objective:

The goal of this activity is to promote understanding and discussion about the conscious, ethical, and safe use of the internet and social media, encouraging children to adopt responsible practices when using digital tools. Furthermore, the activity seeks to explain the main dangers of inappropriate internet use, helping children recognize them in a practical and accessible way, through discussion groups and interactive games. This way, children will have the opportunity to learn how to navigate the digital environment safely and confidently.

21st Century Skills:

- **Creativity and Innovation:** Children are expected to develop creativity during discussions and scenario creation. Creativity and innovation skills can also be developed during the creation of the board game and its rules.

BNCC Axes and Skills:

- **“THE SELF, THE OTHER AND THE US” (EI03EO04):** Communicate your ideas and feelings to different people and groups.
- **“TRACES, SOUNDS, COLORS, AND SHAPES” (EI03TS02):** Express yourself freely through drawing, painting, collage, folding, and sculpture, creating two-dimensional and three-dimensional productions.
- **“LISTENING, SPEAKING, THINKING, AND IMAGINATION” (EI03EF04):** Retell stories heard and collectively plan scripts for videos and performances, defining the contexts, characters, and structure of the story.

BNCC Computing Axes and Skills - Early Childhood Education:

- **“DIGITAL CULTURE” (EI03CO10):** Use digital technology in a safe, conscious, and respectful manner.

This plan was inspired by the activity plan created by the participants of the Curricular Activity for the Integration of Teaching, Research and Extension (ACIEPE) “Computer Education for 4 and 5 year old children: training teachers to become active users of technology”.

Materials needed for the activity:

- Pre-designed board models
- Cardboard
- Bond paper
- Gouache
- Pen/pencil
- Glue

Activity development:

1. Problem Identification (Initial Conversation)

- Start a conversation by asking children what they know about the internet. For example, ask:
 - "What do you like to do online?"
 - "Do you think everything on the internet is safe?"
 - "What do you think it means to be safe on the internet?"
- Explain in simple terms that the internet offers cool things, like games and videos, but also dangers, like messages from strangers or suspicious links. Use everyday examples to make the topic more accessible, such as "keeping your password safe is like keeping an important key."
- Tell them we'll learn together how to be "Internet Protectors," helping to create a safe and fun digital environment.

2. Reading the comic and discussing malware:

- Present the Turma da Monica comic book about online safety, available at [this link](#). Read the story as a group, encouraging children to observe the situations the characters face.
- As you read, highlight important points, such as protecting a password, avoiding unfamiliar links, and asking an adult for help if you encounter something strange online.
- Ask questions during and after reading, such as: "Why did the character have trouble clicking the link?" or "How did they solve the problem?" This helps connect the narrative with digital security concepts.

3. Ideation - Survey of Solutions

- Create an extension of the comic book narrative, inviting children to become characters in the story. Use puppets, drawings, or role-playing to enrich the experience.
- Present fictional challenges for children to solve, such as identifying suspicious links or creating a secure password to protect a virtual treasure.

This plan was inspired by the activity plan created by the participants of the Curricular Activity for the Integration of Teaching, Research and Extension (ACIEPE) "Computer Education for 4 and 5 year old children: training teachers to become active users of technology".

- Show them visual examples, like a fake email or a dangerous link, so they can spot the warning signs.

4. Board Game Creation: Exploring Internet Safety

- Show an example of a basic board with colored squares representing safe actions (blue) and dangerous actions (red). Explain how the game will teach online safety in a fun way.
- Divide children into small groups and provide pre-designed board templates with spaces to complete with challenges and best practices based on the concepts learned.
- Give concrete examples to include in the game, such as:
 - Safe spaces: "You used a strong password. Move forward two spaces."
 - Dangerous spaces: "You clicked on a suspicious link. Move back three spaces."
 - Questions to move forward: "What is a strong password?" or "What should you do if you receive a message from a stranger?"
- Instruct each group to include clear and simple actions in the game, adjusting according to the children's level of understanding.

5. Playing and Learning

- Guide children through the board game, explaining the rules clearly. Each child can be a piece or represent a digital character.
- Reinforce security concepts with each playthrough, explaining the reason behind in-game rewards and penalties. For example: "You advanced because your password protected your information."

6. Final Production: Online Safety Poster

- Ask the children to create a collective poster at the end of the activity, with drawings and phrases about what they learned in the game and from reading the comic.
- Include messages like "Beware of messages from strangers," "Don't click on unknown links," and "Use strong passwords to protect yourself."
- Use the poster as part of a school awareness campaign to teach other children about internet safety.

7. Final Reflection and Systematization

- Conduct a final discussion to discuss what was learned. Ask, for example:
 - "What would you do differently on the internet now?"
 - "Why is it important to protect our data?"

- Connect the practices learned to everyday life, showing how every child can become an "Internet Protector."

This in my world:

In this activity, we understand that the internet can be a place full of cool and useful things, but we also need to be careful. Just as we learned to look both ways before crossing the street, we need to take precautions when browsing online. Learning about internet safety helps us recognize when something isn't right, such as suspicious messages or requests to share our personal information. This makes us understand that, even in the digital world, it's important to be careful about what we do and protect our data, ensuring our online experience is safe and fun. This way, we can apply all of this to our daily lives, whether using our cell phones to play games, chat with friends, or access websites.

Assessment:

The children will create a collective poster outlining good online safety practices and their feelings about losing personal data. The poster will be used to assess whether the children understand the consequences and best practices related to internet safety.

At the end of the activity, the teacher will ask some simple questions, such as:

- "What can we do to ensure our internet security?"
- "Why shouldn't we share our passwords with anyone?"

The answers will help assess whether children understand the main concepts of safe internet use.

Resources to support teachers:

LearnFree em Português. Segurança na Internet: Sete conselhos para prevenir riscos nas redes sociais. YouTube, 2016. Available at: <<https://www.youtube.com/watch?v=QFdkggG34wo>>. Access in: 06/04/2026.

DuattHub. Todos os Vírus de Computador Explicados em 8 minutos. YouTube, 2025. Available at: <https://www.youtube.com/watch?v=ASJ8QeWPd_o>. Access in: 06/04/2026.

References:

MITNICK, Kevin; SIMON, William L. *The Art of Deception: Controlling the Human Element of Security*. New York: Wiley, 2011.

PFLEEGER, Charles P.; PFLEEGER, Shari L. *Security in Computing*. 5. ed. Upper Saddle River: Prentice Hall, 2015.

SOUZA, Mauricio de; MAURICIO DE SOUSA PRODUÇÕES. *Seja incrível na internet*. São Paulo: Mauricio de Sousa Produções, 2022. Disponível em: <https://turmadamonica.uol.com.br/revistasespeciais/?ed=seja-incrivel-na-internet>. Acesso em: 15 jan. 2025.

STALLINGS, William. *Cryptography and Network Security: Principles and Practice*. 7. ed. Upper Saddle River: Pearson, 2017.

Activity design plan

Theme	Conscious use of technology
Title	How do we deal with the videos we watch on the internet?
Knowledge	Screen time
Age Range	4 and 5 years old
Duration	2 hours ¹

Computer Knowledge:

Computing is integrated into everyday life through screens that mediate interactions on devices such as cell phones, tablets, televisions, and computers. These visual interfaces are designed to facilitate the use of computer systems and ensure a user-friendly experience (Shneiderman et al., 2016). However, excessive screen use can cause negative impacts, such as eyestrain, a sedentary lifestyle, and impaired motor and social development, especially in children (Anderson and Subrahmanyam, 2017).

The concept of healthy screen time seeks to balance the use of these technologies with other essential activities, such as playing, interacting with others, and exercising. While screens are valuable tools for learning and entertainment, their use must be planned to avoid harmful effects. In the context of computer science education, it is essential to address children's relationship with screens, demonstrating that computing is not limited to the passive use of devices, but involves the responsible creation, analysis, and implementation of technologies.

Computing provides access to digital resources, but it also offers opportunities to integrate hands-on, physical activities into teaching. For example, when teaching algorithms, teachers can use games that simulate logical sequences, encouraging children to perform physical movements to represent steps in a program. This approach promotes conceptual understanding while reducing sedentary time, reinforcing the idea of active and integrated learning.

Furthermore, computing education should address the impact of screens on human and social development. Designing accessible interfaces, such as reminders for breaks and display modes that reduce eye strain, exemplifies how computing can mitigate the effects of prolonged device use (Shneiderman et al., 2016). Integrating these concepts into lessons helps children understand that computing can contribute to a more balanced and healthy lifestyle.

¹ This duration is an estimate of time and can be flexible according to the class demand.

On the other hand, studies indicate that excessive screen time is associated with increased sedentary lifestyles and reduced social interactions (Anderson and Subrahmanyam, 2017). Therefore, it is essential to promote the conscious use of technologies, emphasizing that computer-based learning does not replace activities essential to overall development, such as outdoor play and interpersonal interactions.

When teaching computing, teachers can encourage discussions about the impact of screens on daily life and engage children in projects that explore the design of technological solutions that promote healthy habits. For example, children can create prototypes of apps that encourage regular breaks or messages that encourage physical activity. These activities reinforce the notion that computing is not just a technical field, but also a discipline committed to human well-being.

Computer science education, therefore, must balance the inclusion of screens with the appreciation of hands-on activities, promoting a responsible integration between technology and human development. This approach ensures that children understand not only how to use technologies but also how to design them ethically and sustainably, aligning computer learning with health and well-being.

21st Century Skills:

Enable the child to understand how problematic it is to spend too much time using a screen, and to suggest new ideas about time allocation.

Habilidades do Século XXI:

- **Critical thinking and problem-solving:** The child will analyze the time of the suggested video and consider a new way to recreate the same video, demonstrating quality time in transmitting information.

BNCC Axes and Skills:

- **“THE SELF, THE OTHER AND THE US” (EI03EO03):** Expand interpersonal relationships, developing attitudes of participation and cooperation.
- **“THE SELF, THE OTHER AND THE US” (EI03EO04):** Communicate your ideas and feelings to different people and groups.
- **“TRACES, SOUNDS, COLORS AND SHAPES” (EI03TS03):** Recognize the qualities of sound (intensity, duration, pitch, and timbre), using them in sound productions and when listening to music and sounds.
- **“LISTENING, SPEAKING, THINKING AND IMAGINATION” (EI03EF04):** Retell stories heard and collectively plan scripts for videos and performances, defining the contexts, characters, and structure of the story.
- **“SPACES, TIMES, QUANTITIES, RELATIONS AND TRANSFORMATIONS” (EI03ET01):** Establish comparison relationships between objects, observing their properties.

This plan was inspired by the activity plan created by the participants of the Curricular Activity for the Integration of Teaching, Research and Extension (ACIEPE) “Computer Education for 4 and 5 year old children: training teachers to become active users of technology”.

BNCC Computing Axes and Skills - Early Childhood Education:

- **“DIGITAL CULTURE” (EI03CO10):** Use digital technology in a safe, conscious, and respectful manner.
- **“DIGITAL CULTURE” (EI03CO11):** Adopt healthy habits when using computer artifacts, following recommendations from competent health agencies.

Materials needed for the activity:

- Digital media (cell phone, computer, video camera, multimedia projector, internet);
- Chalkboard and chalk.

Activity development:

1: Introduction to Using Screens

- Start a conversation to explore children's screen time. Ask:
 - "What devices do you use daily, like your cell phone, tablet, or TV?"
 - "What do you most enjoy doing on these devices?"
 - "How much time do you think you spend using screens?"
- Explain the concept of healthy screen time: "It's important to balance screen time with other activities, such as playing outdoors, talking with family, and resting. This way, screens help us learn and have fun without harming our health."
- Show an example of a balanced schedule for a child's day:
 - **Morning:** Breakfast, playing outdoors, watching an educational video (30 minutes).
 - **Afternoon:** School activities, playing with toys, watching a cartoon (20 minutes).
 - **Evening:** Family dinner, reading a book, early bedtime.
- Explain that the purpose of the schedule is to help organize time so you can enjoy the day with several different activities.

2: Watching the Video and Alternative Activities

- Show a short video (approximately 5 minutes).
 - **Suggestion:** Short video about forest animals or professions, such as "Teca na TV" Channel.
- Have children do another activity while watching the video, such as drawing or playing with simple objects.
- Ask:
 - "Was it easy or difficult to do something else while watching the video?"
 - "How did you feel about dividing your attention between two things?"

- Relate the experience to healthy screen time use: “Sometimes it's better to focus on a single activity to learn or better enjoy what we're doing.”

Tip: A YouTube channel that offers educational content suitable for young children is the "Mundo Bitá" Channel (<https://www.youtube.com/@MundoBita/videos>).

3: Comparison between Long and Short Videos

- Present two videos on the same topic (e.g., animals), one longer and one shorter.
- Video suggestions:
 - Short video: "Forest Animals" (5 minutes).
 - Long video: Children's documentary about animals (15-20 minutes).
 - Examples are available on YouTube Kids or trusted educational channels.
- Before watching, ask:
 - "Do you think shorter or longer videos teach us more?"
 - "What changes when we watch videos of different lengths?"
- After watching the videos, ask children to reflect on their use of time:
 - "What did you learn from the short video?"
 - "And from the long video?"
 - "Did the length of the video influence how you spent the rest of your day?"
- Explain that short videos can be useful for learning something quickly and freeing up time for other activities, while long videos are good for deepening your knowledge of a topic.

4: Collaborative Project - Planning an Ideal Video

- Organize the children into small groups and have them create a script for a short video. Instruct them:
 - “Choose a simple topic, like caring for plants, playing in the park, or telling a fun story.”
- Ask the group:
 - "How can we teach or show something in just a few minutes?"
 - "What images or scenes are most important for the video?"

Tip: Show examples of simple storyboards to help children organize their ideas with drawings or notes.

5: Reflection and Connection with Everyday Life

- Conclude the activity with a conversation. Ask:
 - "What have you learned about using screen time healthily?"
 - "How can we use what we've learned to organize our day?"
- Ask children to draw a picture of how they would balance screen time with other activities, such as playing, talking, or moving around.

This plan was inspired by the activity plan created by the participants of the Curricular Activity for the Integration of Teaching, Research and Extension (ACIEPE) “Computer Education for 4 and 5 year old children: training teachers to become active users of technology”.

- Reinforce that screens are valuable tools, but it's important to use them in a balanced way, also taking advantage of time to interact and play.

This in my world:

In our daily lives, we're constantly surrounded by screens, such as televisions, cell phones, and tablets. They're part of our play, our conversations, and even our learning. But, as in other areas of our lives, it's important to know when to use them and when to take a break. In this activity, we'll help children understand that screen time should be balanced. Just as we need good nutrition and time to exercise, we also need to use screens in a way that doesn't affect our health and allows us to engage in other important activities, such as playing outdoors, talking with family, or drawing. Understanding this balance is essential to ensuring that screen time is a positive and healthy part of our daily lives.

Assessment:

After recreating the videos, the children would be assessed through the production of drawings.

Each child will receive a sheet of paper divided into two parts. On one side, they will draw a healthy screen-use practice, such as watching a cartoon for a short period and then playing outside. On the other side, they will draw an unhealthy practice, such as spending too much time in front of the TV without doing other activities. These drawings will allow the teacher to assess the children's understanding of balance in technology use.

After completing their drawings, the children will participate in a discussion circle to share their work. Each child will explain their drawing, encouraging reflection on healthy and unhealthy practices. This discussion will help reinforce the concepts learned and allow the teacher to clarify any confusion that arises.

During the discussion, the teacher will ask a few questions to check whether the children understand the concept of healthy screen time and how it applies to their daily lives:

- "When is it healthy to use a cell phone or tablet?"
- "What else can we do instead of watching TV for too long?"

These questions will help assess whether children can relate what they have learned to everyday situations.

Resources to support teachers:

Explicatricks. Celular e crianças: uso de telas YouTube, 2024. Available at: <<https://www.youtube.com/watch?v=kNcVSlr9ars>>. Access in: 06/04/2026.

References:

ANDERSON, Craig A.; SUBRAHMANYAM, Kaveri. *Digital Screen Time and Youth: Benefits, Risks, and Policy Recommendations*. Journal of Children and Media, v. 11, n. 4, p. 367-372, 2017.

PAPERT, Seymour. *Mindstorms: Children, Computers, and Powerful Ideas*. New York: Basic Books, 1980.

SHNEIDERMAN, Ben; PLAISANT, Catherine; COHEN, Max; JACOBS, Steven. *Designing the User Interface: Strategies for Effective Human-Computer Interaction*. 6. ed. Boston: Pearson, 2016.

APPENDIX H

Interview guide with children (Diagnostic phase)

Structured Interview Script with Children (Diagnostic phase)

Objective: To gather information about children's relationship with technology, knowledge of basic computing concepts, and necessary data for creating participant profiles.

Duration: Approximately 15 minutes

Child's Profile

1. How old are you?
2. Who do you live with at home? (Encourage answers about family members who live with the child, such as parents, siblings, grandparents, etc.)
3. What do you like to do most when you are at home? Do you have a favorite toy or activity?
4. At school, what activity do you like to do the most? (Ex.: drawing, playing with friends, listening to stories)

Technology Use and Knowledge

1. Have you ever used a cell phone, tablet, or computer? Which one do you use the most?
2. What do you like to do with it the most? (Watching videos, playing games, drawing?) *(Explores familiarity and use of technology – basis for evaluating progress)*
3. Do you use it every day or just sometimes? Do you have a set time to use it? *(Assesses frequency and routine – may influence learning)*
4. When something new appears on the screen, do you try to figure out what it is or do you ask for help? How do you do it? *(Critical thinking – exploration/autonomy)*
5. Have you ever had a computing class? *(Prior knowledge – basis for analyzing later assimilation)*

Your Ideas and Curiosities

1. Have you ever wondered how things appear on the tablet or computer? *(Critical thinking – supposition and curiosity)*
2. Have you ever tried to play in a way different from what you usually do? Tell me how it was. *(Creativity – originality)*
3. Do you like to invent things or imagine different ways to do something? Give me an example! *(Creativity – fluency and flexibility)*

Thinking to Solve Things

1. If you had a problem at home (for example: finding a lost toy), do you think the cell phone or tablet could help you? How? *(Critical thinking – application and implications)*
2. When you see something difficult or new, do you try to solve it alone or do you ask for help? What do you do first? *(Critical thinking – analysis and decision-making)*

APPENDIX I

Interview guide with children (Final phase)

Structured Interview Script with Children (Final phase)

1. Do you think anything has changed in your playtime with your tablet or computer since the last time we talked? What?
2. What do you most enjoy doing when using your tablet, cell phone, or computer?
3. When something new comes up, do you try to figure it out on your own or ask for help? Has that changed?
4. Have you tried using your tablet or computer in a different way than you did before?
5. Do you think more about how your tablet or computer works? What do you think makes things appear on the screen?
6. Have you had any new or different ideas lately for playing or using your tablet?
7. Do you think you can use your cell phone or tablet to help someone at home or at school? How would you do that?

Just for experimental group::

1. In the last few weeks, do you remember the activities we did here at school?
2. Did you think about those activities when you were using your tablet or computer afterward? Did they give you new ideas?

Creating my computer:

1. Do you know the names of the computer parts?
2. And can you explain to me how a computer works?

Topological Routine:

1. When we give a command to the computer, is it important to have a correct sequence? Why?

Maze of Sounds:

1. Where does information enter the computer?
2. What happens after the information enters the computer?

Story with Codes:

1. Can you tell me how numbers work on the computer? Are they the same as the ones we use in real life or not?
2. What do 0 and 1 mean?

APPENDIX J

Creativity and Critical Thinking Test Protocol

Activity Focused on Creativity:

Creative Problems - Suggested Time: 5 to 10 minutes

- **Diagnostic phase:** Present a scenario where a doll needs to cross a river and offer three simple objects for the child to choose a solution (e.g., a rope, a boat, a bridge). The child must choose an object and explain how they would help the doll.
- **Final phase:** Use the same scenario, but with different objects (e.g., a balloon, a rock, a piece of wood). The goal is to create a solution with a similar level of challenge, but using new materials.
- **Difficulty Level:** The central problem remains the same (helping the doll cross the river), but the objects are different to verify the use of new strategies.

Diagnostic phase Kit

5 paper clips
3 popsicle sticks
3 disposable plastic cups

Final phase Kit

2 milk cartons
3 string (30cm)
3 toilet paper rolls

Activity Focused on Critical Thinking:

Sequencing Challenges - Suggested Time: 5 to 10 minutes

- **Diagnostic phase:** Show a sequence of simple events, such as preparing a meal (e.g., setting the plate, serving the food, eating). Ask the child to organize the images in the correct order.
- **Final phase:** Use a similar sequence, such as caring for a plant (e.g., picking up the watering can, putting water, watering the plant). The difficulty level remains, but the context is different.
- **Difficulty Level:** The logic of the sequence remains the same, with everyday activities that the child can understand.

APPENDIX K

Creativity assessment rubric

Creativity Assessment Instruments

Did the group consider many ideas?

- ☐ () The children considered one idea.
- ☐ () The children considered some ideas.
- ☐ () The children considered many ideas.

Did the group consider many types of ideas?

- ☐ () The students considered one type of idea.
- ☐ () The students considered some types of ideas.
- ☐ () The students considered many types of ideas.

Did the group develop new ideas?

- ☐ () The children developed a common idea that many other children would have suggested and/or replicated an existing idea.
- ☐ () The children developed an interesting idea that several other children would have suggested and/or minimally added to an existing idea.
- ☐ () The children developed an unusual idea that few other children would have suggested and/or substantially built upon an existing idea.

Did the group elaborate on the ideas?

- ☐ () The children added a few details and improvements to their ideas.
- ☐ () The children added some details and improvements to their ideas.
- ☐ () The children added many details and improvements to their ideas.

Did the group propose useful ideas?

- ☐ () The children proposed ideas that may meet the needs of the end-user under certain conditions.
- ☐ () The children proposed ideas that would meet the needs of the end-user.
- ☐ () The children proposed ideas that would meet the needs of the end-user and significantly add value to their lives.

APPENDIX L

Critical thinking assessment rubric

Critical Thinking Assessment Instruments

Did the group summarize topics or arguments?

- ☐ The children did not organize the information, which led to an inadequate understanding.
- ☐ The children inconsistently demonstrated the ability to organize information, which led to an inadequate understanding.
- ☐ The children consistently demonstrated the ability to organize information, which led to an adequate understanding.

Did the group consider prior assumptions?

- ☐ Assumptions were defined but not explained as having meaning for the position.
- ☐ Assumptions were defined and linked to the topic ideas, but were not clearly explained or elaborated.
- ☐ Assumptions were defined and linked to the topic ideas; the children were able to elaborate on assumptions and discuss implications.

Does the group communicate a point of view?

- ☐ The children do not identify their own position on the subject.
- ☐ The children identify their own position on the subject, drawing support from experience.
- ☐ The children identify their own position on the subject, drawing support from experience and information not available in designated sources.

Does the group provide research evidence?

- ☐ No evidence was provided to support the argument.
- ☐ Accepts evidence at face value, even if it is incorrect, inadequate, or misrepresented to support the argument.
- ☐ Information is collected from appropriate and reliable sources to support the argument.

Did the group analyze data?

- ☐ No analysis of a topic. The children merely listed or defined concepts of the topic.
- ☐ The children demonstrated the ability to analyze and make interpretations of the topics.
- ☐ The children demonstrated the ability to analyze and elaborate on interpretations of the topics.

Does the group consider perspectives and positions?

- ☐ No identification of other perspectives and positions.
- ☐ Identifies other perspectives and positions.
- ☐ Identifies and evaluates other perspectives and positions.

Did the group draw implications?

- () The children are unable to explain or witness the impact of new information.
- () The children can explain or witness the impact of new information.
- () The children explain the impact of learning new information, make predictions, and generate new ideas.

Does the group evaluate conclusions?

- () No reflection on the evolution of the idea in the development of the argument.
- () Limited reflection on the evolution of the idea in the development of the argument.
- () Extensive reflection on the evolution of the idea in the development of the argument.

References:

SHIVELY, K.; STITH, K. M.; RUBENSTEIN, L. D. Measuring what matters: Assessing creativity, critical thinking, and the design process. *Gifted Child Today*, SAGE Publications Sage CA: Los Angeles, CA, v. 41, n. 3, p. 149–158, 2018.

APPENDIX M

Interview guide with teachers

Interview Script with the Teacher (Final phase)

1. Development of Children's Skills

1. Did you notice any change in the quantity and variety of ideas the children began to suggest over time? (*Combines fluency and flexibility*)
2. Did the children start proposing original or unexpected ideas? Can you describe an example? (*Direct focus on originality.*)
3. Did the children start detailing their ideas more or proposing more applicable improvements and solutions? (*Addresses elaboration and usefulness of ideas.*)
4. Did you observe changes in how children organize and communicate their ideas over time? (*Relates to clarity, structure, and evolution of reasoning.*)
5. Did the children start justifying their choices better or considering different possibilities? (*Covers assumptions, point of view, and consideration of alternatives.*)
6. Did you perceive whether the children started reflecting more on what they learned or on the results of the activities?

Just for experimental control teacher

2. General Perception of the Framework

1. How do you evaluate your overall experience applying the framework in the classroom?
2. Were the framework's guidelines and materials clear and sufficient for carrying out the activities?
3. Did you face any difficulties during the application? Can you describe how you dealt with them?
4. Was it necessary to adapt any activity of the framework? What motivated this decision, and what was the result?

3. Computing Concepts and Interest in Technology

1. Did the children show increasing interest or curiosity in topics related to technology or computing?
2. Did the playful activities help the children understand basic computing concepts? Can you cite a concrete example?
3. Did any child show greater difficulty in assimilating computing concepts? How did you address this situation?

4. Final Perceptions and Suggestions

1. If you could suggest changes or improvements to the framework, what would they be?
2. How has this experience influenced your pedagogical practice? Would you like to continue using elements of the framework in the future?