Exploring the Characteristics of Interactive Digital Tools to Enhance Engagement and Reduce Fatigue in Children With Autism Spectrum Disorder (ASD)

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Abstract

This research explores the characteristics of interactive digital tools that enhance engagement and mitigate fatigue in children with Autism Spectrum Disorder (ASD). Given the rising global prevalence of ASD, there is a demand for effective interventions that address the unique cognitive and sensory challenges of these children. Traditional therapeutic methods often struggle with attention maintenance, frequently leading to autistic fatigue and reduced session efficacy. Adopting a qualitative research design, this study conducted semi-structured interviews with five experienced therapists from the National Autism Society of Malaysia (NASOM). Data were analyzed using Braun and Clarke's six-step thematic analysis framework, facilitated by NVivo software to ensure methodological rigor and transparency. The analysis identified five main themes which are digital technology platforms, interface design and user experience, educational outcomes and social learning, system usability and therapeutic efficacy, and implementation barriers. Results indicate that tools featuring simple instructions, adaptive difficulty, multisensory feedback, and relatable social scenarios significantly improve participation while preventing sensory overload. The findings indicate that successful digital tools must balance engaging activity with ease of use by employing simple steps and consistent, predictable patterns. This study concludes with a thematic map that offers practical guidelines for therapists and developers to improve digital tool design. By focusing on simple, sensory-friendly features that put the child first, these digital tools can become more reliable and effective, ultimately supporting better learning and emotional growth for children with ASD.

Keywords: Autism Spectrum Disorder (ASD), interactive digital tools, engagement, fatigue, thematic analysis

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Introduction

The global rise in the prevalence of Autism Spectrum Disorder (ASD), with recent estimates indicating that approximately 1 in 36 children are diagnosed with the condition, has intensified the demand for specialized interventions (Maenner, 2021; Salloum-Asfar et al., 2024). ASD is a complex neurodevelopmental condition marked by challenges in social interaction, communication, and repetitive behaviors. Standard therapy often struggles to keep children with ASD focused, as they may show little interest in schoolwork or become restless during tasks (Siyam & Abdallah, 2023). Furthermore, the inherent sensory and cognitive demands of these conventional activities often lead to heightened fatigue, which significantly reduces the efficacy of learning and therapeutic sessions (Keville et al., 2021). To address these challenges, there is a growing interest in leveraging interactive digital tools such as mobile applications, video games, and virtual reality to create supportive and motivating learning environments (Cardy et al., 2023). Research suggests that gamified environments can significantly improve social and emotional skills by providing immediate feedback and safe spaces for practice (Daud et al., 2023; López-Bouzas & Del Moral-Pérez, 2025). Additionally, virtual reality allows children to participate in interactive scenarios that simulate real-life situations, facilitating better skill acquisition (Kourtesis et al., 2023; Soleiman et al., 2023). Because children with ASD often have a natural affinity for screen-based media, these tools can make the therapeutic process more appealing, leading to increased participation and better generalization of learned behaviors (Cardy et al., 2023; Pliska et al., 2023). Despite these benefits, a critical gap remains in understanding how these technologies specifically influence fatigue levels. For children with ASD, fatigue is a serious issue that makes it difficult for them to concentrate and harms their overall well-being (Keville et al., 2021). Failure to incorporate these specific neurodivergent requirements into the design of digital tools may inadvertently exacerbate cognitive overload and burnout, thereby impeding sustained therapeutic progress and long-term developmental outcomes (Cardy et al., 2023). Therefore, this study employs a qualitative research method to explore the experiences of therapists at the National Autism Society of Malaysia (NASOM). By identifying the specific characteristics of interactive digital tools that enhance engagement while mitigating fatigue, this research aims to develop a thematic map to guide the design of more sustainable and effective digital interventions for children with ASD.

Literature Review

Defining the Autism Spectrum Disorder (ASD)

Autism Spectrum Disorder (ASD) represents a neurodevelopmental conditions primarily defined by persistent challenges in social communication, reciprocal interaction, and the presence of restricted, repetitive patterns of behavior (Atsalaki & Kazanidis, 2025; Posar & Visconti, 2023). The clinical manifestation of ASD is heterogeneous, where individuals display a unique constellation of strengths and deficits (Vetri & Roccella, 2020). While some individuals possess fluent verbal communication skills, others may be nonverbal, necessitating the use of augmentative and alternative communication (AAC) strategies (Aftab et al., 2023; Bhana et al., 2023). Cognitive profiles also vary extensively, ranging from profound intellectual impairment to superior intellectual capabilities (Christensen & Zubler, 2020). Consequently, the level of required support is individualized where some require substantial assistance with daily living, while others achieve high levels of independence (Maggio et al., 2023). As a lifelong condition, the needs and challenges of individuals with ASD evolve across the lifespan, requiring dynamic adjustments in support systems and environmental accommodations (Kumar & Bhattacharya, 2024; Naithani et al., 2022). The evolution of

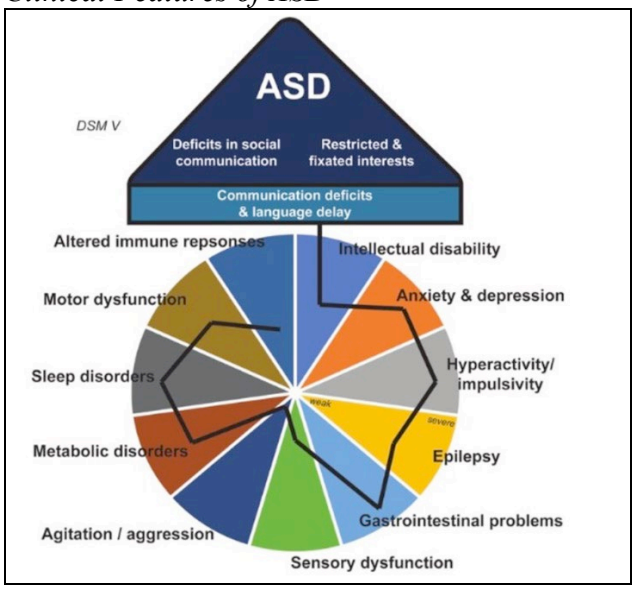
diagnostic criteria, particularly with the transition to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5), has shifted the focus from distinct subcategories to a single, unified spectrum (Waterhouse, 2022). ASD is characterized by two primary domains are the social domain and the behavioral domain (Coffey et al., 2020; Zacharov et al., 2021). The DSM-5 classification introduces three levels of severity based on the intensity of support required: Level 1 (requiring support), Level 2 (requiring substantial support), and Level 3 (requiring very substantial support) (Posar & Visconti, 2023). This classification system acknowledges the diversity in intellectual and linguistic abilities, which can range from significant impairment to exceptional proficiency (Vogindroukas et al., 2022). However, the inherent heterogeneity of the disorder, often complicated by co-occurring medical, genetic, or psychiatric conditions, continues to challenge rigid categorization, reinforcing the view that ASD is not a unitary disorder but a multifaceted spectrum of biological and behavioral manifestations (Renzo et al., 2021; Waterhouse, 2022).

ASD Indicators

The behavioral markers of ASD typically emerge during infancy and early childhood (Abualait et al., 2024). In the social-communication domain, common signs include a lack of eye contact, diminished response to one's name, and difficulties in engaging in reciprocal or imaginative play (Okoye et al., 2023). Behavioral patterns often include stereotyped movements, an insistence on sameness, rigid adherence to routines, and fixated interests (Petrolini et al., 2023; Zacharov et al., 2021). In addition to these main symptoms, many children face co-occurring conditions such as anxiety, hyperactivity, and sleep problems, which can make their primary symptoms even more difficult to manage (Qi et al., 2023; Tsai et al., 2020). Identifying the condition early is a primary goal, as providing support as soon as possible is closely linked to better long-term progress and development (McCarty & Frye, 2020). Emerging technologies, such as artificial intelligence, machine learning, and eye-tracking, are increasingly utilized to provide objective and efficient diagnostic screening, overcoming the limitations of traditional, subjective clinical assessments (Peng et al., 2021; Cortese et al., 2025; Solek et al., 2025). Figure 1 shows the clinical features of ASD, highlighting the core diagnostic criteria alongside a range of associated comorbidities.

Figure 1

Clinical Features of ASD



Source: Sauer et al., 2021

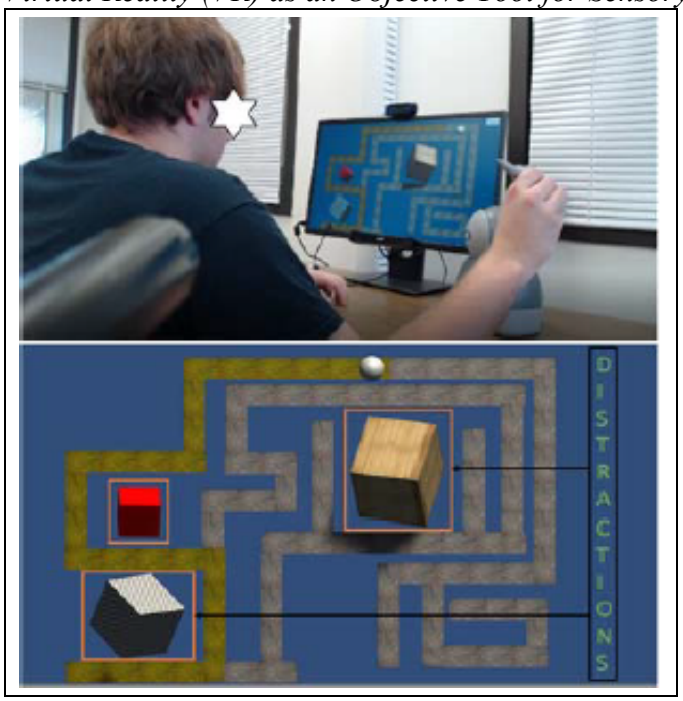
As illustrated in Figure 1, the primary standards for diagnosing ASD involve difficulties with social communication and the presence of narrow, repeated interests. While these core traits are essential for a diagnosis, other issues like language delays and communication gaps also commonly define the experience of those with ASD. The diagram uses a pie chart to show related health conditions, such as anxiety, depression, and sensory issues, which vary in how much they affect a person. For example, the chart highlights severe challenges like epilepsy and stomach problems, while noting that others, such as motor skills or immune system changes, may be less intense. Ultimately, this visual emphasizes that ASD is highly diverse, meaning every individual faces a unique combination of symptoms at different levels of severity.

Digital Therapy Integration

Traditional intervention approaches for ASD are categorized into behavioral, educational, and technological strategies. Behavioral interventions, specifically Applied Behavior Analysis (ABA), emphasize the systematic reinforcement of adaptive behaviors (Eckes et al., 2023). Educational strategies focus on creating predictable, structured environments to accommodate atypical sensory processing and attentional profiles (Mallory & Keehn, 2021). Recently, technological interventions including serious games and social robots have gained prominence due to their structured, interactive, and predictable nature (Scarcella et al., 2023). These digital platforms provide a safe environment for skill acquisition, reducing the uncertainty often associated with human-led social interactions. Interactive digital tools are particularly effective in addressing cognitive impairments, social communication deficits, and sensory sensitivities by offering tailored, engaging content that manages cognitive load and provides immediate, constructive feedback (Liu et al., 2021; Rezayi et al., 2023). The application to address neurodevelopmental needs is demonstrated in Figure 2, which illustrates the use of Virtual Reality (VR) as a tool for sensory assessment in ASD by integrating haptic feedback and eye-tracking systems to monitor real-time behavioral responses.

Figure 2

Virtual Reality (VR) as an Objective Tool for Sensory Assessment in ASD



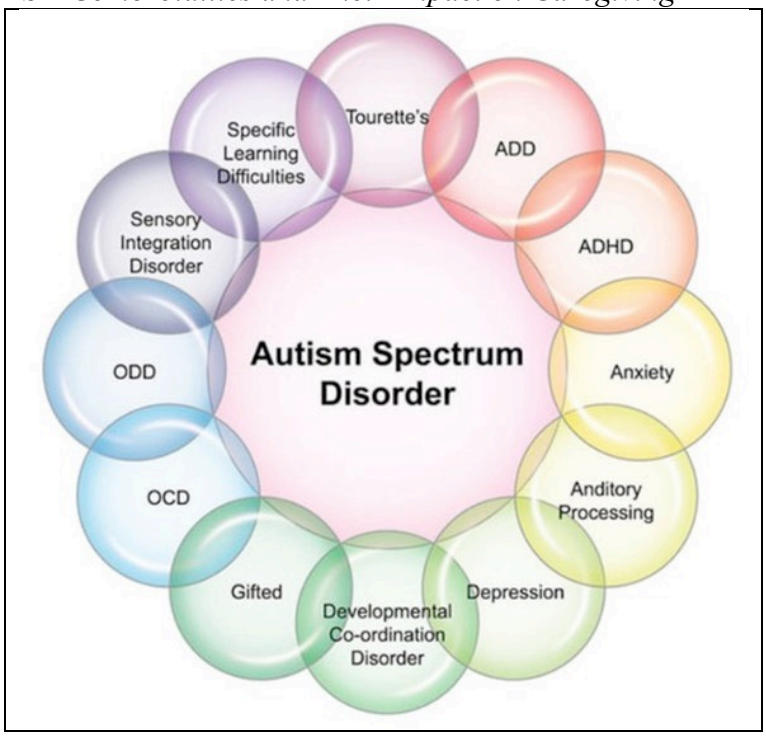
Source: Koirala et al., 2019

The study by Koirala et al. (2019) demonstrated that VR can objectively assess sensory processing differences in children with ASD, addressing the core drivers of engagement and fatigue. In this study, researchers utilized a Sensory Assessment Virtual Reality (SAVR) system that integrated haptic robots and eye-trackers to record real-time behavioral data with high spatial and temporal resolution. The findings revealed that children with ASD exhibited distinct visual and tactile processing patterns compared to typically developing peers, including a higher susceptibility to visual distractions. This research also mention that participants did not request breaks or report significant fatigue despite the complexity of the tasks. This suggested that the structured, predictable, and interactive nature of digital tools specifically their controllability sustained engagement without triggering the frustration or exhaustion typically associated with traditional clinical assessments. These results supported the premise that specific digital characteristics can be optimized to manage the sensory load and energy expenditure of children with ASD in therapeutic settings.

Fatigue Management in ASD

Fatigue, often referred to as autistic burnout or autistic fatigue, is a pervasive somatic symptom that significantly impairs daily functioning (Keville et al., 2021). In children with ASD, fatigue is frequently the result of navigating a world not designed for their sensory and cognitive processing styles (Keville et al., 2021). The effort required for social camouflaging the suppression of autistic traits to meet neurotypical expectations serves as a primary driver of chronic stress and subsequent exhaustion (Mahony & O'Ryan, 2022). This fatigue negatively impacts learning by hindering concentration and the ability to process new information (Mallory & Keehn, 2021). Addressing these energy regulation challenges is essential for facilitating meaningful participation in academic and therapeutic contexts.

Figure 3
ASD Comorbidities and Their Impact on Caregiving



Source: READS Consultancy, 2023

As depicted in Figure 3, the management of Autism Spectrum Disorder involves navigating an interconnected web of comorbidities that significantly intensify the logistical and emotional demands placed upon caregivers. This figure delineates the complex network of co-occurring conditions frequently associated with Autism Spectrum Disorder (ASD), illustrating the multifaceted challenges inherent in managing the disorder. As visualized, these comorbidities ranging from Attention Deficit Hyperactivity Disorder (ADHD) and Obsessive-Compulsive Disorder (OCD) to specific learning difficulties and anxiety function as interconnected layers of clinical complexity. These conditions necessitate a comprehensive therapeutic approach to address a child's simultaneous developmental, emotional, and cognitive requirements. Consequently, caregivers must navigate a demanding landscape of concurrent medical interventions, educational modifications, and specialized therapies. The synergistic effect of these disorders, including sensory integration challenges and depression, often leads to unique behavioral manifestations that intensify the demand for professional support. Ultimately, the interconnected nature of these conditions underscores the substantial emotional, financial, and temporal investments required by families to sustain the child’s long-term well-being and developmental progress.

Managing Fatigue Through Digital Tools

Interactive digital tools possess inherent characteristics that can significantly contribute to addressing fatigue in children with Autism Spectrum Disorder (ASD). A primary factor is the natural appeal and high acceptance of digital technologies by children with ASD, who are consistently reported to be attracted to screen-based media and video games, often preferring these formats for learning activities (Pliska et al., 2023). This inherent inclination fosters active engagement and provides motivating avenues for teaching skills and delivering supports (Cardy et al., 2023). By leveraging this natural preference, digital tools can make interventions less demanding and more enjoyable, thereby indirectly mitigating the mental exhaustion that leads to fatigue. Furthermore, these technologies are designed to help children with ASD experience less stress and neurophysiological distress, which are direct contributors to fatigue (Pergantis et al., 2025). By creating environments that specifically address and reduce these stressors, digital tools can help alleviate the physiological and psychological burden that often leads to exhaustion. This targeted reduction in discomfort allows for more comfortable and sustained participation in activities, potentially leading to improved energy regulation over time. The concept of "autistic fatigue" and "autistic burnout" highlights the critical need for interventions that acknowledge and alleviate these unique sources of tiredness in individuals with ASD (Keville et al., 2021). The capacity of digital tools to provide customizable and adaptable content is crucial (Cardy et al., 2023). By tailoring interfaces and tasks to match the specific needs and sensory sensitivities of each child, digital platforms minimize cognitive overload, a significant factor in digital fatigue (Supriyadi et al., 2025).

The ability of digital tools to adapt and personalize the learning environment is also critical, as this can greatly reduce cognitive overload by presenting information in manageable, digestible formats tailored to the individual's needs and capabilities (Keville et al., 2021). Personalization extends to pacing, allowing children to proceed at their own speed and repeat activities as necessary, which reduces pressure and anxiety that exacerbate fatigue. Moreover, the use of digital media enables creative and constructive environments, allowing for the development of differentiated, meaningful, and high-quality activities tailored to the individual's needs (Santos et al., 2016). Additionally, digital tools offer the opportunity to incorporate regular breaks and promote physical movement, strategies identified as effective in reducing digital fatigue (Murugan & M, 2024). Integrating timely reminders for breaks and exercises within the digital

platform encourages balanced engagement, thereby reducing the likelihood of prolonged screen exposure and its associated fatigue effects (Korunovska & Spiekermann, 2019). Moreover, anxiety, a common comorbidity in children with ASD, is often associated with depressive symptoms and self-injurious behavior but can be decreased with physical exercise (Lo et al., 2023). Digital technology also provides innovative methods for anxiety assessment and treatment, enabling customization that caters to individual needs (Adams et al., 2022). The adaptability and versatility of digital tools make them well-suited for addressing fatigue in children with ASD (Coulter et al., 2022; Keville et al., 2021; Pliska et al., 2023). Interactive digital tools employ specific strategies to manage and reduce factors that contribute to fatigue in children with ASD. A key approach involves directly alleviating stress and neurophysiological distress, which are recognized precursors to fatigue in this population. Assistive and developing technologies are specifically designed to help children with ASD experience less of these taxing conditions, leading to a more regulated internal state (Pergantis et al., 2025). The strategies employed include customization of interfaces to reduce sensory overload, providing clear and predictable task structures to minimize anxiety, and offering immediate, positive feedback to promote a sense of accomplishment and reduce frustration.

Another important strategy is the use of virtual environments for social skills training. Virtual reality applications, telehealth systems, social robots, and dedicated applications are all utilized to target communication, social learning, and imitation skills, as well as other conditions associated with ASD (Aresti-Bartolome & García-Zapirain, 2014). By simulating real-world interactions in a controlled, predictable setting, children can practice and improve their social abilities without the overwhelming stimuli that often accompany real-life situations. This not only enhances their social competence but also significantly reduces the social anxiety and mental effort required during interactions, thereby conserving energy and preventing fatigue. One of the main advantages of digital tools is the ability to offer multimodal learning experiences tailored to children with ASD. The integration of visual, auditory, and kinesthetic elements into digital platforms caters to different learning styles and sensory preferences, which may help avoid sensory overload. By using technology to identify distractions and potential causes of anxiety, sensory management recommendation systems can be used to give alerts to teachers and caregivers on how to improve risky environmental factors (Deng & Rattadilok, 2022). Moreover, the interactive and engaging nature of digital platforms can make learning more motivating and enjoyable, which reduces the perception of effort and increases willingness to participate. Gamified learning experiences, for example, transform monotonous tasks into engaging challenges, capturing children's attention and sustaining their engagement while diminishing the mental energy expenditure associated with traditional learning methods (Moreno et al., 2019). Another strategic characteristic of these tools is their ability to address sensory overload, a significant source of fatigue. Excessive noise, for example, can lead to sensory overload and increased anxiety in children with autism (Kwong et al., 2025). Technologies, such as aural perception controllable headsets, are developed as intervention tools to manage such sensory inputs, thereby directly reducing a common trigger for distress and subsequent fatigue (Kwong et al., 2025). By mitigating these environmental stressors and emotional burdens, interactive digital tools contribute to a less draining experience, promoting sustained engagement and conserving the child's energy reserves. In addition to their therapeutic applications, digital tools offer practical benefits that can help manage the daily demands faced by children with ASD.

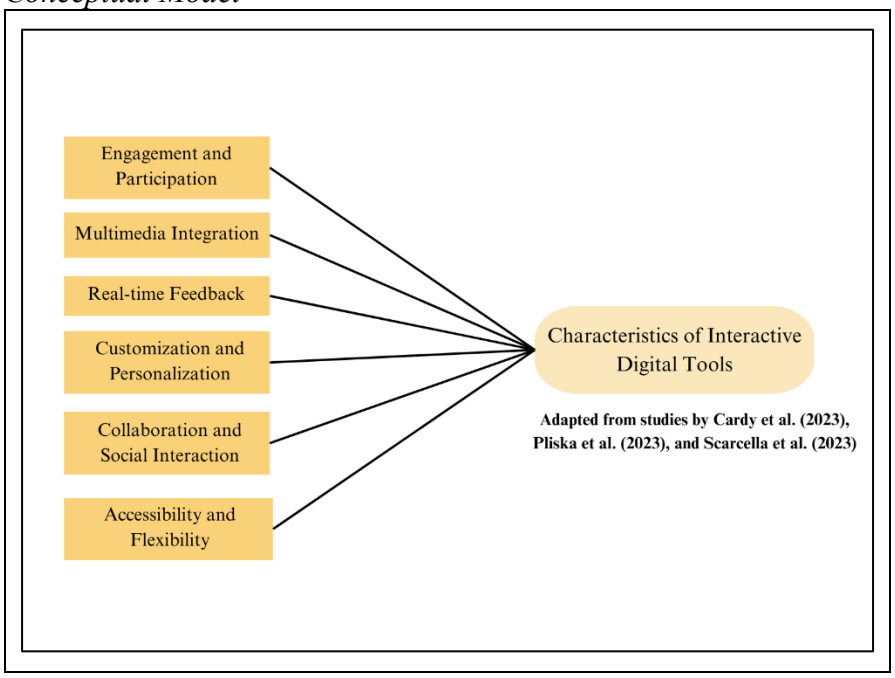
Research Gap

Although current studies emphasize the general advantages of digital tools for Autism Spectrum Disorder (ASD), a significant gap exists in understanding how specific design features affect fatigue management. Many existing tools focus on immediate engagement or skill building but often overlook the long-term sensory impact of extended use. In Malaysia, this issue is worsened by limited access to specialized resources and trained experts. This study addresses these gaps by exploring the professional insights of therapists at NASOM to identify the key features of interactive digital tools that support lasting engagement and emotional well-being for children with ASD.

Research Methodology

This study utilizes a qualitative research design grounded in the interpretivist paradigm to gain a deep understanding of the lived experiences of therapists working with children with Autism Spectrum Disorder (ASD) at NASOM. This philosophical approach is essential for exploring the complex perceptions and subjective experiences associated with digital tool usage within active therapy sessions. To ensure the collection of rich, expert data, five therapists were selected via purposive sampling, a technique that prioritizes relevant expertise and professional representation to address the specific research objectives. The primary data collection involved semi-structured interviews designed to capture nuanced insights into how interactive digital tools influence both engagement and fatigue-related outcomes.

Figure 4
Conceptual Model



The analytical phase followed Braun and Clarke's (2006) rigorous six-phase thematic analysis framework, which includes data familiarization, initial coding, theme generation, review, definition, and final reporting. This systematic process was supported by NVivo software to enhance coding accuracy and facilitate the visualization of emergent patterns. As illustrated in Figure 4, the conceptual model outlines the dimensions of interactive digital tools including multimedia integration, personalization, and accessibility to provide a structured framework

for analyzing their impact on therapeutic engagement and fatigue mitigation in children with ASD. This framework, adapted from foundational studies by Cardy et al. (2023), Pliska et al. (2023), and Scarcella et al. (2023), served as the structural basis for developing the final thematic map. By synthesizing these theoretical characteristics with therapist insights, the study successfully identifies the specific digital features required to foster sustainable engagement while mitigating the sensory and cognitive toll on children with ASD.

Results and Discussion

This section presents a thematic analysis of the characteristics of interactive digital tools used to enhance engagement and mitigate fatigue in children with ASD. Utilizing Braun and Clarke's (2006) six-step framework, qualitative data were collected from five therapists at the NASOM through purposive, criterion-based sampling. Participants were selected based on their professional qualifications, a minimum of one year of direct experience with ASD, and practical expertise in integrating digital software into therapy sessions. Although the sample size was focused, data saturation was systematically achieved by the fourth interview, at which point no new codes or meanings emerged regarding the phenomenon. The resulting thematic map addresses the study's core objectives by investigating current engagement challenges and identifying the specific tool characteristics such as sensory integration and adaptive difficulty most effective in clinical practice. This rigorous analysis provides grounded, information-rich insights into the role of digital interventions in optimizing therapeutic and learning outcomes for children with ASD in the Malaysian context.

Familiarization and Immersion

In the initial phase of data analysis, semi-structured interview transcripts from five therapists at the NASOM were systematically prepared and managed using NVivo qualitative analysis software. This computational tool facilitated the efficient organization of large textual datasets, the maintenance of an audit trail for coding decisions, and the extraction of salient terms and patterns. Complementing this technical process, an immersive phase involved iterative readings of each transcript alongside the original audio recordings to ensure that contextual meanings, emotional subtleties, and the nuanced lived experiences of the therapists were faithfully captured. This deep engagement allowed for the organic detection of emerging themes, grounding subsequent analysis in participant insights rather than preconceived notions. To enhance the rigor of this familiarization process, automated computational insights were integrated with manual interpretation. A systematic scan of the documents was performed to group content sharing conceptual similarities, ensuring a comprehensive identification of recurring ideas that might otherwise be overlooked. These identified concepts were then tabulated by frequency of mention and reviewed in a checklist format to synthesize the raw text into manageable, meaningful clusters. To maintain maximum precision and fidelity to the participants' original utterances, coding was conducted at the sentence level.

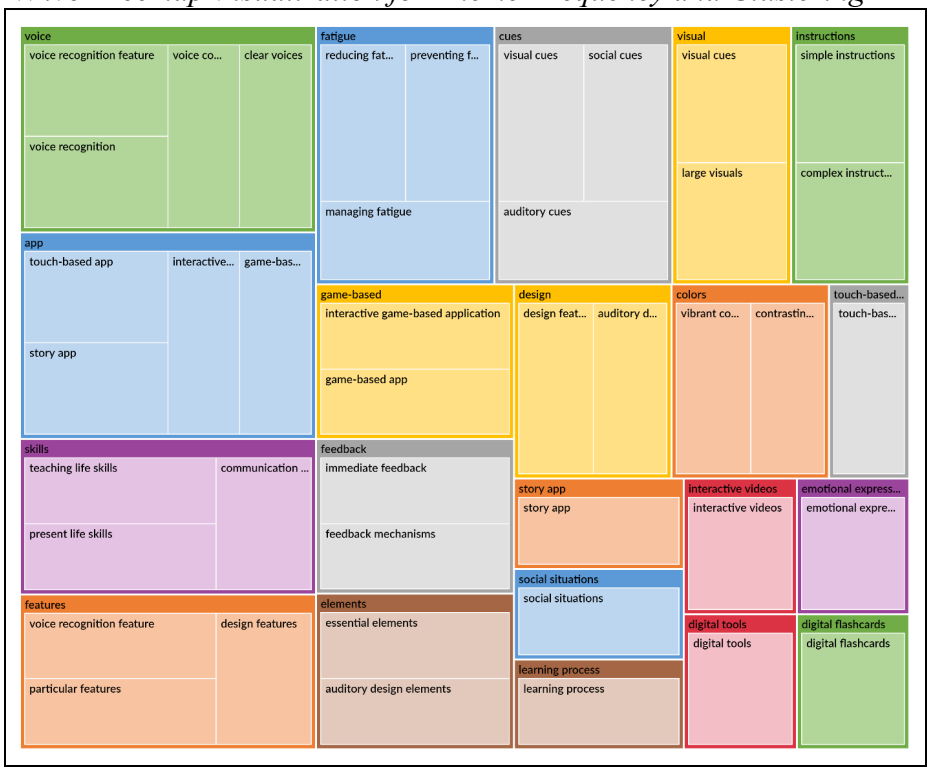
The resulting analysis was organized into a hierarchical system, enhancing the traceability and transparency of the analytical workflow. Visual representation of these coded transcripts emphasized the most significant concepts, where the prevalence of specific themes corresponded to their frequency in the data. Key insights from this stage included:

1. Dominant Therapeutic Tools
   Categories such as *story apps*, *touch-based apps*, and *game-based apps* emerged as the most frequently discussed interventions, indicating their perceived impact in autism therapy.

2. Thematic Clustering
   Broad categories including *visual, voice, features,* and *fatigue* effectively grouped related sub-themes, demonstrating how therapists naturally link specific digital functionalities to clinical outcomes.
3. Hierarchical Interplay
   The nesting of specific codes, such as *auditory cues* and *social situations* within larger thematic categories, revealed a layered structure of experience and a contextual interplay between digital features.
4. Analytical Prioritization
   This data-driven mapping established a clear rationale for subsequent inquiry, allowing for the systematic refinement of codes and the prioritization of themes most relevant to managing engagement and fatigue in children with ASD.

As illustrated in Figure 5, the treemap provides a thematic grouping of codes, highlighting prevalent topics such as *voice*, *fatigue*, *instructions,* and *design* through a color-coded hierarchical structure. This visualization facilitates a quantitative comparison of the data, where the relative size of blocks such as *voice recognition feature* and *reducing fatigue* indicates the primary emphasis placed by therapists on specific clinical preferences or practices. Furthermore, the map reveals a significant degree of interconnectedness, as cross-cutting priorities like *feedback* and *visual cues* emerge across multiple clusters rather than as isolated features. High-frequency themes, specifically *reducing fatigue* and *simple instructions*, underscore the core concerns tied to maintaining engagement while meeting the practical therapeutic needs of children with ASD. Ultimately, this data-driven visualization establishes a rigorous rationale for subsequent analysis, ensuring that the intervention design is grounded in the most salient, participant-driven elements of the research.

Figure 5
NVivo Treemap Visualization for Theme Frequency and Clustering



Generating Initial Codes

The systematic review of interview transcripts facilitated the extraction of initial codes that delineate the intersection of digital technology and ASD therapeutic practices. This foundational phase identified that therapists utilize a diverse array of platforms, including interactive game-based applications, digital flashcards, and animated story apps, to target specific developmental milestones such as communication and life skills. However, the data reveals significant attention and engagement challenges, as children frequently lose focus or become overwhelmed by complex interfaces and information processing overload. To address these barriers, therapists emphasize the importance of effective design features, specifically citing voice recognition responsiveness, vibrant colors, and immediate feedback mechanisms as critical drivers of sustained participation. The management of fatigue emerged as a dominant priority within the coding structure, with practitioners advocating for content segmentation and short sessions to prevent rapid exhaustion. Strategic interventions, such as breaking down complex scenarios into manageable parts and providing a balanced pace of activities, were identified as essential for maintaining a child's regulatory state. Furthermore, the analysis highlighted the necessity of sensory processing accommodations, including the use of clear, large visuals and calm auditory cues to minimize overstimulation. These initial codes collectively underscore that for digital tools to be therapeutically efficacious, they must balance high-interactivity with essential design principles like simple instructions and adaptive difficulty levels.

Table 1

Group Initial Codes and Corresponding Themes

Research Category	Initial Codes & Key Concepts	Summary of Findings
1. Digital Tools & Technologies	Game-based, Digital flashcards, Touch-based apps, Interactive videos, Story apps, Mobile apps, Digital tools.	Therapists utilize a diverse range of platforms including voice-recognition games and animated stories to teach communication and life skills.
2. Attention & Engagement Challenges	Lose focus, Tired quickly, Frustrated, Hard to focus, Overwhelmed, Information processing overload.	Maintaining attention is difficult due to complex interfaces, repetitive activities, or information overload, which leads to rapid fatigue.
3. Effective Design Features	Voice recognition, Visual cues, Colorful images, Shapes/Colors, Physical interaction, Character-driven scenarios.	Engagement is highest when tools incorporate multisensory elements like touch, voice responsiveness, and relatable characters.
4. Fatigue Management Strategies	Short sessions, Frequent breaks, Balanced pace, Short bursts of content, Manageable parts, Content segmentation.	Fatigue is managed by breaking complex tasks into small segments and allowing children to work at an individualized, self-paced speed.
5. Essential Design Principles	Clear/Simple instructions, Vibrant colors, Physical engagement, Flexible difficulty, Positive reinforcement, Immediate feedback.	Success depends on simplicity in functionality and the use of immediate rewards to maintain motivation and prevent frustration.

Research Category	Initial Codes & Key Concepts	Summary of Findings
6. Sensory Accommodations	Bright/Contrasting colors, Large visuals, Icons, Soft auditory cues, Movement, Background music.	Beneficial elements include clear visual hierarchies and calm, soothing audio to prevent sensory overstimulation during therapy.

As presented in Table1, the initial coding process identifies diverse digital platforms such as game-based applications, digital flashcards, and interactive videos used to facilitate learning at NASOM. The table further delineates critical challenges and effective design features, highlighting how voice recognition, visual cues, and content segmentation are utilized to manage attention deficits and reduce sensory fatigue. The qualitative analysis identifies a broad spectrum of digital platforms used in ASD therapy, ranging from voice-recognition games to animated story apps, which are designed to facilitate the acquisition of communication and life skills. While therapists face significant challenges with children losing focus or becoming overwhelmed by information overload, engagement is effectively sustained through multisensory design features such as physical touch, vibrant visual cues, and relatable character-driven scenarios. To mitigate rapid fatigue, the findings emphasize the necessity of essential design principles like content segmentation, adaptive difficulty levels, and the use of calm auditory cues to prevent sensory overstimulation.

Searching for Themes

The third phase of the data analysis involved developing themes by systematically organizing initial codes into meaningful categories aligned with the research objectives. This stage employed an inductive analysis approach, prioritizing the natural emergence of patterns from the data without the constraints of pre-existing theoretical frameworks. As a bottom-up strategy, inductive analysis facilitates a data-driven exploration that ensures findings remain grounded in the authentic voices and lived experiences of the participants.

In practice, coded segments were iteratively reviewed to identify conceptual similarities and contextual relevance. Initial codes were then clustered into broader thematic categories representing distinct dimensions of therapists' experiences with interactive digital tools for children with Autism Spectrum Disorder (ASD). NVivo qualitative analysis software supported this development by identifying code co-occurrences and refining themes to ensure conceptual integrity. Following this systematic clustering, six key themes were identified. These themes—ranging from digital tool technologies to social learning outcomes (see Table 4.3)—provide a structured framework for addressing the study’s research objectives.

Table 2
Group Initial Codes and Corresponding Themes

Initial Codes	Themes
• Interactive game-based applications • Touch-based interactive apps • Voice recognition applications • Game-based learning platforms • Digital flashcards • Interactive videos	Digital Tools and Technologies

Initial Codes	Themes
• Animated story applications • Character-driven scenarios	
• Attention deficits • Distractibility from complex interfaces • Difficulty sustaining focus • Information processing overload • Rapid fatigue onset • Decreased engagement over time • Repetition intolerance • Frustration with delayed feedback	Attention and Engagement Challenges
• Voice recognition responsiveness • Touch-based interaction • Immediate feedback mechanisms • Character connection features • Vibrant colors and visual cues • Clear visual contrast • Large, simple icons • Calm auditory elements	Effective Design Features
• Clear, simple instructions • Adaptive difficulty levels • Self-paced learning options • Intuitive navigation • Break integration for fatigue management • Content segmentation • Positive reinforcement systems • Overstimulation prevention	Essential Design Principles
• High contrast visual elements • Bright, engaging colors • Clear visual hierarchy • Simplified visual interfaces • Calm, clear audio cues • Soothing background music • Volume control options • Multi-sensory integration	Sensory Processing Accommodations
• Social situation scenarios • Emotional expression recognition • Life skills training • Communication enhancement • Emotional expression apps • Relatable character interactions • Social cue understanding • Behavioral modeling tools	Social and Emotional Learning

Reviewing Themes

The refinement of the thematic framework synchronized the raw qualitative data with the study's core objective which identifying digital characteristics that optimize engagement while mitigating sensory and cognitive fatigue. By cross-referencing therapist narratives against the emergent themes, the analysis moved beyond mere categorization to establish a functional relationship between interface design and clinical efficacy. For instance, the initial overlap between *visual cues* and *game-based tools* was refined into distinct themes of Interface Design and User Experience versus Digital Technology Platforms, ensuring that the specific aesthetic drivers of attention such as high-contrast visuals and simple icons were isolated as critical success factors. This iterative validation process further clarified how sensory processing accommodations act as a direct buffer against the attention and engagement challenges identified in earlier coding phases. By merging related concepts like *short bursts of content* and *content segmentation* into the overarching theme of System Usability, the research underscores a pivotal finding that *high controllability* and structured pacing are the primary mechanisms for managing a child's energy expenditure. Consequently, the finalized thematic structure does not merely list features but provides a data-driven map that illustrates how digital environments can sustain therapeutic participation by addressing the specific neurodivergent needs of children with ASD.

Defining and Naming Themes

The final analytical stage focused on the precise definition and naming of each theme. Building on the iterative review, code groups were refined into finalize themes representing unique dimensions of the therapeutic experience. Each theme was assigned a descriptive name and a formal definition outlining its scope and relevance to the research goals. Table 3 illustrates this progression from initial codes to finalized defined themes. This structured process ensures transparency and analytical credibility, providing a clear framework for the subsequent presentation of findings.

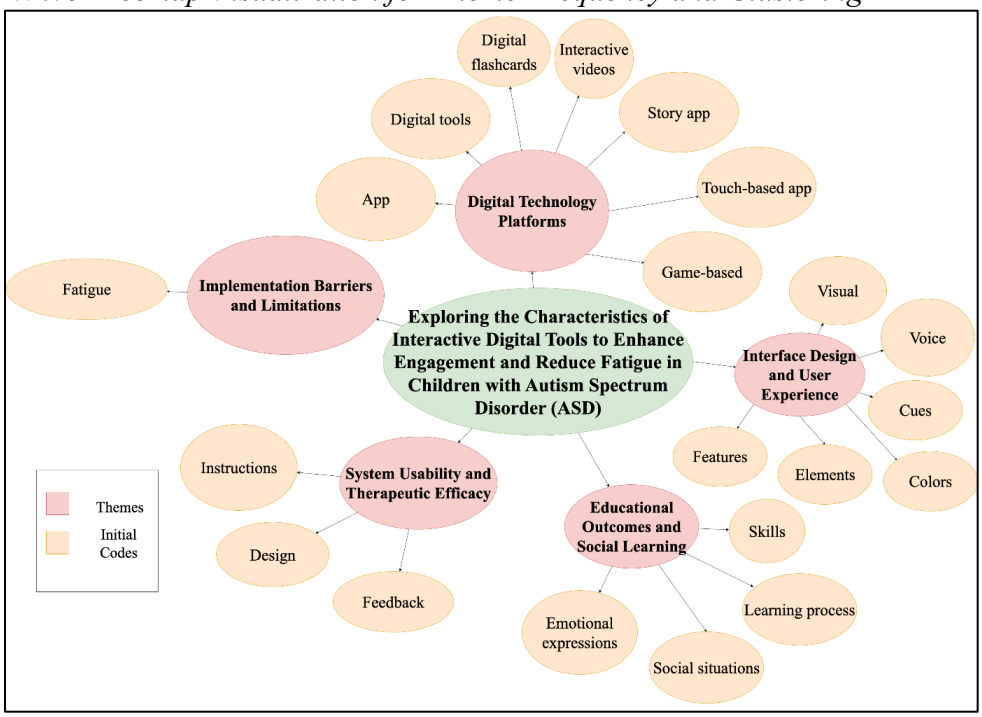
Table 3
Thematic Refinement Matrix

Initial Codes	Themes	New Defined Themes	Theme Definitions
• app • digital tools • digital flashcards • interactive videos • story app • touch-based app • game-based	Technology Types and Applications	Digital Technology Platforms	Encompasses the various digital platforms, applications, and technological tools employed in ASD therapy and educational interventions, including interactive games, multimedia content, and specialized therapeutic software.
• visual • voice • cues • colors • elements • features	User Interface and Interaction Design	Interface Design and User Experience	Refers to the design components, interactive elements, and sensory modalities that facilitate user engagement, comprehension, and accessibility in digital therapeutic tools.

Initial Codes	Themes	New Defined Themes	Theme Definitions
• skills • learning process • social situations • emotional expressions	Learning and Skill Development	Educational Outcomes and Social Learning	Focuses on the educational outcomes, social-emotional learning objectives, skill acquisition, and therapeutic goals facilitated through digital interventions in ASD therapy.
• instructions • design • feedback	Usability and Accessibility	System Usability and Therapeutic Efficacy	Addresses the ease of use, accessibility features, user experience considerations, and therapeutic effectiveness factors essential for successful technology adoption in ASD therapy.
• fatigue	Therapeutic Challenges and Barriers	Implementation Barriers and Limitations	Identifies the obstacles, limitations, adverse effects, and challenges that may impede the successful implementation and sustained use of digital therapeutic interventions.

The findings derived from the thematic analysis are illustrate in Figure 6, which presents a thematic map illustrating the complex interconnections between the identified core themes. This visual framework clarifies how specific digital tool characteristics and therapeutic practices converge to influence developmental outcomes for children with ASD. The analysis revealed five primary themes that capture essential dimensions of the therapeutic experience where Digital Technology Platforms, which serve as the foundational hardware and software mediums for intervention delivery; Interface Design and User Experience, focusing on sensory and interactive elements that optimize engagement while mitigating cognitive load; Educational Outcomes and Social Learning, reflecting observed cognitive and social-emotional skill development; System Usability and Therapeutic Efficacy, addressing the practical integration, adaptability, and clinical effectiveness of tools within established routines; and Implementation Barriers and Limitations, which identifies technical and resource-based obstacles to sustained success. Collectively, these themes offer a holistic understanding of the facilitators and challenges inherent in using interactive digital tools to enhance engagement and manage fatigue within an ASD therapeutic context.

Figure 6
NVivo Treemap Visualization for Theme Frequency and Clustering



Conclusion

This study explored the characteristics of interactive digital tools that enhance engagement and reduce fatigue in children with Autism Spectrum Disorder (ASD), focusing on insights from therapists at the National Autism Society of Malaysia (NASOM) Setia Alam. The research found that interactive digital tools particularly gamified and visually engaging applications have the potential to increase motivation, sustain attention, and improve learning outcomes among children with ASD (Cardy et al., 2023; Daud et al., 2023). The findings revealed that effective tools share several critical features: visual clarity, personalization, predictable interface design, and real-time feedback mechanisms. These characteristics promote sustained engagement and reduce cognitive fatigue, allowing children to participate more actively in therapy and educational sessions (Pliska et al., 2023; Scarcella et al., 2023). Additionally, adaptive technologies such as virtual reality and augmented reality provide immersive experiences that help children develop emotional regulation and social interaction skills in a safe and controlled environment (Kourtesis et al., 2023). Despite these positive outcomes, therapists identified challenges such as overstimulation, screen dependency, and limited accessibility of certain digital platforms. Therefore, balancing technology-assisted interventions with traditional therapeutic practices remains essential to ensure holistic child development (Keville et al., 2021). This research contributes to the growing body of literature on digital interventions for autism therapy by providing qualitative evidence from practitioners' experiences. Future research should involve user-centered design approaches, integrating feedback from children with ASD and their families to refine digital tools for greater therapeutic value (Albaum et al., 2024). Overall, the study highlights that well-designed interactive digital tools, when effectively implemented, can significantly enhance engagement and reduce fatigue among children with Autism Spectrum Disorder.

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Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

The author declares that AI tools, specifically Quillbot and Gemini, were used solely for language editing and proofreading to enhance the readability of this manuscript. These tools were not used to generate research content or original ideas. The conceptualization, data collection, and analysis remain the original work of the author, ensuring the integrity and authenticity of the research findings.

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