CS 6700 - Advanced Artificial Intelligence
M.Eng Project

Leveraging AI and UX to Improve Learning and Education for Children with Autism

Divya Darshni Suresh (DS996)

Abstract

This study explores the integration of artificial intelligence (AI) and user experience (UX) technologies to enhance learning and education for children with Autism Spectrum Disorder (ASD). ASD presents challenges in social interaction, communication, and behavior, making traditional learning methods difficult for affected children. Early detection of ASD traits using an ensemble model based on the AQ-10 test is crucial for timely intervention. The proposed approach emphasizes the role of UX design in creating a positive and engaging learning experience for children with autism, considering factors such as simplifying complexity, incorporating visual aids, ensuring predictability and consistency, addressing sensory needs, and providing feedback and reinforcement. By combining the strengths of AI and UX, educators and healthcare providers can provide personalized and effective support, ultimately improving outcomes and the quality of life for children with autism.

Keywords

Autism, autism spectrum disorder, education, learning, Artificial Intelligence, AI, User Experience, UX, personalized learning, social interaction, assistive technology, simplifying complexity, visual aids, predictability, consistency, sensory considerations, feedback, and reinforcement, Ensemble Model, AQ - 10 test, Linear regression, Naive Bayes, SVM, Random Forest, Decision Tree.

1 Introduction

Autism is a neurodevelopmental disorder that is characterized by a range of symptoms including delayed speech, communication difficulties, repetitive behavior, hyperactivity, and atypical emotional reactions [3]. Despite the efforts of therapists and educators to develop effective strategies to support individuals with autism, it is common for these strategies to be forgotten and in need of review. Additionally, due to the wide spectrum of symptoms and varying learning and functioning styles of individuals with autism, no single solution can be applied across the board.

User Experience
User Experience(UX) refers to the overall experience a user gets while interacting with the system. The UX process involves user research, design, implementation, and evaluation. This is a cycle and it makes sure to encompass all aspects of user interaction. So, it can play a vital role to create an inclusive, accessible, and engaging experience for autistic students. We can incorporate to tailor to meet the specific needs of the individuals.

Artificial Intelligence
Artificial Intelligence is a transformative technology with great potential to revolutionize various aspects of lives. Their ability to analyze vast data, recognize patterns and provide valuable insights can be utilized in ASD research and intervention.

Together AI amd UX can enhance engagement, provide a seamless integration and assit in early detection and the caregivers themselves. Autism Spectrum Disorder (ASD) is a neurodevelopmental condition that presents challenges in learning and education for affected children due to difficulties in social interaction, communication, and behavior. However, early detection of autism and providing appropriate learning support can have a significant positive impact on these children. The integration of artificial intelligence (AI) and user experience (UX) technologies offers promising opportunities to enhance learning and education for children with autism. This paper explores the potential of AI and UX in improving the educational experiences of children with autism by tailoring interventions to their unique learning needs and facilitating better communication and interaction with their surroundings.

The paper highlights the importance of early detection, which can be achieved using an ensemble model based on the AQ-10 test to identify ASD traits. When aid is required, the proposed method emphasizes the role of UX design in creating a positive and engaging learning environment for children with autism. This involves simplifying complex concepts, incorporating visual aids, establishing predictability and consistency, considering sensory factors, and providing constructive feedback and reinforcement. By leveraging the strengths of both AI and UX, educators and healthcare providers can deliver more effective and personalized support to enhance the educational journey and overall well-being of children with autism.
In conclusion, the combination of AI and UX has the potential to revolutionize learning and education for children with autism. By detecting ASD early and employing tailored interventions that prioritize positive user experiences, educators and healthcare professionals can significantly improve outcomes and enhance the quality of life for these children.

2 Literature Review

Autism is a neurodevelopmental disorder characterized by various symptoms, including communication difficulties, delayed speech, repetitive behavior, hyperactivity, and atypical emotional reactions[3]. While therapists and educators have made efforts to develop effective strategies to support individuals with autism, these strategies often require frequent review and lack universality due to the diverse spectrum of symptoms and learning styles among individuals with autism. Assistive technologies have been developed to support the learning exercises of children with autism. However, several studies have reported limitations in the user interface and evaluation techniques used. For example, [3] developed a customizable augmented reality (AR) application for visual learning exercises but found that the current user interface did not accommodate the limited attention span of children with autism. [7] developed an AI-powered video-calling prototype with an "expressiveness mirror" for feedback based on facial expressions, but the evaluation technique used had limited data due to the Wizard of Oz technique.

In contrast, other studies such as Li et al. (2020) and Puspitasari et al. (2022) [12, 18] employed non-participatory user-centered and real-world classroom test-

ing approaches to develop teacher-teleoperated robots and MIKA, an assistive technology for communication learning, respectively. These studies emphasized the importance of incorporating end-user feedback and considering cultural and linguistic factors in assistive technology development. Furthermore, research has examined the effects of pet robot therapy on Thai autistic children, highlighting the positive impact on social interaction and communication skills [16]. Another study focused on a user-centered design and assessment of a wearable application for children with Autism Spectrum Disorder (ASD), demonstrating the effectiveness of the application in supporting daily activities[10].

The development and evaluation of a communicative Android application for reinforcement-based learning among autism personnel was explored, emphasizing the gamified approach and its effectiveness in enhancing communication skills (Abeer et al., 2018). Moreover, the design of a social story teaching aid based on computational thinking showed promising results in enhancing social skills and reducing challenging behaviors in children with autism[13]. A systematic mapping of the literature on mobile apps for people with Autistic Spectrum Disorder (ASD) provided an overview of the types, features, and outcomes of mobile apps developed for this population[11]. The preferences of autistic children in designing user interfaces were investigated, revealing the importance of visual simplicity, consistency, and predictability[15]. In terms of inclusive environments, a qualitative study examined the use of the multisensory space "Hoomie" for the inclusion of autistic children in a primary school setting, demonstrating its effectiveness in providing a calming and safe environment for sensory regulation and social interaction [25]. The need-finding study focused on the challenges faced by educators in monitoring the progress of autistic children across therapy sessions, emphasizing the importance of a user-friendly, customizable, and automated tool to support educators in tracking progress and adapting therapy plans[20].

Additionally, the research explored the use of game therapy for delivering visualization instructions to regressive autistic children, showing significant improvements in visualization abilities[17]. Sentiment analysis in Chinese websites related to nonverbal autistic children revealed predominantly negative sentiments among parents and caregivers, underscoring the need to address their emotional needs[9]. Furthermore, the potential of motion-based touchless games for supporting the learning of autistic children was investigated, highlighting

their effectiveness in improving cognitive and motor skills[6]. The study emphasized the integration of touchless games into educational settings to enhance the learning experience of autistic children.

In the study by Schadenberg (2021) [1], predictable robots were designed and tested with autistic children, revealing that individual differences in robot behavior and autistic characteristics influenced child-robot engagement. This finding underscored the importance of considering individual differences in designing technology for autistic children. Another study by Ahmed et al. (2020) [14]explored the relationship between robot expressive behavior and autistic traits, suggesting that children with higher levels of autistic traits were more responsive to predictable behavior and less responsive to expressive behavior. The study emphasized the need for adaptable robots that cater to individual differences to improve engagement and communication with children with autism.

These studies collectively provide valuable insights into the development of assistive technologies for individuals with autism. They emphasize the importance of user-centered design, incorporating end-user feedback, and cultural considerations, and considering individual differences in symptoms and learning styles. Additionally, they highlight the need for effective evaluation techniques to accurately assess the impact and effectiveness of assistive technologies.

In conclusion, the literature review demonstrates the diverse approaches and advancements in the field of assistive technologies for individuals with autism. From customizable AR applications to wearable devices, teacher-teleoperated robots, and game-based interventions, researchers have explored various avenues to support learning, communication, social interaction, and sensory regulation among individuals with autism. The studies emphasize the importance of user-centered design, incorporating feedback from end-users and considering cultural and linguistic factors. Furthermore, they highlight the need for effective evaluation techniques and the consideration of individual differences in symptoms and learning styles. Overall, these findings contribute to the development of more effective and tailored assistive technologies for individuals with autism, ultimately enhancing their quality of life and promoting their inclusion in society.

3 Proposed Method

The study proposes a novel approach that involves collecting details of the child's diagnosis from parents and utilizing AI and UX techniques to provide personalized services based on their specific needs. The research focuses on leveraging AI's capabilities to facilitate personalized learning, social interaction, early detection and diagnosis, and feedback and reinforcement while incorporating UX design principles to improve attention and understanding. By combining these methodologies, the study aims to offer a comprehensive solution to enhance educational outcomes for children with autism.

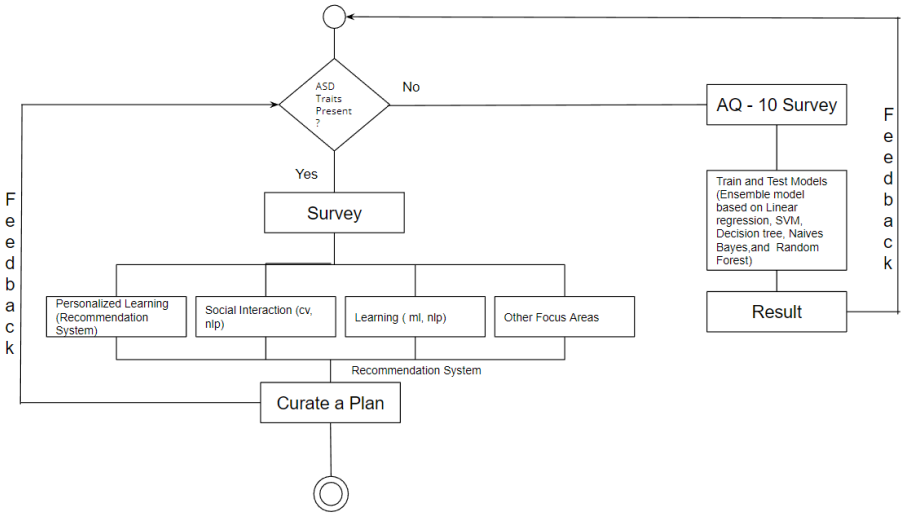


Figure 1: Flowchart of the proposed idea

3.1 Introduction

Children with autism face unique challenges in their educational journey, requiring tailored approaches to support their learning and development. This section introduces the research objective of leveraging AI and UX to improve learning and education for children with autism. It highlights the significance of integrating AI techniques to unlock new opportunities and presents the role of UX design in understanding their specific needs and enhancing attention.

3.2 Data Collection and Parental Input

To develop a comprehensive understanding of the child's diagnosis and individual requirements, this research proposes collecting details of the child's diagnosis from parents. Parents will be requested to provide relevant information regarding their child's diagnosis, including medical reports, evaluations, and any specific areas they seek assistance with. This approach ensures that the AI and UX solutions are tailored to meet the unique needs of each child if they know that their child has ASD traits. If they are concerned and not aware, they can do the AQ-10 Questionnaire survey for early detection of ASD traits in their child.

3.3 AI Integration

Based on the inputs from the parent we can curate a personalized recommendation plan that can include but not be limited to:

a. Personalized Learning: AI algorithms will adapt learning content and pace to match the child's strengths, weaknesses, and learning style. By analyzing performance data, the system will provide tailored educational materials and exercises to optimize the learning experience. This can include the use of NLP, recommendation, and BERT algorithms for speech and textual teaching.

b. Social Interaction: AI-driven virtual agents and chatbots will facilitate safe environments for practicing social skills and receiving immediate feedback. These agents will simulate real-world scenarios, promoting social interaction and improving communication skills. Along with computer vision detection of emotions with the camera to assist them and learning emotions, gamification of learning their neighborhood and other social skills through storyboards.

c. Early Detection and Diagnosis: AI algorithms will analyze historical and real-time data to aid in the early detection and diagnosis of autism. By identifying patterns and correlations, the system can assist healthcare professionals in making informed decisions and provide timely interventions.

3.4 UX Design Implementation

This subsection emphasizes the importance of UX design in understanding the needs of children with autism and improving their attention and understanding. It outlines the key UX design principles and features that will be incorporated in the proposed system, including:

a. User-Friendly Interface: The system will have a simple and intuitive interface to accommodate the unique characteristics and preferences of children with autism. Clear navigation and minimal distractions will enhance usability.

b. Visual Aids: Visual aids, such as images, videos, and diagrams, will be incorporated to support visual learning and facilitate better comprehension of educational materials.

c. Predictability and Consistency: The system will maintain a consistent and predictable user interface to reduce anxiety and create a sense of familiarity for children with autism.

d. Sensory Considerations: UX design will take into account sensory sensitivities of children with autism, including color contrast, font size, and sound effects. The aim is to create a comfortable and non-overstimulating environment.

e. Feedback and Reinforcement: The system will provide immediate feedback and positive reinforcement to motivate and engage children in their learning journey. Progress tracking and personalized recommendations will be included to enhance their educational experience.

3.5 System Development and Evaluation

The proposed system will be developed by integrating AI algorithms and UX design principles. The development process will involve coding and implementing the AI functionalities, designing the user interface, and integrating the backend and frontend components. Throughout the development phase, regular evaluations and user testing will be conducted to ensure the effectiveness and usability of the system.

The system will be providing feedback and working in a loop to better itself as it is vital for the system to personalize it for the requirement of the child itself.To evaluate the proposed system for improving learning and education for children with autism, we can consider the following evaluation metrics and methods:

a.User Feedback: Collect feedback from the target users, such as children with autism, their parents, and educators. Use surveys, interviews, or usability testing sessions to gather qualitative feedback on the system's usability, effectiveness, and impact on learning outcomes.

b.Performance Metrics: Define and measure specific performance metrics to assess the system's effectiveness. For example, you can track improvements in learning outcomes, academic progress, engagement levels, or behavioral changes

in children with autism compared to traditional approaches.

c. Data Analysis: Data collected through the system, such as user interactions, learning progress, and engagement metrics. Use data-driven techniques, such as data mining or machine learning algorithms, to extract insights and patterns that can inform the evaluation of the system's performance and effectiveness.

4 Early Detection System

One of the key aspects of my project is the early detection of Autism. An ensemble model that combined the predictions of multiple machine learning algorithms like logistic regression, random forest, Naive Bayes, Support Vector Machine (SVM), and decision tree to improve accuracy. The data set on which the model was trained was Toddlers AQ - 10 data set [21, 22, 23, 24] which had 1054 entries and 19 columns. The model takes users' input i.e. parent or caregivers will provide input on a child's behavior related to the 10 questions in the AQ-10 test, a test that helps in the quick detection of ASD traits but is not necessarily an effective screening tool.

4.1 Data Exploration

To commence our data analysis, we first examine the heatmap to discern prevalent patterns and trends 2. Subsequently, an intriguing exploration of the distribution of Autism Spectrum Disorder (ASD) traits based on ethnicity revealed that individuals of White European descent exhibit a higher likelihood of ASD traits 3a. Furthermore, our findings validate the survey's indication that ASD traits are present in a ratio of 1:4 between girls and boys 3b.

4.2 Model

Ensemble methods refer to techniques that combine multiple individual models or algorithms to make predictions or decisions. The idea behind the ensemble method is to harness the collective wisdom of diverse models to improve overall performance and robustness which will be its advantage over the existing systems that rely on a single model.

Initially the project just commenced with ML models like logistic regression, random forest, Naive Bayes, Support Vector Machine (SVM), and decision tree

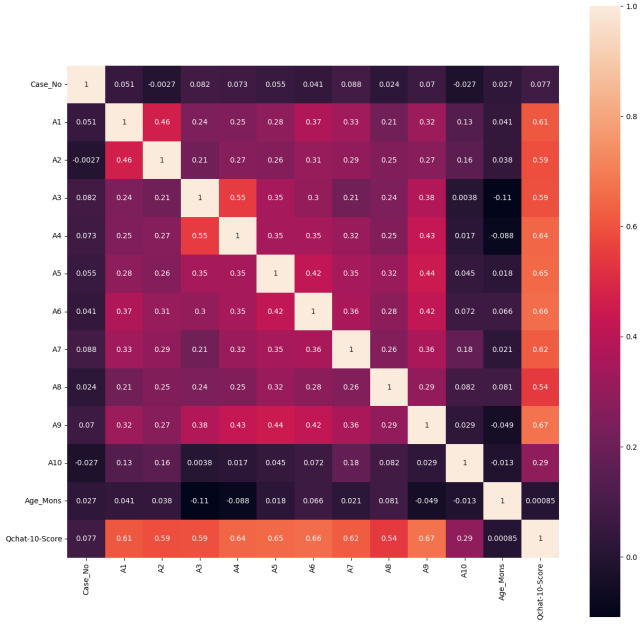
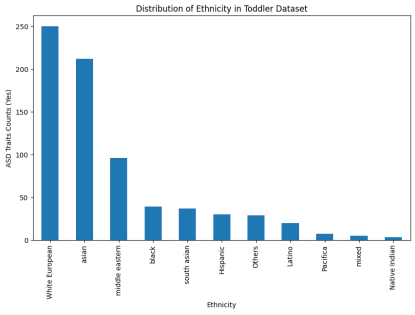
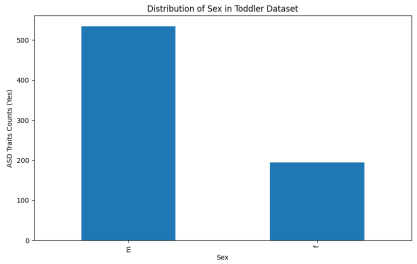


Figure 2: Heatmap of the dataset



(a) ASD traits distribution over Ethnicity



(b) ASD traits distribution over Sex

Figure 3: Data Analysis

and as the results was not that satisfactory 1 an ensemble method of this project was introduced to combine the predictive capabilities of multiple AI models 4 where each model provides its own predictions based on the training from the dataset and the ensemble method later combines them with voting technique to generate a final prediction. The accuracy the model was able to obtain was 99% 1leveraging the strengths and diversity of the different models.
The model takes in the user input, calculates the AQ - 10 test score based on the training and provides the output if there is ASD traits are present or not, and suggest taking a screening test by a physician to get accurate results as it is just a prediction model and not a screening tool itself.

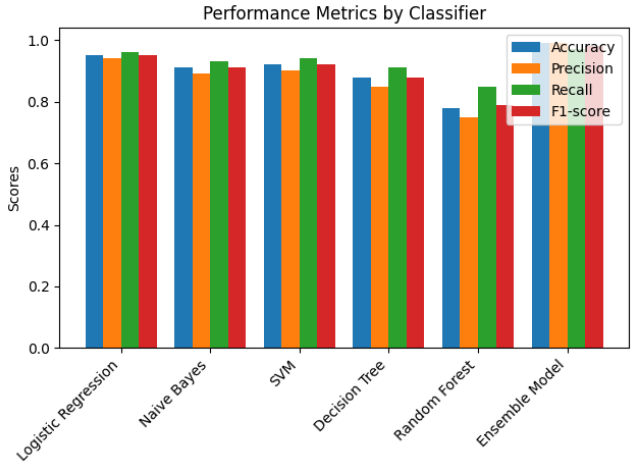


Figure 4: Accuracy of the individual training models

Classifier	Accuracy	Precision	Recall	F1
Logistic Regression	0.95	0.94	0.96	0.95
Naive Bayes	0.91	0.89	0.93	0.91
SVM	0.92	0.90	0.94	0.92
Decision Tree	0.88	0.85	0.91	0.88
Random Forest	0.78	0.75	0.85	0.79
Ensemble Model	0.99	0.99	0.97	0.98

Table 1: Performance Metrics by Classifier

5 Conclusion and Future Works

The proposed methods aim to leverage the integration of AI and UX to improve learning and education for children with autism. By combining AI's capabilities in personalized learning, social interaction, early detection and diagnosis, and feedback and reinforcement, with UX design principles that enhance attention and understanding, the research seeks to provide a comprehensive solution for addressing the unique educational needs of children with autism. By analyzing the data provided by parents and utilizing AI and UX techniques, the system aims to offer personalized and effective educational services. Through continuous evaluation and improvement, the research endeavors to contribute to the enhancement of learning outcomes and overall educational experiences for children with autism. It is important to acknowledge the limitations of the proposed research. Factors such as individual differences among children with autism, the availability of comprehensive data from parents, and technical constraints may impact the system's effectiveness. Future work can focus on refining the AI algorithms, expanding the dataset for improved accuracy, and incorporating additional features based on user feedback. The ensemble model can be further enhanced by incorporating additional features or integrating with other screening tools. And Overall, work on the system to provide assistance to learning Autistic children.

6 Acknowledgement

I would like to express my sincere gratitude to Professor Bart Selman for his invaluable guidance and support throughout my MEng project as my mentor and for sharing his expertise in the Advanced AI course.

A Appendix

The project comprises of three sections: an extensive literature survey, the design of the proposed system, and the early detection model. The proposed systems visualization as an application through Figma can be viewed using the link here.

References

[1] Predictable robots for autistic children-variance in robot behaviour, idiosyncrasies in autistic children's characteristics, and child robot engagement. *ACM Transactions on Computer-Human Interaction*, 28, 10 2021.

[2] Ifti Azad Abeer, Anik Saha, Anik Sinha, and Nova Ahmed. Reinforcement based learning through communicative android app for autism personnel. pages 132–138. Association for Computing Machinery, Inc, 9 2018.

[3] Tooba Ahsen, Christina Yu, Amanda Obrien, Ralf W. Schlosser, Howard C. Shane, Dylan Oesch-Emmel, Eileen T. Crehan, and Fahad Dogar. Designing a customizable picture-based augmented reality application for therapists and educational professionals working in autistic contexts. Association for Computing Machinery, Inc, 10 2022.

[4] Susana Alarcon-Licona and Lian Loke. Autistic children's use of technology and media: A fieldwork study. pages 651–658. Association for Computing Machinery, Inc, 6 2017.

[5] Simon Baron-Cohen, Sally Wheelwright, Richard Skinner, Joanne Martin, and Emma Clubley. The autism-spectrum quotient (aq): Evidence from asperger syndrome/high-functioning autism, males and females, scientists and mathematicians. *Journal of Autism and Developmental Disorders*, 31:5–17, 2001.

[6] Laura Bartoli, Clara Corradi, Franca Garzotto, and Matteo Valoriani. Exploring motion-based touchless games for autistic children's learning. In *Proceedings of the 12th International Conference on Interaction Design and Children*, IDC '13, page 102–111, New York, NY, USA, 2013. Association for Computing Machinery.

[7] Andrew Begel, John Tang, Sean Andrist, Michael Barnett, Tony Carbary, Piali Choudhury, Edward Cutrell, Alberto Fung, Sasa Junuzovic, Daniel McDuff, Kael Rowan, Shibashankar Sahoo, Jennifer Frances Waldern, Jessica Wolk, Hui Zheng, and Annuska Zolyomi. Lessons learned in designing ai for autistic adults. Association for Computing Machinery, Inc, 10 2020.

[8] Asma Bouden, Tianyuan Yu, Wei Tang, Yanguo Wang, Xiantao Tai, fpsyt Copyright, Shouyao Zhang, Shuang Wang, Ruilu Liu, Hang Dong, and

Xinghe Zhang. A bibliometric analysis of research trends of artificial intelligence in the treatment of autistic spectrum disorders.

[9] Aonan Guan, Jie Chen, and Tiffany Y. Tang. "voices of autism": Sentiment analysis in three chinese websites on nonverbal autistic children. pages 115–120. Association for Computing Machinery, 12 2018.

[10] Yiannis Koumpouros and Thomas Toulias. User centered design and assessment of a wearable application for children with autistic spectrum disorder supporting daily activities. pages 505–513. Association for Computing Machinery, 6 2020.

[11] Maico Krause and Macilon Araújo Costa Neto. Systematic mapping of the literature on mobile apps for people with autistic spectrum disorder. pages 45–52. Association for Computing Machinery, 11 2021.

[12] Jamy Li, Daniel Davison, Alyssa Alcorn, Alria Williams, Snezana Babovic Dimitrijevic, Suncica Petrovic, Pauline Chevalier, Bob Schadenberg, Eloise Ainger, Liz Pellicano, and Vanessa Evers. 6.

[13] Xin Zhu Li, Chun Ching Chen, and Xin Kang. Design of social story teaching aid for autistic children based on computational thinking and its case study. Association for Computing Machinery, 5 2021.

[14] Peter E. McKenna, Ayan Ghosh, Ruth Aylett, Frank Broz, Ingo Keller, and Gnanathusharan Rajendran. Robot expressive behaviour and autistic traits. In *Proceedings of the 17th International Conference on Autonomous Agents and MultiAgent Systems*, AAMAS '18, page 2239–2241, Richland, SC, 2018. International Foundation for Autonomous Agents and Multiagent Systems.

[15] Aurea Melo, Jonathas Santos, Luis Rivero, and Raimundo Barreto. Searching for preferences of autistic children to support the design of user interfaces. Association for Computing Machinery, 10 2017.

[16] Jagkapong Pipitpukdee and Wantanee Phantachat. The study of the pet robot therapy in thai autistic children, 2011.

[17] Imaniar Purbasari, Jayanti Putri Purwaningrum, and Hutomo Rusdianto. Visualization instructions through game therapy in regressive autistic. Association for Computing Machinery, 9 2020.

[18] Ira Puspitasari, Margaretha Margaretha, Sri Retno Yuliani, Nishrina Khamida, and Vitotamma Emir Muhammad Wikantono. 10.

[19] Nitin Sawhney, Emily. Reard, and Juan Pablo. Hourcade. *IDC 2013 : proceedings of the 12th International Conference on Interaction Design and Children : June 24-27, 2013, New York City.* ACM, 2013.

[20] Bob R. Schadenberg, Jamy J. Li, Suncica Petrović, Dennis Reidsma, DIrk K.J. Heylen, and Vanessa Evers. Helping educators monitor autistic children's progress across sessions: A needfinding study. pages 436–438. IEEE Computer Society, 3 2020.

[21] Fadi Tabtah. Autism spectrum disorder screening: Machine learning adaptation and dsm-5 fulfillment. In *Proceedings of the 1st International Conference on Medical and Health Informatics 2017*, pages 1–6, Taichung City, Taiwan, 2017. ACM.

[22] Fadi Thabtah. ASDTests. A mobile app for ASD screening. `www.asdtests.com`. [accessed December 20th, 2017].

[23] Fadi Thabtah. Machine learning in autistic spectrum disorder behavioural research: A review. *Informatics for Health and Social Care Journal*, 2017.

[24] Fadi Thabtah, Fedor Kamalov, and Khaled Rajab. A new computational intelligence approach to detect autistic features for autism screening. *International Journal of Medical Informatics*, 117:112–124, 2018.

[25] Irene Zanardi. Hoomie sweet home: A qualitative study on the small multisensory space "hoomie" for inclusion of autistic kids in a primary school. 2022.

[26] Irene Zanardi. Hoomie sweet home: A qualitative study on the small multisensory space "hoomie" for inclusion of autistic kids in a primary school. In *Extended Abstracts of the 2022 CHI Conference on Human Factors in Computing Systems*, CHI EA '22, New York, NY, USA, 2022. Association for Computing Machinery.

[27] Doğa Çorlu, Şeyma Taşel, Semra Gülce Turan, Athanasios Gatos, and Asim Evren Yantaç. Involving autistics in user experience studies: A critical review. pages 43–55. Association for Computing Machinery, Inc, 6 2017.