Available online at
https://jcrinn.com/
https://crinn.conferencehunter.com/

Journal of Computing Research and Innovation 9(1) 2024

Journal of Computing Research and Innovation

Extraction of Interaction and Physical Design Principles as Guidelines in Designing Wearable Technology for Individual with Autism

Mohamad Isa Ab Malik[1], Siti Zulaiha Ahmad[2*], Romiza Md Nor[3], Nursuriati Jamil[4], Sakinah Idris[5], Noorhaniza Wahid[6], Liew Bee Wah[7]

[1,2,3]*College of Computing, Informatics, and Mathematics, Universiti Teknologi MARA Perlis Branch, Arau Campus, Malaysia*
[4]*College of Computing, Informatics, and Mathematics, Universiti Teknologi MARA Shah Alam, Selangor, Malaysia*
[5]*Faculty of Medicine, Universiti Teknologi MARA Selangor, Sungai Buloh, Malaysia*
[6]*Faculty of Computer Science and Information Technology, Universiti Tun Hussien Onn Malaysia, Batu Pahat, Malaysia*
[7]*National Autism Society of Malaysia Setia Alam, Shah Alam, Malaysia*

ARTICLE INFO

Article history:
Received: 27 January 2024
Revised: 15 February 2024
Accepted: 19 February 2024
Online first: 1 March 2024
Published 1 March 2024

Keywords:
Autism Spectrum Disorder
Wearable Technology
Interaction Design
Physical Design

DOI:
10.24191/jcrinn.v9i1.408

ABSTRACT

Autism Spectrum Disorder is a neurodevelopmental condition characterized by challenges in social interaction, communication, and behavior, with each individual exhibiting unique characteristics due to the diverse symptoms and varying severity levels across the spectrum. Individuals with autism often face difficulties in behavior, communication, and interaction, occasionally leading to stress and tantrums due to their limited verbal expression of emotions. Traditional methods such as therapy and medication have not been enough to fully help individual with autism. Nowadays, technology, especially wearable technology offers promising opportunities for autism intervention. Recognizing their unique characteristics, this study aims to explore the wearable technology design principles that will cater their needs. Two common concepts which are the interaction and physical design components have been identified as essential in the designing the wearable technology for individual with autism. The extraction of the elements and design principles for both components have been done through an extensive process involving literature reviews and focus group discussions. After the validation process through an expert review survey, four key elements for each component, along with their respective design principles, are proposed by the study. The interaction design component includes navigation tools, feedback, direct manipulation, and multimedia elements, while the physical design component comprises material, screen display, safety, and portability. The proposed components, elements, and design principles outlined in this paper will serve as a valuable guideline in designing wearable technology to effectively meet the distinctive needs of individuals with autism.

1. INTRODUCTION

[2*] Corresponding author. *E-mail address*: sitizulaiha@uitm.edu.my
https://doi.org/10.24191/jcrinn.v9i1

Autism, or autism spectrum disorder (ASD), is a neurodevelopmental condition marked by challenges in social interaction, communication, and behavior (Malik et al., 2023; Valencia et al., 2021). It is recognized as a spectrum due to the diverse symptoms and varying severity levels, with each individual exhibiting unique characteristics (K. Sagayaraj et al., 2020; Skjeldal & Isaksen, 2023). Individual diagnosed with ASD encounter challenges in both social interaction and communication. The severity of these symptoms varies across the spectrum, ranging from mild to severe. Consequently, individual with ASD (IASD) frequently experience associated morbidities, such as depression and anxiety, as a result of these challenges. Additionally, difficulties in expressing frustration or stress due to communication impairments contribute to experiences of temper tantrums and aggression, further worsening parental stress (Carlier et al., 2019). Nowadays, various intervention and treatment have been utilized for ASD community. The technology-based interventions have been applied to assist ASD person to minimize their difficulties and help them to improve their daily life (K. Sagayaraj et al., 2020).

According to Scarcella et al. (2023), several studies have shown that technology-based interventions, such as serious games, social robots, and ICT tools, can be effective in improving social skills and behavioural abnormalities associated with ASD. Moreover, the utilization of wearable technology (WT) as an intervention for ASD, exhibit significant promise in transitioning towards an empowerment approach for individual with autism (Williams & Gilbert, 2020). There are three types of wearable technology which include head-mounted technology, body-worn technology, and accessories or clothing technologies (Black et al., 2020). In this era, WT exhibits the capacity to continuously measure physiological responses, including heart rate and body temperature, through sets of sensors, this technological advancement facilitates the real-time monitoring of behavior for IASD, thereby enhancing the formulation of more effective intervention strategies (Fioriello et al., 2020; Rong et al., 2021). Furthermore, the implementation of WT as an intervention strategy not only mitigates medical expenses but also grants person diagnosed with ASD more freedom, diverging from reliance only on conventional therapeutic approaches, which are considered by both time-intensive processes and elevated costs (Koo et al., 2018). Consequently, these characteristics provide unique opportunities to enhance the lives of the IASD.

However, certain researchers have discerned a gap in the understanding of the design factors and user preferences regarding the design of existing WT especially for individual diagnosed with ASD (Francés-Morcillo et al., 2020). Valencia et al. (2021), state that existing studies lack of discussions on specific attributes, component, or design factors pertaining to the development of systems tailored for individuals with ASD, particularly in relation to user experience (UX) factors. The issues result in the ineffectiveness of designed WT for IASD and contribute to design challenges and appropriate design. Hence, this study identifies two essential components in designing of WT, specifically to meet the unique requirements of IASD which include the interaction design and physical design which start as follows.

2. DESIGN CONCEPT

Two design components, emphasized by numerous existing studies, serve as the foundation for extracting elements and principles for WT in IASD. The subsequent section discussed into a detailed of each design component.

2.1 Concept of Interaction Design

Hussain et al. (2016) define interaction design (IxD) as the discipline of designing interactive products to support people in their everyday lives, focusing on system behavior, form, and content. This component is crucial in addressing challenges faced by IASD, particularly anxiety, which affects more than half of individuals with ASD, especially those with higher cognitive skills (Di Salvo & Tamborrini, 2017). Over the years, interactive visual displays have been used to improve interventions for IASD, aiding them in

https://doi.org/10.24191/jcrinn.v9i1

practicing social skills, including communication, and enhancing intervention outcomes (Washington et al., 2016). Therefore, it is essential to consider appropriate interaction design tailored to the unique characteristics of ASD users to ensure that the end product is not only useful and functional but also effective in assisting them. Although wearable technology is a potential technology-based intervention for ASD, design limitations persist, with the most challenging component being the design of the user interface (Motti & Caine, 2015). Therefore, this study aims to explore the elements and principles for designing an effective User Interface (UI) and User Interaction (UX) to meet the needs of IASD.

2.2 Concept of Physical Design

The physical design of wearable technology encompasses its tangible and visible characteristics, such as size, weight, and shape, as well as the incorporation of specific hardware. These elements contribute to the device's external appearance and structural features, affecting its usability, comfort, and aesthetic appeal (Garside, 2019; Rong et al., 2021). It is crucial for the physical design to prioritize practicality, safety, and durability, considering the diverse range of symptoms experienced by IASD. Symptoms related to the physical appearance of wearable products, such as sensory issues and discomfort with physical sensations, can be triggers for IASD (Koo et al., 2018). Ensuring durability and safety is vital for a wearable product designed for IASD, guaranteeing long-term functionality and safeguarding their well-being (Vitullo & Benitez, 2019). A literature review has been conducted to identify the physical design principles specifically tailored for IASD.

3. METHODOLOGY

This section covers all the activities involved in extracting the principles related to the interaction design and physical design components of wearable technology for IASD. The extraction process comprises two phases: extraction and validation. In the extraction phase, a thorough exploration of literature from previous works was conducted to identify and propose the most relevant design principles for both components. Additionally, suggestions of design principles also were extracted from a focus group discussion conducted with autism practitioners. In the validation phase, the extracted design principles were reviewed and validated with experts to ensure their relevance to IASD. This validation process involved an expert review survey. Fig. 1 below summarizes the activities in both phases.

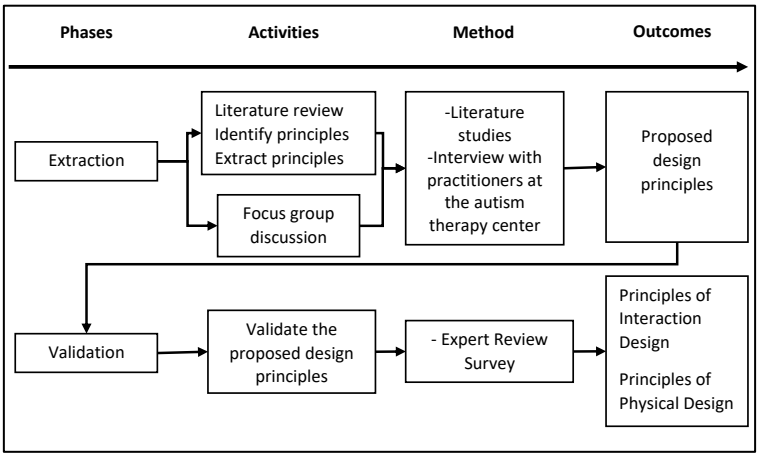

Fig. 1. Research Methodology

4. EXTRACTION OF DESIGN PRINCIPLES

https://doi.org/10.24191/jcrinn.v9i1

This section outlines the process of extracting elements related to interaction design and physical design. These elements were derived from chosen studies and recommendations provided by practitioners from the autism center. The design principles extracted are grounded in the design guidelines proposed in the selected studies. Consistent with the extraction process, a comparative analysis was undertaken to select the most suitable elements for both interaction design and physical design components. The elimination of irrelevant elements was carried out, and the identified elements, along with their descriptions, are detailed in Table 1 the extracted element of interaction design and Table 2 the extracted element of physical design below.

Table 1. Elements of Interaction Design

Component	Element	Description
Interaction Design	Navigation Tools	Navigation tools are different ways users can move around the interface, like menus, buttons, and links, giving users a clear and consistent way to access different features and functions of the system.
	Feedback	Feedback gives users information about what is happening in the system and the results of their actions, helping them understand the impact and feel satisfied with their actions.
	Direct Manipulation	Direct manipulation is an interface interaction where users can easily and visibly interact with tasks and objects by directly using their fingers, hands, or other physical inputs on the device. Direct manipulation interaction styles encompass actions like swiping, clicking, and tapping.
	Multimedia elements	The visual representation of information on the system often incorporating different hues, shades, or patterns to convey specific information, prompt actions, or create a visually engaging and user-friendly interface for colour. Other type of content whether it be in the form of sounds, images or other animations.

Table 2. Elements of Physical Design

Component	Element	Description
Physical Design	Material	The choice of material affects the comfort and durability of the wearable product.
	Screen display	Relates to how the screen looks on a device, covering aspects like size, shape, resolution, and aspect ratio
	Safety	Involves steps to make sure the product is safe for its intended users, considering factors like the materials used, device stability during use, and potential harm during operation.
	Portability	The flexibility of the product to be carried or moved.

The elements listed in both tables are the extracted elements for the interaction design components and physical design component. The principles for each element will be discussed at the end of this paper.

5. VALIDATIONS OF THE EXTRACTED DESIGN PRINCIPLES

https://doi.org/10.24191/jcrinn.v9i1

To validate the relevance of the proposed design principles, an expert review survey method was conducted. As outlined in the previous section, the review process initiated with the preparation of instruments encompassing components, elements, and design principles. These instruments were then sent via email to a group of targeted reviewers who agreed to participate in the review, comprising experts in computer sciences, human-computer interaction (HCI), software engineering, and autism practitioners. The expert selection from a variety of expertise provides a broad perspective on the design of wearable technology for autistic children. These professionals were chosen because they have all had direct experience working with autistic children. They gain a thorough understanding of the characteristics of and the difficulties IASD encounter as a result of this experience. Computer science professionals have also had experience creating information systems that are user-friendly and accessible to people with disabilities. They are ideally suited to offer advice on the creation of information systems for IASD because of their combination of specialities. A two-week timeframe was allocated for the experts to complete the review and submit their feedback. Experts were chosen based on their expertise to gather additional suggestions and confirm the proposed principles, leveraging their experience in each field and familiarity with IASD. By the end of the allocated period, nine experts have submitted their feedback. This number of experts have been sufficient and convincing for expert evaluation (Dworkin, 2012).

Upon analyzing the feedback, a majority of respondents agreed that the elements within the interaction design components are both relevant and vital for constructing the interface and navigation in wearable technology for IASD. These elements play a vital role in shaping the design to meet the distinctive characteristics of IASD which include the selection of color, multimedia content and navigation tools. According to the experts, utilizing a combination of multimedia elements, including videos and audio, may be suitable methods to divert individuals with autism. Some experts proposed incorporating soft vibrations with a low frequency for feedback on each action. There is also a suggestion to provide automatic pop-up visual message notifications as alerts. However, the suggestion was rejected due to concerns about potential distractions for IASD (Carlier et al., 2019). In general, all experts expressed that the user interface (UI) has the potential to divert individuals with autism from stress and alleviate the severity of their behavioural issues.

Furthermore, the physical design components received positive feedback from the experts, with many offering comments on the selection of materials which are the critical elements that significantly contribute to the appearance of wearable technology. For the actual design, the use of durable and water-resistant materials to ensure extended longevity is suggested by experts. Additionally, the consideration of wearable or flexible batteries as a power source is also recommended. In terms of safety, an unnoticeable design implies that the physical design should be well placed on the user's body, causing no disruption to their movement or attention, then could prevent stress and distraction to the IASD when using the WT. The screen display stands out as a crucial element, with certain experts recommending the use of a touchscreen, an AMOLED display, and a high-resolution screen, as these elements received predominantly positive feedback. They recommended clearly specifying the shape of the screen that is deemed appropriate for use.

Derived from expert feedback, this study proposed the validated elements and design principles for both interaction and physical design component in designing wearable technology for IASD. The following section discussed the outcomes of the validated design principles for both components.

6. RESULT AND DISCUSSION

In this section, the extracted and validated design principles for the interaction and physical design of wearable technology for IASD are outlined. The interconnected elements and principles within each category hold relevance and have the potential to meet the requirements for designing wearable technology for IASD. The subsequent section elaborates on these principles.

https://doi.org/10.24191/jcrinn.v9i1

6.1 Interaction Design Principles

(i) Navigation Tools

Implement a button style for selecting actions - Offer users a straightforward and uniform method for accessing different features and functions of the system. Moreover, button promote the ease of use for IASD as most of them may have sensory sensitivities or motor coordination challenges. Considerations for the designed button style encompass aspects such as button size, tactility, and visual characteristics, ensuring comfort for users ASD and effective engagement with the wearable technology.

Use recognizable graphical icons for buttons – Utilizing universally recognizable icons for specific functions reduces user effort in understanding the system and enables them to anticipate the outcomes of their actions. The familiarity of icons not only prevents confusion for users with ASD but also helps lessen potential stress.

Provide concise and precise instructions – Short labels for buttons are also necessary as alternatives to assist in cases of potential confusion.

Choose soft and contras colour for the button – IASD exhibits sensitivity to color choices, with bright colors potentially triggering anxiety and causing distractions to them. Additionally, the selection of colors should consider the contrast between the background color and the button to ensure button visibility.

Provide consistent and static button – Maintaining a consistent design throughout the interface is a fundamental aspect of the navigation style. Promoting a predictable interaction pattern, buttons should remain static, ensuring their position and appearance consistency across interfaces. This design principle is aimed at fostering a reliable and user-friendly experience.

(ii) Feedback

Provide vibration for action taken - Incorporating vibration feedback into wearable applications is effective, serving as a distraction for children and offering gentle, discreet reminders to users.

Use low frequency vibration – Low-frequency vibrations are generally milder and less forceful, offering benefits, especially for sensitive ASD users who have specific sensory requirements. This offers a less disruptive feedback method, improving the overall user experience while minimizing the likelihood of discomfort or distraction.

(iii) Direct Manipulation

Use a touch-and-slide approach – This method lessens the requirement for users to have advanced motor skills when using the device. It offers a straightforward approach to user interaction, commonly seen in touchscreen devices. In this style, users can easily control and navigate the interface with intuitive touch movements, promoting user engagement and responsiveness. The touch-and-slide approach aligns with the idea of direct manipulation, allowing users to directly interact with on-screen elements for actions or navigation.

https://doi.org/10.24191/jcrinn.v9i1

Prevent automatic pop-up alerts – Implementing pop-up notifications for alerts is unsuitable for IASD as it can cause distraction. However, if pop-ups are deemed necessary, they should be customized in a way that minimizes disruption and ensures the message appears on the screen in a suitable manner.

Avoid multiple objects or operation for single button - This functionality has the potential to create confusion for users, especially IASD, who may be prone to sensory overload, resulting in heightened stress levels. Therefore, single operation in one button is necessary.

(iv) Multimedia elements

Use soft and pastel colour – 70% of reviewer recommended soft and pastel colors over bright ones. Pastel colors enhance physical visibility, incorporating at least five different colors for improved clarity. Selecting colors is crucial to address the emotions of individuals IASD, as many of them are sensitive to bright colors. Hence, softer colors are more suitable.

Use short dynamic visual – The duration of dynamic visual videos should be short or customizable based on the needs of IASD users. Lengthy visuals can induce stress and lead to disliking the product. Visuals for persuasion, like breathing techniques, could be brief, lasting only three to five seconds.

Use short audio cues – The elements of audio are also essential for verbal instruction. IASD. Using a combination of multimedia elements, such as images and audio, can be an effective method to divert individuals with autism. It not only provides users with feedback but also enhances their overall experience.

6.2 Physical Design Principles

(i) Material

Use flexible materials – Flexible design facilitates the wearable product in conforming to the user's body contours, ensuring a comfortable and unrestricted fit. This design element enhances adaptability to different body shapes and movements, promoting greater flexibility in the wearable technology.

Use lightweight materials – The use of lightweight materials is essential for an improved user experience when wearing the product. Light materials reduce the burden and facilitate easy portability of the product to any location.

Use durable materials – Utilizing strong materials like water-resistant materials guarantees the durability of the wearable product in response to users' conditions. This durability contributes to the prolonged use and longevity of the wearable product.

(ii) Screen display

Use multitouch screen – Multitouch touchscreens can engage IASD by enhancing their communication and attention, fostering a seamless interaction between users and devices. Activation can also occur through pen touch in addition to finger touch.

Use AMOLED screen – The screens provide bright colors, strong contrast, and fast response times. This vivid display improves visual clarity, making content more accessible and enjoyable. AMOLED screens use power efficiently, ensuring a longer battery life, without needing to recharge often.

https://doi.org/10.24191/jcrinn.v9i1

(iii) Safety

Separate heat dissipating components – Regulate the heat produced by the wearable device to prevent overheating, ensuring the wearables remain comfortable and safe for users, considering the sensitivity of IASD to temperature changes.

Provide insulation for electrical current – Insulate the hardware that provides electrical current within the wearable device to safeguard users from potential electric shocks, prioritizing safety for IASD.

(iv) Portability

Use flexible battery – The flexible characteristic of the battery enables it to fit to the shape of the designed wearable, promoting comfort for the wearer and allowing integration into various designs beyond conventional wearable forms.

Provide wireless connectivity – Establishing a connection between the wearable worn by IASD and their parents is essential for enhanced monitoring and increased parental awareness of their ASD children's condition. Wireless connectivity further ensures the wearable device facilitates smooth communication and data transfer without relying on physical connections.

7. CONCLUSIONS

This study explores the design principles crucial for designing Wearable Technologies (WT) tailored for individuals with autism spectrum disorder (IASD). The study identified two integral components, namely, interaction design and physical design. Through a literature review and focus group discussion, elements and principles were extracted to address behavior problems in IASD. Through the extraction process, the study identified four key elements for both components. In interaction design, these include Navigation Tools, Feedback, Direct Manipulation, and Multimedia elements. For physical design, elements encompass Material, Screen display, Safety, and Portability. Nine experts validated these elements and associated principles through an expert review survey. The study aims to serve as a guideline for developing WT that caters to the unique characteristics of IASD and aids in crafting effective intervention strategies to improve behavior problems in their daily lives. However, these outcomes need to be extended to explore more components, elements, and principles related to WT that are tailored with IASD. The recommended future work will ensure the proposed design principles are applicable and effective in assisting IASD in their life through the WT.

8. ACKNOWLEDGEMENTS/ FUNDING

The authors would like to express their gratitude to The Ministry of Higher Education Malaysia (MOHE) and Universiti Teknologi MARA Malaysia (UiTM) for their contributions to this study. This research was funded by the grant of Fundamental Research Grant Scheme (FRGS) Reference Code: FRGS/1/2021/ICT03/UITM/02/2. The authors also would like to thank the Research board committee (REC) for the approval of this research, Reference code: REC/01/2023 (PG/MR/3).

9. CONFLICT OF INTEREST STATEMENT

The authors declare that this research has no conflict of interest. It is affirmed that there is no financial, personal, or professional relationship that could potentially influence the research findings or bias the interpretation of the results.

https://doi.org/10.24191/jcrinn.v9i1

10. AUTHORS' CONTRIBUTIONS

The research paper was conducted by a team of researchers. The research was carried out by Mohamad Isa Ab Malik, who also wrote and revised the article. The research design and supervision were handled by Siti Zulaiha Ahmad and Romiza Md Nor. The data collection process was supervised by Sakinah Idris and Liew Bee Wah, who also analyzed the data. The review and validation of the research results were led by Nursuriati Jamil and Norrhaniza Wahid, who approved the article submission.

11. REFERENCES

Black, M. H., Milbourn, B., Chen, N. T. M., McGarry, S., Wali, F., Ho, A. S. V., Lee, M., Bölte, S., Falkmer, T., & Girdler, S. (2020). The use of wearable technology to measure and support abilities, disabilities and functional skills in autistic youth: a scoping review. *Scandinavian Journal of Child and Adolescent Psychiatry and Psychology*, *8*(1), 48–69. https://doi.org/10.21307/sjcapp-2020-006

Carlier, S., Van Der Paelt, S., Ongenae, F., De Backere, F., & De Turck, F. (2019). Using a serious game to reduce stress and anxiety in children with autism spectrum disorder. *PervasiveHealth: Pervasive Computing Technologies for Healthcare*, 452–461. https://doi.org/10.1145/3329189.3329237

Di Salvo, A., & Tamborrini, P. M. (2017). Interaction design tools for autism. *Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering, LNICST*, *178*, 243–253. https://doi.org/10.1007/978-3-319-49616-0_23

Dworkin, S. L. (2012). Sample size policy for qualitative studies using in-depth interviews. *Archives of Sexual Behavior*, *41*(6), 1319–1320. https://doi.org/10.1007/s10508-012-0016-6

Fioriello, F., Maugeri, A., D'Alvia, L., Pittella, E., Piuzzi, E., Rizzuto, E., Del Prete, Z., Manti, F., & Sogos, C. (2020). A wearable heart rate measurement device for children with autism spectrum disorder. *Scientific Reports*, *10*(1), 1–7. https://doi.org/10.1038/s41598-020-75768-1

Francés-Morcillo, L., Morer-Camo, P., Rodríguez-Ferradas, M. I., & Cazón-Martín, A. (2020). Wearable design requirements identification and evaluation. *Sensors (Switzerland)*, *20*(9). https://doi.org/10.3390/s20092599

Garside, K. D. C. (2019). *Behavioral Monitoring to Identify Self-Injurious Behavior Among Children with Autism Spectrum Disorder* [Doctoral dissertation, Virginia Tech]. https://vtechworks.lib.vt.edu/server/api/core/bitstreams/9ccaf9fc-03bf-460d-89c5-aa3c4bc1551b/content

Hussain, A., Abdullah, A., Husni, H., & Mkpojiogu, E. O. C. (2016). Interaction Design Principles for Edutainment Systems: Enhancing the Communication Skills of Children with Autism Spectrum Disorders. *Revista Tecnica De La Facultad De Ingenieria Universidad Del Zulia*, *39*, 45–50. https://doi.org/10.21311/001.39.8.06

K. Sagayaraj, C. N. Ram Gopal, & S. Karthikeyan. (2020). The Efficacy of Technology and Non-Technology Based Intervention for Children with Autism Spectrum Disorder: A Meta-Analysis. *International Journal of Innovative Science and Research Technology*, *5*(3), 863–868. www.ijisrt.com863

Koo, S. H., Gaul, K., Rivera, S., Pan, T., & Fong, D. (2018). Wearable technology design for autism spectrum disorders. *Archives of Design Research*, *31*(1), 37–55.

https://doi.org/10.15187/adr.2018.02.31.1.37

Malik, M. L. A., Ahmad, S. Z., Nor, R. M., Jamil, N., Idris, S., & Wah, G. L. B. (2023). A Hybrid Wearable Technology Model for Autism Behaviour Intervention: Components and Elements Analysis. *13th IEEE Symposium on Computer Applications and Industrial Electronics, ISCAIE 2023* (pp. 293–298). https://doi.org/10.1109/ISCAIE57739.2023.10165579

Motti, V. G., & Caine, K. (2015). Micro interactions and multi dimensional graphical user interfaces in the design of wrist worn wearables. *Proceedings of the Human Factors and Ergonomics Society*, *2015-Janua* (pp. 1712–1716). https://doi.org/10.1177/1541931215591370

Rong, G., Zheng, Y., & Sawan, M. (2021). Energy solutions for wearable sensors: A review. *Sensors*, *21*(11), 1–23. https://doi.org/10.3390/s21113806

Scarcella, I., Marino, F., Failla, C., Doria, G., Chilà, P., Minutoli, R., Vetrano, N., Vagni, D., Pignolo, L., Di Cara, M., Settimo, C., Quartarone, A., Cerasa, A., & Pioggia, G. (2023). Information and communication technologies-based interventions for children with autism spectrum conditions: a systematic review of randomized control trials from a positive technology perspective. *Frontiers in Psychiatry*, *14*. https://doi.org/10.3389/fpsyt.2023.1212522

Skjeldal, O. H., & Isaksen, J. (2023). Autism - A brief update. *Translational Science of Rare Diseases*, *6*(4), 101–115. https://doi.org/10.3233/TRD-230058

Valencia, K., Rusu, C., & Botella, F. (2021). User experience factors for people with autism spectrum disorder. *Applied Sciences (Switzerland)*, *11*(21). https://doi.org/10.3390/app112110469

Vitullo, K., & Benitez, M. (2019). A wearable therapy and technology garment for kids. *Proceedings - International Symposium on Wearable Computers, ISWC* (pp. 329–333). https://doi.org/10.1145/3341163.3346933

Washington, P., Voss, C., Haber, N., Tanaka, S., Daniels, J., Feinstein, C., Winograd, T., & Wall, D. (2016). A wearable social interaction aid for children with autism. *Conference on Human Factors in Computing Systems - Proceedings* (pp. 2348–2354). https://doi.org/10.1145/2851581.2892282

Williams, R. M., & Gilbert, J. E. (2020). Perseverations of the academy: A survey of wearable technologies applied to autism intervention. *International Journal of Human Computer Studies*, *143*(January), 102485. https://doi.org/10.1016/j.ijhcs.2020.102485

https://doi.org/10.24191/jcrinn.v9i1