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A Systematic Mapping of the Literature on the Development of Accessible Digital Interfaces for Children with Autism Spectrum Disorder (ASD)

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Abstract
This paper presents a systematic mapping study on the development of accessible digital interfaces for children with Autism Spectrum Disorder (ASD), focusing on personalization strategies, sensory overload minimization, and the use of reusable components. The study was conducted based on the methodology proposed by Kitchenham and Charters (2007), including protocol definition, study selection criteria, and data analysis. A total of 795 studies were initially identified across relevant scientific databases, from which 21 primary studies were selected for final analysis. The results indicate that the most common approaches involve configurable user profiles, sensory stimulus control, and predictable interface elements. However, there is a lack of integration among these strategies, as well as limited adoption of more advanced adaptive technologies, such as artificial intelligence. Additionally, most studies present methodological limitations, including the absence of empirical validation in real educational settings. As a contribution, this work systematizes existing evidence and identifies research gaps, supporting the development of more accessible, adaptive, and user-centered digital interfaces for children with ASD.
Keywords: *Digital accessibility; Autism Spectrum Disorder; Customizable interfaces; Sensory overload; Inclusive design.*

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1 Introduction

Equitable access to digital education remains a recurring challenge in educational contexts involving children with Autism Spectrum Disorder (ASD). These children often face sensory, cognitive, and social barriers when interacting with digital interfaces that are not designed to meet their specific needs. Factors such as hypersensitivity to visual and auditory stimuli, difficulties with predictability, variations in sensory processing, and the need for individualized support make interaction with digital environments a critical element in the teaching and learning process. Despite technological advancements and the increasing adoption of digital educational platforms, there is still a limited availability of resources effectively adapted to neurodivergent profiles, revealing a gap between the inclusive potential of technology and its practical application in everyday school settings. In the Brazilian context, this gap is further accentuated by structural challenges related to digital inclusion, teacher training, and equitable access to assistive technologies in public schools.

In recent years, research in Human-Computer Interaction (HCI) and Computer Science has emphasized the importance of developing user-centered solutions, particularly for audiences with specific cognitive and sensory characteristics. In the case of children with ASD, this involves considering not only technical or pedagogical constraints but also contextual factors, individual characteristics, required support levels, and communication particularities. The literature highlights the need for interfaces that reduce excessive stimuli, provide clear and immediate feedback, support action predictability, and enable personalized interaction paths aligned with the child's pace and preferences.

In this context, inclusive design and interface personalization emerge as key strategies to promote accessibility, engagement, and autonomy in educational environments. Personalization allows visual, auditory, and interactive elements to be adapted according to each child's profile, respecting their sensory sensitivities, learning styles, and emotional characteristics. These adaptations may include adjustments in color, contrast, and typography, as well as the modulation of sounds, animations, narratives, and feedback mechanisms. Additionally, the use of reusable and standardized components contributes to the predictability and consistency of the digital experience—features that are particularly valued by users with ASD, who tend to respond better to stable environments with minimal unexpected variation.

Furthermore, the growth of digital educational technologies aimed at literacy, alternative communication, socio-emotional development, and gamification highlights the need to evaluate the quality of these solutions and identify effective practices to minimize sensory overload. Studies indicate that digital experiences can either enhance learning or trigger discomfort when aspects such as sensory stimuli, information density, and response time are not carefully designed. Therefore, understanding how digital interfaces for children with ASD have been designed, evaluated, and implemented in educational contexts is essential to guide developers, educators, and researchers in building more inclusive and effective tools.

In light of this context, this paper presents a systematic mapping study on the development of accessible digital interfaces for children with ASD, with a focus on the educational domain. The study follows the protocol proposed by Kitchenham and Charters (2007) and adopts a PRISMA-style flow for the identification, screening, eligibility, and inclusion of primary studies, in order to ensure transparency and reproducibility. The objective is to identify and analyze the main strategies adopted in recent literature regarding (i) interface personalization, (ii) sensory overload minimization, and (iii) the use of reusable components, considering their impact on interaction, engagement, and socio-emotional development. By mapping the state of the art, this study aims not only to synthesize existing advances but also to identify research gaps and support

the development of evidence-based guidelines for more accessible digital solutions tailored to children with ASD.

The remainder of this paper is organized as follows: Section 2 presents the theoretical foundations; Section 3 describes the systematic mapping methodology; Section 4 details the results; Section 5 discusses the findings in relation to the literature; and Section 6 concludes the paper and outlines future research directions.

2 Theoretical Background

The development of accessible and effective digital interfaces for children with Autism Spectrum Disorder (ASD) requires the integration of principles related to accessibility, usability, neurodiversity, and user-centered design. This integration is essential given the sensory, cognitive, and behavioral specificities that characterize individuals with ASD and directly influence how they interact with digital technologies (American Psychiatric Association, 2013).

According to Norman (2013), human-centered design aims to create systems that are both usable and useful, grounded in users' needs, limitations, and preferences. In the context of ASD, this involves considering characteristics such as hypersensitivity to visual or auditory stimuli, the need for predictability, and difficulties with abstraction. The use of soft colors, stable layouts, and consistent feedback mechanisms are commonly recommended practices to promote comfort, safety, and improved performance during interaction (Fernández-Andrés et al., 2015).

Digital accessibility, in turn, is a right ensured by public policies and technical standards, such as the Web Content Accessibility Guidelines (WCAG) 2.2 (W3C, 2023), which represent the most recent international guidelines for digital accessibility, based on the principles of content being perceivable, operable, understandable, and robust. In Brazil, digital accessibility is also supported by the Brazilian Inclusion Law (Law No. 13.146/2015) and by federal regulations that require accessibility in publicly funded educational technologies, reinforcing the alignment between international standards and national policies. The adoption of these guidelines from the early stages of system development is essential to ensure effective inclusion. However, as highlighted by Gomes et al. (2021), there is still a lack of projects that apply these principles in ways adapted to the cognitive and sensory profiles of neurodivergent users, such as children with ASD.

Personalization is identified as an effective strategy to address the heterogeneity of ASD. Interfaces that allow adjustments in colors, sounds, pacing, and complexity levels tend to enhance user engagement, autonomy, and sustained interaction (Silva et al., 2020). The literature also points to the potential of adaptive technologies, such as artificial intelligence-based systems, which can dynamically adjust the interface based on user behavior. However, their application in educational contexts for children with ASD remains limited (Alzahrani, Uitdenbogerd e Spichkova (2022).

Another central aspect is sensory overload, which can negatively affect both performance and engagement in digital activities. According to Chandler and Sweller (1991), Cognitive Load Theory suggests that excessive stimuli can hinder information processing and, consequently, learning—especially in non-adaptive digital environments. In the context of children with ASD, this theoretical perspective supports the design of interfaces that minimize unnecessary stimuli, present information in a clear and structured manner, and provide sensory control mechanisms. Such approaches contribute not only to improved usability but also to more effective teaching and learning processes aligned with diverse sensory sensitivities and emotional profiles.

Finally, the use of reusable components and design systems, such as the Atomic Design model (Frost, 2016), has gained increasing attention as a strategy to ensure consistency,

predictability, and accessibility in educational systems. Standardized components facilitate interface maintenance and support the creation of more fluid and reliable user experiences—particularly for users who benefit from stable visual routines, as is often the case with children with ASD (Frost, 2016; Oliveira, 2022). The practical adoption of these approaches in interfaces designed for children with ASD is examined empirically in Section 4.3 (RQ3), where the use of design systems, modular component libraries, and accessibility-oriented frameworks identified in the primary studies is analyzed.

In this context, the theoretical foundation of this study is based on the convergence of digital accessibility, user-centered design, personalization strategies, cognitive load management, and interface architecture, aiming to address the specific needs of children with ASD in the use of educational technologies.

3 Research Methodology

To identify and analyze studies in the literature on the development of accessible digital interfaces for children with Autism Spectrum Disorder (ASD), a systematic mapping study (SMS) was conducted based on the methodology proposed by Kitchenham and Charters (2007). This approach enables a structured analysis of the state of the art, allowing the identification of research trends, commonly adopted strategies, and existing gaps in the field, particularly within educational contexts.

The adopted methodology consists of three main phases. The first phase corresponds to the study planning, which involves defining the research protocol, including the formulation of the Main Research Question (MRQ) and Secondary Research Questions (RQs), the construction of search strings, the selection of data sources, and the definition of inclusion and exclusion criteria. The second phase, referred to as the study conduct, consists of applying the defined protocol to identify, select, and filter relevant studies, ensuring the systematic application of the established criteria. The selection process follows a PRISMA-style flow (identification, screening, eligibility, and inclusion), which is graphically summarized in Figure 1 (Section 3.4), in order to ensure transparency, traceability, and reproducibility. Finally, the data extraction and analysis phase involves both qualitative and quantitative examination of the selected studies, enabling the organization, interpretation, and synthesis of the findings. This process aims to answer the research questions and provide a consolidated overview of the evidence identified in the literature. In addition, threats to validity related to the search strategy, the temporal scope, and the selection of databases are explicitly discussed at the end of this section, in line with the methodological guidelines for systematic mapping studies in software engineering.

3.1 Research Questions

In order to guide the systematic mapping study and define the scope of the investigation, a Main Research Question (MRQ) was established, along with three Secondary Research Questions (RQs), as recommended by Kitchenham and Charters (2007).

The Main Research Question that guides this study is:

MRQ. How have accessible digital interfaces been designed to meet the needs of children with Autism Spectrum Disorder (ASD), considering aspects of personalization, sensory overload minimization, and the use of reusable components in educational contexts?

Based on this main question, the following secondary research questions were defined:

RQ1. What personalization strategies have been used in digital interfaces to adapt content and interaction to the characteristics of children with ASD?

RQ2. How have digital interfaces been designed to minimize sensory overload and support the development of socio-emotional skills in children with ASD?

RQ3. How does the use of reusable components impact the development and user experience of children with ASD in digital interfaces?

3.2 Search Strategy

To identify relevant studies related to the development of accessible digital interfaces for children with Autism Spectrum Disorder (ASD), search strings were defined in both English (EN) and Brazilian Portuguese (PT-BR), based on the core terms extracted from the research questions. The strings were intentionally built around four high-precision keywords—"interface," "autism," "accessibility," and "usability"—combined with the Boolean operator AND. This precision-oriented strategy was adopted to retrieve studies in which the four concepts appear jointly, prioritizing relevance over recall, given the broad volume of literature on autism and on digital accessibility considered separately. The limitations of this design choice, particularly regarding the absence of synonyms and Boolean disjunctions (OR), are explicitly discussed in Section 3.5 (Threats to Validity).

A pilot search was conducted on a subset of the selected databases to confirm that the combination of the four core terms returned a manageable and topically relevant set of studies in both languages. Cross-language equivalence was preserved by mirroring the English terms in Portuguese ("interface," "autismo," "acessibilidade," "usabilidade"), and no automatic translation or query expansion was performed.

The final search strings used in this study are presented in Table 1.

Table 1: Defined search strings.

Language	Search strings
EN	"Interface" AND "Autism" AND "Accessibility" AND "Usability"
PT-BR	"Interface" AND "Autismo" AND "Acessibilidade" AND "Usabilidade"

To ensure the retrieval of recent and topically relevant studies, the temporal scope was restricted to publications from 2020 onwards, covering the period in which digital accessibility for neurodivergent users gained increased attention in the literature, particularly during and after the intensification of remote education contexts. The search was conducted across the following scientific databases: ACM Digital Library, IEEE Xplore, Scopus (via ScienceDirect), Web of Science, and Google Scholar. These databases were selected due to their relevance in the fields of Human-Computer Interaction, Informatics in Education, and Computer Science, as well as their broad coverage of high-impact journals and conference proceedings.

The application of the search strings across the selected databases resulted in a total of 795 studies, as presented in Table 2.

Table 2: Results of studies retrieved by database

Research Databases	Number of Studies

ACM Digital	343
IEEE Xplore	02
Google Scholar	269
Scopus (via ScienceDirect)	178
Web of Science	03
Total Publications Retrieved	**795**

3.3 Selection Criteria

To identify and select the most relevant studies for this research, inclusion criteria (IC) and exclusion criteria (EC) were defined and systematically applied throughout the study selection process.

The inclusion criteria were defined as follows:

IC1. Studies that analyze the impact of sensory overload in digital environments and present mitigation strategies.

IC2. Studies addressing accessibility and usability in digital interfaces designed for children with Autism Spectrum Disorder (ASD), particularly in educational contexts.

IC3. Studies focusing on the personalization of digital interfaces to adapt user interaction for individuals with ASD.

The exclusion criteria were defined as follows:

EC1. Studies focused exclusively on gamification without direct relevance to interface adaptation for children with ASD.

EC2. Studies analyzing only the interaction of teachers or caregivers, without considering the perspective of users with ASD.

EC3. Studies focused exclusively on digital games without emphasis on learning or interface adaptation.

EC4. Studies published in languages other than English or Portuguese.

EC5. Studies with restricted access or without full-text availability.

EC6. Duplicate studies identified across multiple databases or across language versions of the same work.

EC7. Studies lacking a clear methodology or relevant theoretical foundation.

The criteria were applied in two sequential stages. In the first stage, titles and abstracts of the 795 retrieved studies were screened against IC1–IC3 and EC1–EC7, removing duplicates and clearly out-of-scope studies. In the second stage, the introduction and conclusion of each remaining study were analyzed, and full-text verification was performed against the primary source to confirm authorship, year, venue, and topical alignment with the research questions. This verification step led to the removal of studies whose declared metadata did not match the actual document, of works targeting populations other than children with ASD (e.g., adults with intellectual disabilities, university students, second-language learners), and of duplicated entries corresponding to the same study published in two languages. The final corpus retained 21 primary studies, distributed as shown in Table 3.

Table 3: Results of study selection based on exclusion criteria

Research Databases	Number of Studies

ACM Digital	6
IEEE Xplore	0
Google Scholar	14
Scopus (via ScienceDirect)	01
Web of Science	0
Total Publications Retrieved	**21**

3.4 Study Selection

The selection of primary studies followed a structured, PRISMA-style flow comprising four stages: identification, screening, eligibility, and inclusion. The complete flow is summarized in Figure 1.

Identification. After applying the search strings across the selected databases, a total of 795 studies were initially identified.

Screening. Duplicate records were removed, considering overlaps among the different scientific databases and language versions of the same work. The remaining studies were screened through the analysis of titles and abstracts against the inclusion and exclusion criteria defined in Section 3.3. This step removed studies that were clearly out of scope, reducing the set to 32 potentially relevant studies. The exact number of duplicates removed at this stage was not separately recorded; their removal was merged with the title/abstract screening step.

Eligibility. A second selection stage was performed by analyzing the introduction and conclusion of each remaining study, in order to assess adherence to the research objectives and inclusion criteria. In addition, a full-text verification was conducted against the primary source of each study, in order to confirm authorship, year of publication, venue, and topical alignment with the three analytical axes (RQ1–RQ3). This verification step led to the removal of 11 studies, in the following categories: (i) entries whose declared metadata did not match the actual document retrieved, (ii) studies targeting populations other than children with ASD (e.g., adults with intellectual disabilities, university students, or foreign-language learners), and (iii) duplicated entries corresponding to the same study published in two languages.

Inclusion. At the end of this process, 21 primary studies were retained for data extraction and analysis. Their distribution per database is presented in Table 3 (Section 3.3), and the full list of included studies, with corresponding metadata, is detailed in Table 4.

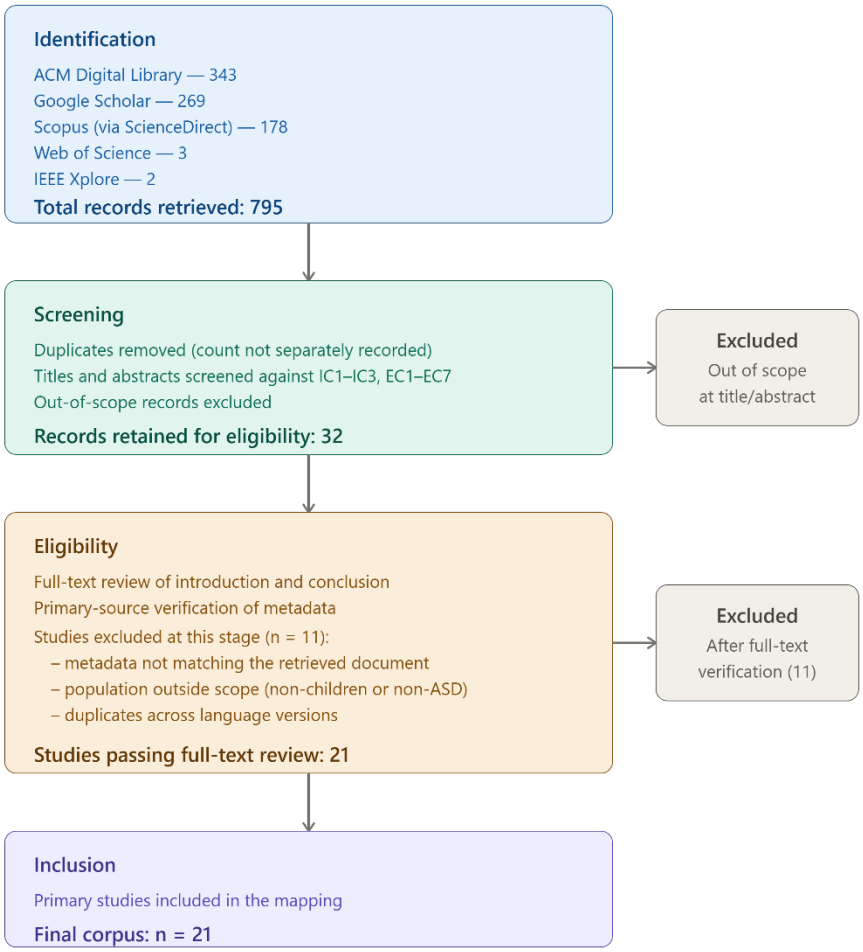

Figure 1: PRISMA-style flow diagram of the study selection process.

At the end of this process, 21 primary studies were selected for the data extraction and analysis phase, as presented in Table 3 and detailed in Table 4.

Table 4: Primary studies included in the systematic mapping, organized by source database.

Database	ID	Study title	Year
ACM Digital Library	E1	Designing Interactive Technology to Support Children with Autism	2024
	E2	Evaluation of digital games for autistic children using heuristics and observation tests	2020
	E3	Investigating the first user experience and accessibility of educational applications for autistic children	2020
	E4	Impact of animated objects on autistic and non-autistic users	2022
	E5	Accessibility-oriented design with a focus on autism aspects: designing a mobile application for autistic children's daily routine	2020
	E6	Crowdsourcing in the prioritization of accessibility and usability criteria for autism	2024

Scopus (via ScienceDirect)	E7	Unlocking inclusive education: a quality assessment of software design in applications for children with autism	2024
Google Scholar	E8	A Experiência do Usuário no Contexto de Desenvolvimento de um Aplicativo para Crianças com TEA	2022
	E9	Um Processo de Design de Interface com Foco em Usuários com TEA: Uma Experiência Prática	2022
	E10	Priorizando Critérios de Usabilidade de Recursos Digitais para Usuários com Autismo Através de Crowdsourcing	2023
	E11	Design de Interface para Usuários Neurodivergentes: Um Estudo de Acessibilidade à Web	2022
	E12	Interfaces com Acessibilidade para Pessoas com TEA: Uma Análise das Diretrizes	2022
	E13	Métricas para Avaliação de Usabilidade, Acessibilidade, Utilidade e Adequação às Necessidades de Comunicação de Indivíduos com TEA para Aplicativos de CAA	2023
	E14	Uma Abordagem Inclusiva para Design com Crianças com Autismo	2024
	E15	Construindo Pontes Digitais: Um Site Acessível Focado no TEA	2024
	E16	Uma Revisão Integrativa de Diretrizes Voltadas ao Desenvolvimento de Software para Usuários com TEA	2022
	E17	Desenvolvimento e Avaliação do Plugin para o Figma para Documentação de Acessibilidade para Interfaces — DAI	2022
	E18	Aplicativos Móveis para Crianças com TEA: Análise de Acessibilidade de Interfaces	2023
	E19	AutismGuide: Sistema de Avaliação de Usabilidade e Acessibilidade em Produtos Digitais para Pessoas no Espectro Autista	2024
	E20	Acessibilidade e Educação em Recursos Educacionais Digitais Móveis: Um Estudo Sobre as Necessidades e as Ofertas de Aplicativos de Linguagens e suas Tecnologias para Alunos com Autismo no Ensino Médio	2023
	E21	A Importância da Acessibilidade no Desenvolvimento de Software: Perspectivas Educacionais e Profissionais	2024

The selection process described above ensures transparency, traceability, and reproducibility of the systematic mapping, in line with the methodological guidelines proposed by Kitchenham and Charters (2007). The full-text verification step against the primary source of each study, in particular, allowed for the correction of metadata inconsistencies that were initially detected in the retrieved records, reinforcing the reliability of the final corpus presented in Table 4.

3.5 Threats to Validity

This section discusses the main threats to the validity of this systematic mapping study, organized into four categories commonly adopted in software engineering empirical studies (Wohlin et al., 2012): construct validity, internal validity, external validity, and conclusion validity. The mitigation strategies adopted in each case are also described, together with the limitations that remain open.

Construct validity. The first threat concerns whether the search strategy effectively captures the body of literature on the topic. The search strings were intentionally built around four high-precision keywords (interface, autism, accessibility, usability) combined with the Boolean operator AND, without the use of synonyms or Boolean disjunctions (OR). This design favors precision over recall and may have excluded relevant studies that use alternative terminology, such as "Autism Spectrum Disorder," "neurodivergent users," "human-computer interaction," or "inclusive design". To mitigate this risk, the strings were applied in two languages (English and Portuguese) and validated through a pilot search in selected databases. Nevertheless, the limited breadth of the string remains an acknowledged limitation of the present mapping.

A second construct-related threat concerns the definition of the three analytical axes (RQ1, RQ2, RQ3) and the criteria used to classify each study against them. To mitigate ambiguity, each axis was operationalized through a set of recurring sub-categories drawn from the literature (for example, configurable user profiles, layout and pacing adaptation, and use of artificial intelligence under RQ1). However, the classification of individual studies into these sub-categories ultimately depends on the analyst's interpretation, which is also discussed below as a threat to internal validity.

Internal validity. The selection process involved two screening stages, supported by inclusion and exclusion criteria and complemented by a full-text verification against the primary source of each study. This verification step allowed for the correction of metadata inconsistencies and the removal of studies that did not match their declared scope. Despite this safeguard, the exact number of duplicates removed during the screening stage was not separately recorded; duplicate removal was merged with the title and abstract screening step, which limits the granularity of the reported flow. The selection and classification of studies were conducted primarily by one researcher, which introduces a potential single-reviewer bias. To partially mitigate this risk, each decision was documented and revised against the primary sources, and the resulting corpus is made fully traceable through Table 4.

External validity. The generalizability of the findings is constrained by the temporal scope (2020 onwards), the restricted set of databases consulted (ACM Digital Library, IEEE Xplore, Scopus via ScienceDirect, Web of Science, and Google Scholar), and the inclusion of studies in English and Portuguese only. Studies published in other languages, in regional venues not indexed by the selected databases, or before the temporal cutoff were not considered. Within this scope, the corpus is biased toward Brazilian and Latin American academic production retrieved through Google Scholar, which on the one hand strengthens the analysis of the Brazilian context but on the other limits the comparability of findings with broader international literature. The conclusions of this mapping should therefore be read as a structured overview of the recent literature accessible through the selected sources, rather than as a comprehensive account of the field.

Conclusion validity. The conclusions of this study are based on a qualitative synthesis of 21 primary studies, complemented by counts of how many studies address each analytical axis and sub-category. Because a single study may contribute to more than one axis, the quantitative counts presented in Table 5 should be interpreted as indicators of thematic emphasis in the literature, not as exhaustive measurements. The replicability of the mapping is supported by the explicit description of the protocol, the search strings, the inclusion and exclusion criteria, the

PRISMA-style flow (Figure 1), and the full list of included studies (Table 4), which together allow other researchers to reproduce or extend the study.

4 Research Results

The final selection of studies comprised 21 primary studies that address three main analysis axes derived from the research questions: personalization strategies (RQ1), sensory overload minimization and socio-emotional development (RQ2), and the use of reusable components (RQ3). Each study may contribute to more than one axis, as the three dimensions are conceptually complementary and frequently co-occur in the analyzed works. Table 5 presents the distribution of the number of studies associated with each of these axes.

Table 5: Results of the final selection of studies based on inclusion criteria

Analytical Axis	Number of Articles
RQ1 – Personalization strategies	17
RQ2 – Sensory overload and socio-emotional development	17
RQ3 – Reusable components	08

Note: A single study may be associated with more than one axis; therefore, the sum of values in this table may exceed the total number of included studies (n = 21).

When analyzing the temporal distribution of the selected studies, a concentration of publications can be observed between 2022 and 2024, a period that jointly accounts for approximately 86% of the corpus (18 of 21 studies), with 2022 and 2024 emerging as the most frequent publication years (seven studies each), as shown in Figure 2. This result indicates a growing academic and scientific interest in the field of accessibility and personalization of digital interfaces for children with Autism Spectrum Disorder (ASD), reflecting recent technological advancements and increased awareness of digital inclusion.

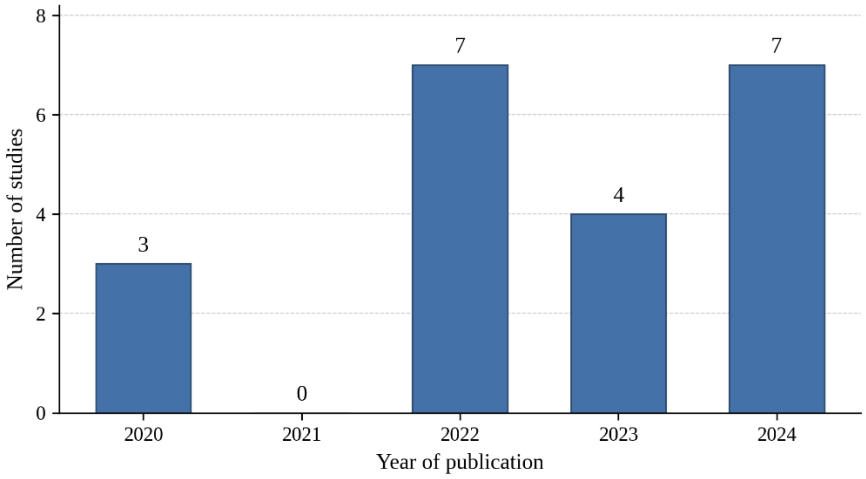

Figure 2: Temporal distribution of the included primary studies.

The concentration of publications from 2022 onwards is consistent with the post-pandemic period, during which the intensification of remote and hybrid education has highlighted the need for accessible educational solutions for neurodivergent users, reinforcing the demand for adaptive interfaces sensitive to their characteristics.

To address the defined research questions, a full-text analysis of each selected study was conducted. This section presents the main findings derived from the analysis of the selected articles, organized according to the research questions (RQ1, RQ2, and RQ3) defined in the systematic mapping study.

4.1 Response to Research Question RQ1

The personalization of digital interfaces designed for children with Autism Spectrum Disorder (ASD) is a key factor in promoting safer, more effective learning experiences aligned with users' individual needs. Considering that ASD is characterized by high heterogeneity, different children may respond differently to visual, auditory, interactive, and content-related stimuli. In this context, adapting the interface to each user's profile becomes a fundamental strategy to ensure a more inclusive, accessible, and functional experience.

To address Research Question RQ1, which investigates which personalization strategies have been used in digital interfaces to adapt content and interaction to the characteristics of children with ASD, an analysis of 17 studies from the included corpus was conducted. The studies were classified into seven main personalization categories: configurable user profiles, layout and pacing adaptation, use of artificial intelligence, participatory design, feedback personalization (visual and auditory), behavior-based adaptation, and content customization. Figure 3 presents the distribution of these strategies across the analyzed studies.

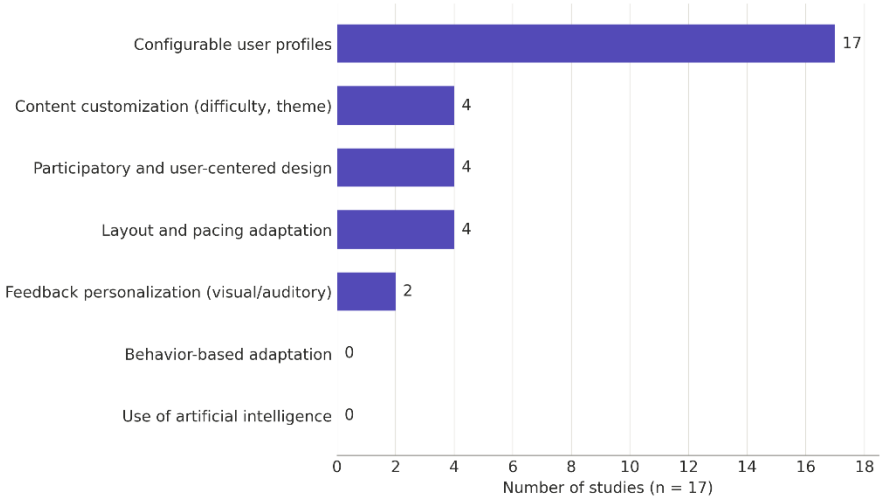

Figure 3: Distribution of personalization strategies across the analyzed studies.

Among the identified strategies, configurable user profiles emerge as the universally adopted approach, being present in all 17 studies analyzed under RQ1. This approach reflects a clear preference for solutions that allow adjustments of parameters such as colors, sounds, fonts, task duration, and task complexity, enabling a more responsive experience tailored to each child's individual characteristics. The recurrence of this strategy reinforces its central role in the development of user-centered adaptive interfaces in the context of ASD.

Wu (2024) [E1] proposes interactive technologies based on augmented reality and wearable devices, in which the adaptation of visual and auditory stimuli, as well as the personalization of interaction modalities, are identified as essential elements to promote engagement and reduce user

frustration. The results indicate that children with ASD demonstrate higher motivation when technology provides control over sensory stimuli, thereby supporting the learning process.

Alves Junior and Melo (2022) [E16], in an integrative review of guidelines for software development targeting users with ASD, highlight that interface customization is consistently recommended as a central element. The ability to adjust layout, navigation, and sensory stimuli is presented as an effective strategy to minimize cognitive and sensory barriers, as well as to promote sustained user engagement in digital activities.

Layout and pacing adaptation, although less frequent (identified in 4 of the 17 studies), also emerges as a relevant strategy for reducing sensory overload and improving user focus during interaction. Adjustments in visual organization, information density, and response timing contribute to making navigation more predictable and comfortable, accommodating different cognitive and sensory profiles. For example, Chinchay et al. (2024) [E7] discuss how the quality assessment of software for children with autism depends on adaptable layout structures that can accommodate diverse cognitive profiles.

Participatory design also stands out as an important approach, identified in four of the analyzed studies. This strategy involves caregivers, healthcare professionals, and, in some cases, the children themselves in the interface development process. The inclusion of users in the design process contributes to the creation of more empathetic, context-aware, and user-centered solutions. Ferreira (2024) [E14], in a doctoral thesis adopting a participatory design approach with autistic children, demonstrates how the active engagement of end users in early design stages produces more inclusive outcomes than caregiver-only consultations.

Content customization, including the adaptation of difficulty levels, themes, and language complexity, appears in four studies, often combined with configurable user profiles. Pinheiro and Marques (2020) [E5], for instance, present an accessibility-oriented design process in which content adaptation is integrated with proto-personas representing different sensory and cognitive profiles of autistic children.

On the other hand, the use of artificial intelligence (AI) for dynamic personalization and behavior-based adaptation were not identified in any of the 17 studies of the curated corpus. Although these approaches present significant potential for automatically adapting interfaces based on user behavior, their absence in the recent ASD-focused literature may be associated with factors such as implementation complexity, the need for sensitive data collection from minors, infrastructure constraints, and ethical challenges related to the use of adaptive technologies with vulnerable users. This is a relevant gap in the current state of the art, particularly considering the potential of such techniques to address the heterogeneity of the autism spectrum.

Overall, there is a clear predominance of conventional personalization strategies, particularly configurable user profiles, over more advanced, automated approaches. Additionally, most studies lack robust empirical validation involving children with ASD, highlighting the need for more applied research that integrates multiple strategies and considers evaluation in real-world contexts. These findings suggest that, although important advances have been made, significant gaps remain in the development of truly adaptive and inclusive digital interfaces for this population.

4.2 Response to Research Question RQ2

Minimizing sensory overload is one of the main challenges in the development of digital interfaces for children with Autism Spectrum Disorder (ASD). Considering that many individuals on the spectrum present hypersensitivity or hyposensitivity to visual and auditory stimuli, the way interface elements are organized directly impacts both user experience and learning processes. In addition, such interfaces can also serve as relevant tools for the development of socio-emotional

skills, such as empathy, self-regulation, and emotion recognition, provided they are designed in a way that is sensitive to the specific characteristics of this population.

To address Research Question RQ2, which investigates how digital interfaces have been designed to minimize sensory overload and support the development of socio-emotional skills in children with ASD, 17 studies from the included corpus were analyzed.

Studies such as those by Al-Azawei, Serenelli and Lundqvist (2016) and Hourcade et al. (2012) demonstrate that poorly designed digital environments, characterized by excessive sensory stimuli, can lead to negative effects such as anxiety, distraction, and rejection of technology use. In this context, design guidelines such as the use of soft colors, readable typography, controlled audio, limited animations, and consistent visual organization are essential to reduce sensory overload and promote a more comfortable and accessible experience.

From the perspective of Cognitive Load Theory (Chandler and Sweller, 1991), excessive exposure to stimuli can impair information processing and hinder learning, particularly in users with heightened sensory sensitivity. Therefore, digital interfaces for children with ASD should be designed to reduce extraneous cognitive load by organizing content in a clear, predictable, and structured manner, while also providing sensory control mechanisms that allow users to adjust the intensity of stimuli according to their individual needs.

The analysis of the included corpus confirms that sensory control and predictability are the most consistently addressed dimensions of RQ2. Alzahrani, Uitdenbogerd and Spichkova (2022) [E4], for example, provide empirical evidence that animated interface elements significantly affect task performance in autistic users, exacerbating frustration and increasing mental effort, which reinforces the need for restraint in the use of animation, sound and visual density. In a complementary perspective, França, Gambogi and Gibertoni (2022) [E12] and Alves Junior and Melo (2022) [E16] consolidate design guidelines for ASD-oriented interfaces, in which predictability, consistent visual organization and the avoidance of abrupt layout changes are recurrent recommendations. Pinheiro and Marques (2020) [E5], in turn, illustrate how these principles can be operationalized in the design of mobile applications for the daily routine of autistic children, integrating accessibility-oriented design with proto-personas that explicitly account for sensory sensitivities.

Beyond sensory control, several studies in the corpus highlight the potential of digital technologies to support the development of socio-emotional skills, such as empathy, self-regulation, and emotion recognition. However, this dimension appears in a more incipient and indirect form in the mapped literature. Strategies such as expressive avatars, social simulations, positive emotional feedback, and gamified narratives are mentioned as design opportunities in studies such as Ferreira (2024) [E14] and Rodrigues et al. (2022) [E9], typically embedded in broader inclusive design processes rather than as the main contribution of the work. No study in the curated corpus presents an interface explicitly designed and empirically validated around socio-emotional skill development for children with ASD as its central objective.

More advanced technologies, such as sensors and real-time emotional monitoring, were not identified in the corpus. This absence highlights an opportunity for the development of more adaptive interfaces capable of dynamically responding to users' emotional states. However, their adoption requires careful consideration of cognitive load, privacy concerns, and ethical issues related to the use of sensitive data collected from minors.

Despite the identified best practices, most studies present methodological limitations, such as small sample sizes, lack of longitudinal evaluations, and limited involvement of the target population in validation processes. These limitations point to the need for more robust research that integrates methodological rigor, empirical validation, and active participation of children with ASD in the development of digital solutions.

Overall, the results indicate that the literature mapped under RQ2 is concentrated on sensory overload minimization, while the systematic design and validation of digital interfaces for socio-emotional development in children with ASD remains an open research gap. Addressing both dimensions in an integrated manner, through flexible, configurable, and evidence-based interfaces, would contribute simultaneously to the advancement of digital inclusion and to the cognitive, emotional, and social development of children with ASD.

4.3 Response to Research Question RQ3

The use of reusable and standardized components in digital interfaces constitutes a relevant strategy for promoting accessibility, predictability, and navigation fluency for children with Autism Spectrum Disorder (ASD). When elements such as buttons, menus, forms, and feedback messages follow consistent patterns of appearance and behavior, the user experience becomes more stable and understandable, contributing to reduced cognitive effort, improved system familiarity, and increased user autonomy during interaction.

To address Research Question RQ3, which investigates how the use of reusable components impacts the development and experience of children with ASD in digital interfaces, 8 studies from the included corpus were identified as addressing this axis. The remaining studies, while discussing accessibility or usability for ASD, do not explicitly engage with design systems, component libraries, or modular interface architectures.

The predictability enabled by the consistent use of components directly impacts the learning process and the acceptance of technology by users. Fragmented interfaces, or interfaces presenting unexpected variations such as abrupt changes in buttons, menus, or layout patterns, can lead to discomfort, anxiety, and interaction breakdown. Alves Junior and Melo (2022) [E16], in their integrative review of guidelines for ASD-oriented software development, identify visual and functional standardization as a recurrent recommendation across multiple sources, supporting faster recognition of interface elements and the memorization of interaction routines. This stability reduces cognitive load and improves interaction fluency, particularly for users with higher sensitivity to change.

Among the analyzed studies, two examples illustrate the systematic adoption of component-based approaches with explicit accessibility orientation. Anjos (2024) [E19], in the AutismGuide system, develops a usability and accessibility evaluation tool for digital products targeting users on the autism spectrum, building the application with ReactJS and Material-UI and adopting modularity, reusability, and accessibility as core principles. This approach integrates technical implementation with ASD-oriented design guidelines, enabling the development of more predictable interfaces aligned with users' sensory needs, while also facilitating maintenance, testing, and scalability.

Oliveira (2022) [E17] complements this perspective by addressing the documentation side of component-based design. The author presents the development and evaluation of the DAI plugin for Figma, applying the Atomic Design model to organize and document accessible interface components. Structuring interface elements into atoms, molecules, and organisms helps maintain visual and functional consistency from the early stages of design, supporting the creation of more coherent, reusable, and accessibility-oriented digital products.

Beyond these two studies, where componentization is the central contribution, the topic also appears in a more diffuse form across the corpus. Pinheiro and Marques (2020) [E5] integrate accessibility-oriented components into the design of a mobile application for the daily routine of autistic children, combining proto-personas with reusable interface elements. Rodrigues et al. (2022) [E9] describe an interface design process for ASD users in which standardized components are presented as a contributor to predictability. Chinchay, Gomez and Montoro (2024) [E7] include consistency and reusability among the quality dimensions assessed in their evaluation of

software for children with autism. Ferreira (2024) [E14] and Borges (2024) [E21] reinforce, from the perspectives of inclusive design and software development education respectively, the importance of standardization for users sensitive to change.

Despite the identified benefits, the curated corpus reveals two relevant gaps. First, only a small fraction of the studies treat component-based design as a central contribution, while the majority discuss it conceptually or as a complementary practice. Second, there is a lack of empirical evidence specifically validating the impact of component-based design on the experience of children with ASD, particularly in real educational contexts. The integration between modular architecture and accessibility guidelines targeted at neurodivergent users therefore remains an underexplored area, despite its potential.

Overall, the findings indicate that the use of reusable and standardized components plays a meaningful role in the development of accessible, predictable, and effective digital interfaces for children with ASD. By promoting visual and functional consistency, this approach contributes to reducing cognitive load, supporting the formation of interaction routines, and enhancing user autonomy. The corpus suggests, however, that the practical adoption of design systems explicitly oriented to ASD, such as the cases of Anjos (2024) [E19] and Oliveira (2022) [E17], is still incipient and represents a promising direction for future research.

4.4 Results Analysis

The analysis of the 21 primary studies included in the curated corpus reveals a significant evolution in scientific research focused on the development of accessible digital interfaces for children with Autism Spectrum Disorder (ASD). The temporal distribution shows a concentration of publications between 2022 and 2024, a period that jointly accounts for approximately 86% of the corpus. This concentration is consistent with the post-pandemic period, during which the intensification of remote and hybrid education highlighted the need for digital solutions more sensitive to the demands of neurodivergent users.

Regarding personalization strategies (RQ1), the analyzed studies converge on configurable user profiles as the universally adopted strategy, present in all 17 studies addressing this axis. Other recurrent approaches include layout and pacing adaptation, participatory design, and content customization, each identified in a smaller subset of studies. More advanced techniques, such as artificial intelligence-based personalization and behavior-driven adaptation, were not identified in any of the curated studies. This absence may be associated with implementation complexity, the need for sensitive data collection from minors, infrastructure constraints, and ethical challenges related to the use of adaptive technologies with children, and represents one of the most evident research gaps revealed by the mapping.

With respect to sensory overload minimization and the development of socio-emotional skills (RQ2), the corpus is concentrated on the sensory control dimension. Recommendations such as soft color palettes, controlled audio, restraint in the use of animation, and consistent visual organization are recurrent across the analyzed studies, and are supported by empirical evidence in works such as Alzahrani, Uitdenbogerd and Spichkova (2022) [E4]. The socio-emotional dimension, however, appears in a more incipient and indirect form. Mentions of expressive avatars, social simulations, and emotional feedback are present mainly as design opportunities embedded in broader inclusive design processes, rather than as the main contribution of any of the studies. No work in the curated corpus presents an interface explicitly designed and empirically validated around socio-emotional skill development for children with ASD as its central objective.

Concerning the use of reusable and standardized components (RQ3), the topic appears in 8 of the 21 studies, but only two of them treat componentization as the central contribution: Anjos (2024) [E19], with the AutismGuide system built on ReactJS and Material-UI, and Oliveira (2022)

[E17], with the DAI plugin for Figma based on the Atomic Design model. In the remaining studies, components and standardization appear as complementary practices within broader design or evaluation processes. Approaches based on design systems and modular architectures demonstrate potential for enhancing predictability, reducing cognitive load, and promoting user autonomy. Nevertheless, empirical validation of the impact of component-based design specifically on the experience of children with ASD remains scarce, particularly in real educational settings.

From an integrated perspective, the results indicate that the development of digital interfaces for children with ASD has been predominantly focused on sensory control and on conventional personalization through configurable user profiles. The integration between the three analytical axes is rare, and most studies treat personalization, sensory control, and componentization as separate concerns rather than as combined dimensions of an inclusive interface architecture. The limited adoption of more advanced adaptive technologies, combined with the scarcity of empirical studies conducted in real-world environments and the near-absence of explicit work on socio-emotional development as a central interface goal, highlights the need for more robust, interdisciplinary, and user-centered research.

Thus, the findings of this systematic mapping study demonstrate that, although important progress has been made, the development of accessible digital interfaces for children with ASD still requires more integrated approaches that combine the three analytical axes, consistent empirical validation, and stronger alignment with real educational contexts. These gaps underscore the importance of future research that combines technical, pedagogical, and sensory perspectives in the development of more inclusive, effective, and scalable digital solutions.

5 Discussion

The analysis of the included corpus revealed that most strategies used in the development of digital interfaces for children with Autism Spectrum Disorder (ASD) are concentrated on conventional personalization approaches, such as configurable user profiles and manual interface adjustments. Although effective, these strategies still lack robust empirical validation with the target population and are often evaluated in exploratory studies or with small sample sizes.

A low level of integration among the three analyzed axes, namely personalization (RQ1), sensory control and socio-emotional development (RQ2), and the use of reusable components (RQ3), was also observed. Few studies present approaches that simultaneously address these elements in a cohesive and practically applicable manner within real educational contexts. This fragmentation highlights a significant gap in the development of more comprehensive, sustainable, and truly inclusive digital solutions for children with ASD.

Emerging technologies, such as artificial intelligence based personalization, behavior driven adaptation, and real time emotional sensing, were not identified in any of the curated studies. Although these technologies show strong potential to make interfaces more adaptive and responsive to individual needs, their absence in the recent ASD focused literature may be associated with technical, ethical, and infrastructural challenges, particularly in educational settings. In the Brazilian context, these limitations are even more pronounced due to inequalities in access to digital technologies, budget constraints, and the need for teacher training to effectively integrate such tools.

Another relevant aspect is the scarcity of participatory approaches that directly involve children with ASD in the design process. Among the studies that adopt participatory or co-design methodologies, the active participation of end users themselves is rare, and the design process tends to rely mainly on caregivers, therapists, or educators as proxies for the child's perspective.

While these stakeholders provide valuable insights, the absence of the end user in the design phase limits the inclusiveness of the proposed solutions. The adoption of co-design methodologies and user-centered design approaches with the active participation of autistic children is therefore essential for developing interfaces that genuinely reflect their needs and preferences.

A related concern is the dimension of socio-emotional development. Although the literature often points to digital interfaces as potential tools for fostering empathy, self-regulation, and emotion recognition, no study in the curated corpus presents an interface explicitly designed and empirically validated around socio-emotional skill development for children with ASD as its central objective. This dimension is therefore signaled as an opportunity, but it remains, in practice, an open research gap.

Furthermore, many of the analyzed studies do not report longitudinal evaluations or controlled experiments in real educational environments, which compromises the generalizability of the findings. Although the proposed solutions are promising, their effectiveness must be validated in real-world contexts, with continuous monitoring and clear indicators of impact on learning processes, socio-emotional development, and the well-being of children with ASD.

From an integrated perspective, in addressing the Main Research Question (MRQ), the findings indicate that accessible digital interfaces for children with ASD have been predominantly developed based on isolated strategies, particularly personalization and sensory control, while integrated approaches that combine these elements with reusable component architectures, socio-emotional design, and consistent empirical validation remain rare. This scenario suggests that, although relevant progress has been achieved, the field is still in a consolidation stage, requiring stronger integration between technical, pedagogical, and sensory aspects.

Thus, the discussion reinforces that the development of inclusive digital interfaces for children with ASD must go beyond the implementation of isolated features, requiring a systemic approach that integrates personalization, cognitive load reduction, predictability, and active user participation. These gaps open opportunities for future research aimed at developing more robust, applicable, and context-aware solutions, particularly in educational environments such as the Brazilian context, where challenges related to digital inclusion remain significant.

6 Conclusion

This paper presented a systematic mapping study on the development of accessible digital interfaces for children with Autism Spectrum Disorder (ASD), aiming to identify guidelines, strategies, and approaches related to personalization, sensory overload reduction, and the use of reusable components in this context.

Based on the analysis of 21 primary studies selected through rigorous criteria and verified against their primary sources, this review provided a structured overview of the solutions developed in recent years. The findings indicate that the most common strategies focus on configurable user profiles, present in all studies addressing personalization, complemented by layout and pacing adaptation, content customization, and participatory design. More advanced approaches, such as artificial intelligence based personalization and behavior driven adaptation, were not identified in the curated corpus. Regarding sensory overload reduction, practices such as the use of neutral color palettes, controlled auditory stimuli, restraint in the use of animation, predictable feedback, and simplified visual organization were identified as the most frequently adopted. In terms of socio-emotional development, however, the curated corpus does not present any interface explicitly designed and empirically validated around socio-emotional skill development for children with ASD as its central objective, indicating an open research gap rather than an established practice.

From an integrated perspective, the findings indicate that digital interfaces designed for children with ASD are still predominantly developed based on isolated strategies, lacking approaches that effectively combine personalization, sensory control, and the use of reusable components. Component based design, in particular, appears as a central contribution in only two studies of the corpus, while in the remaining works it is treated as a complementary practice. Additionally, important limitations persist, including the absence of large-scale empirical validation, the scarcity of studies conducted in real educational contexts, and the limited adoption of more advanced adaptive technologies.

As a scientific contribution, this study systematizes relevant evidence that can support researchers, developers, and educators in the design and evaluation of inclusive digital interfaces. By consolidating existing strategies and identifying research gaps, this work contributes to advancing knowledge in the field of Informatics in Education, particularly in the development of more accessible, adaptive, and user-centered solutions for children with ASD.

As future work, further empirical studies involving more diverse participant groups and real educational settings are recommended, as well as the investigation of adaptive approaches based on artificial intelligence and behavior driven personalization, provided that ethical and privacy considerations regarding data collection from minors are properly addressed. The systematic design and empirical validation of interfaces oriented to socio-emotional development in children with ASD is also identified as a priority direction. In addition, the adoption of participatory methodologies that actively involve children with ASD in the design process is emphasized, along with the importance of strengthening interdisciplinary approaches that integrate computing, education, psychology, and design in the development of more inclusive and effective technologies.

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Authors' Contributions (CRediT)

Máira Báz Sanmartin: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Visualization, Writing – Original Draft. Simone Nasser Matos: Conceptualization, Methodology, Supervision, Validation, Writing – Review & Editing. Helyane Bronoski Borges: Validation, Writing – Review & Editing.

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