How to design an educational technological tool for children with autism between the ages of 6 and 11 years old?

Master's thesis

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# How to design an educational technological tool for children with autism between the ages of 6 and 11 years old?

**Abstract.** This Master's thesis aims to find a digital solution for primary school children with autism in the educational context. The research is structured within the Design-based research framework. Both quantitative and qualitative data are gathered and further analysed with the purpose to understand the challenges of children with autism, their parents, and teachers in the class environment. Based on the analysis the design solution in the form of the web platform is presented.

## 1 Introduction

The problem of help and support for disabled people and their families has existed for many years in modern society. The health and social care sectors are actively involved in finding and implementing solutions to help people with special needs.

Autism spectrum disorder (ASD) is a developmental disability caused by differences in the brain (CDC, 2022). It is a neurological condition that begins to affect behaviour in early childhood (DCCINC, 2013). Dr Stephen Shore, a professor at Adelphi University and a current board member of Autism Speaks<sup>1</sup>, says, "If you've met one person with autism, you've met one person with autism" (Flannery and Wisner-Carlson, 2020); with this, Dr Shore means that autism has a large spectrum, and each autistic individual can experience various symptoms. However, there are some similar characteristics for both children and adults with ASD. These include a broad range of challenges with social skills (Autism Speaks, 2017), repetitive behaviours, whether a specific behavioural pattern or a ritual (Greaves et al., 2006) and problems with both verbal and nonverbal communication. For example, autistic people may not understand or appropriately use spoken language, gestures, eye contact, facial expressions, tone of voice or expressions that are not meant to be taken literally. Around one third of people with autism are nonverbal (Autism Speaks, 2017). According to Disability Credit Canada (2013), people with autism typically have difficulty relaying and receiving emotions and are therefore often viewed as socially awkward.

Autism Speaks is an autism advocacy charity and the largest autism research organisation dedicated to promoting solutions across the spectrum and throughout the life span for the needs of individuals with autism and their families. The organisation was founded in 2005 and is based in the United States, with the purpose of increasing the understanding and acceptance of people with autism and advancing research into causes and better interventions for ASD and related conditions (Autism Speaks, 2022). The organisation emphasises the empowering role of such technologies as special educational apps in teaching children with autism social and communicative skills. "Technology can help your child become more independent, work on his or her challenges and improve upon his or her strengths" (Autism Speaks, 2017).

According to the Danish National Board of Health and Welfare (Socialstyrelsen), the number of children with autism in Denmark has been growing in recent years (Nyhuus,

<sup>&</sup>lt;sup>1</sup> 'https://www.autismspeaks.org

2018). There is no overall statement of how many people in Denmark have autism; the latest research shows that the rate of children with autism in Denmark is 68.5 per 10000 (Parner et al., 2011). In 2018, 18250 children between the ages of 0 and 17 in Denmark were diagnosed with autism (Socialstyrelsen, 2020). As this number is based on the Danish National Patient Register (Landspatientregister) and only includes children who have been diagnosed by public hospitals and not by private psychiatrists, the number of children with autism may be higher. This statistic does not include adults, either.

In this time of rapidly developing technologies, different technical tools can provide great help to autistic people in understanding the surrounding world and learning to be more independent. Autism Speaks (2020) affirms that individuals with autism can benefit from using assistive technology devices in all areas of life. They can be used as tools to:

- communicate. For example, the MyTalk Tools app helps individuals to say what they want through words or images ("MyTalkTools", 2022). Emotions and Feelings Autism Social Story app ("Social Story Speech App for Teaching Emotions to Children", 2015) provides a visual platform for autistic individuals to express themselves and to communicate their emotions to other individuals.
- visually schedule routine tasks and work on skills like self-care and daily living. For example, Time Timer ("The Original Visual Timer", n.d.) is an app that helps autistic individuals plan their schedules and manage their time effectively. Users can plan their activities and set times for them, thus making it possible to complete one or more activities in a specific timeframe.
- make small decisions and foster self-advocacy skills by, for example, pointing at a dish to order on a smartphone or tablet.
- motivate, with a favourite game app serving as a reward for positive behaviour;
- make video, which can help with a wide array of skills including hygiene, daily tasks and more.
- socialise through social networking. Going Places ("Model Me Going Places: Community Social Skills for Children with Autism", 2022) is an app that aims to improve the communication and social skills of autistic children between the ages of 2 and 8 years old.
- vocational assistance, where reminders, notes and checklists can help a child stay on top of tasks and complete them in an orderly and successful manner.

Nevertheless, there are not many products or tools on the market that are targeted at autistic children. Thus, more products need to be produced to help such children build their cognitive, social and communication skills and self-direction (Abu-Akel et al., 2020). There should be more educational tools designed for autistic children studying in primary school.

The purpose of this thesis is to find and design a technological tool that would help children with autism better cope with the challenges that they face daily within the educational environment. The tool can also be beneficial for parents and teachers, because it would assist them in educating and explaining societal norms to children with ASD.

The target group for this project is primary school children between the ages of 6 and 11 years old. This target group is chosen due to the possibility of contacting an educational institution and parents of children of this age to collect data and gain insights.

#### 1.1 Research question

The thesis aims to design a prototype for a technological tool that would help primary school children with ASD handle the most challenging daily tasks they perform in an educational context. The tool can also assist parents and teachers in educating autistic children. Therefore, the thesis is based on the research question below:

How to design an educational technological tool for children with autism between the ages of 6 and 11 years old?

To answer the research question, the following sub-questions need to be answered:

Which technological tools have been already designed to assist children with autism and what are the potentials and challenges with these tools?

What is the biggest challenge that children with autism and their surrounding experience in school?

How can primary school children with autism and people related to them benefit from using technologies in the educational process?

How to design a technological tool for primary school children with autism?

## 2 Literature review

This chapter presents a literature review of research on using technologies that help children with autism at schools during the educational process. The aim is to find the latest relevant studies within the field, with a focus on categorising existing research literature to identify potentials, goals, and challenges for further research.

"A literature review is an objective, thorough summary and critical analysis of the relevant available research and non-research literature on the topic being studied" (Hart, 1998). The aim of the literature review is to summarise and criticise a body of literature, and to draw conclusions about the studied topic (Cronin et al., 2008).

To identify the literature to work with the following tasks must be performed: finding, sorting and systemising previous research in creating, studying, or testing technologies that are or can be used at primary schools by children with autism, thus assisting them in the educational environment. Categorisation of the existing literature by specific topics (themes) helps to identify and specify the subject of the further research. The process involves: 1. Developing inclusion/exclusion criteria for literature selection; 2. Identification of keywords and finding relevant studies through literature search on Scopus database using Building blocks strategy; 3. Finding specific themes covered in research. Literature assessment and assessment of literature quality as a last part of the systematic literature review is not at focus, as mapping more specific themes is in a greater focus of the current research.

#### 2.1 Developing inclusion/exclusion criteria for literature selection

Inclusion and Exclusion criteria are important when choosing the right literature (Cronin et al., 2008). These criteria are shown in Table 1. All criteria are divided into four main categories: purpose of study, the type of technology described in the research, the users, and the standard of records. These criteria are important for finding the right literature that would help to answer the research question. The study has to be about special technological tools designed for autistic children because the current research has the design of a technological tool for children with autism in focus. The type of technology described in the research is another important criterion, as some technological tools are not designed for educational purposes, and the focus of the current research is on the assistive technologies that can be used in a school educational environment. As the research targets a specific user group, the study of the searched literature has to target users of the same age. The users have to be between the ages of 6 and 11 years old, which corresponds to the age of primary school children. Teachers and parents of children with autism can also be the users as

assistance and supervision is often required by autistic children when finding and using technological tools. The standard of records criteria helps to eliminate the number of outdated and unreliable studies and narrow down to the most relevant ones.

The research must study technologies and technological tools that are specially made for autistic children. It can include design, redesign, and testing of technologies. The studies must be peer reviewed and not be older than 4 years. The research must include neither studies of the impact of technologies on children with autism, nor studies of technologies made for diagnostics of autism.

Class	Inclusion/exclusion criterion
	Involve design of technology for autistic children in an educational context.
Study numora	Involve explanation of the educational needs that technology meets.
Study purpose	Should not include an impact of technology on children with autism.
	Should not include technologies as diagnostic tools.
	Modern technologies for autistic people that can be used in an educational context.
Technology types	Technology should be designed specifically for educating people with autism, technological tools designed for any type of users, should be excluded.
	Children with autism.
Users	Teachers and/or parents of children with autism.
	Only peer reviewed records are used.
Standard of records	Be primary studies and not reviews.
	Published in 2018-2022.

 Table 1. Inclusion and exclusion criteria for selecting literature (modified from Hart, 1998)

### 2.2 Identification of keywords and finding relevant studies

Table 2 presents an overview of the process of identifying keywords and finding relevant studies through literature searches using Building blocks strategy.

Sources of literature	Where?	Scopus	A database with excess permission from AAU library
		Research question and sub questions	Autism, education, technology
Keyword selection	What?	Wikipedia pages on main topics	Asperger Syndrome, Asperger's, autistic children, school, speech and language therapy, social skills, occupational therapy; tool
		thesaurus.com - dictionary of synonyms	Autistic children; multimedia, app, website; study, teaching, training, school
Search tactics and strategies	How?	Building blocks	Thinning: start with as many results as possible, then reduce them to the mostly relevant ones
Literature selection	Which ones?	Literature that is not older than 4 years Peer reviewed	See Table 1
Documenting your search	What did we do?	The Flow diagram of the review process	See Figure 2

Table 2. A process of searching for literature (modified from Cronin et al., 2008)

The Scopus database was chosen as a source of literature search. Scopus is a sourceneutral abstract and citation database curated by experts who are recognized leaders in their fields (Scopus, 2022). It includes more than 4 million records. 23% of information that the database contains lies within the health sciences sector, to which research about autism relates. The database also contains research within computer science, which makes it possible to find information about design and development of technological tools. The database contains only peer reviewed studies and can be accessed through Aalborg university online library.

The Keyword selection section presents keywords, divided by different categories, or building blocks. Each building block consists of synonyms, similar words and words relevant in the context of the studied field. Initial keywords: technology, autism, education, were taken from the research question and sub-questions. Additional keywords were found in Wikipedia articles on autism, and in the dictionary of synonyms. Keywords found in Wikipedia article "Autism": speech and language therapy, social skills, occupational therapy, Asperger Syndrome, Asperger's. Additional keyword to "technology" found in Wikipedia is "tool". Synonyms to "autism", found in the dictionary of synonyms, are Asperger Syndrome, Asperger's, autistic children; synonyms to "technology" are multimedia, app, website; and synonyms to "education" are study, teaching, training, schooling (was shortened to "school"). The found words were filtered to the most relevant ones and used in Building blocks.

The following Building blocks were used for finding the literature: ("autism" OR "Asperger Syndrome" OR "Aspergers" OR "autistic children") AND ("education" OR "school" OR "study" OR "teaching" OR "training") AND ("technology" OR "multimedia" OR "app" OR "website" OR "tool"). The building blocks are shown on Figure 1 below.



Figure 1: Building blocks (modified from (Boren and Moxley, 2015)

As the Building blocks strategy and a vast combination of different keywords gave 105116 results, the more specific keywords were used to decrease the number of research papers. ("autism" OR "Asperger Syndrome" OR "Asperger's" OR "autistic children") AND ("education" OR "school" OR "study" OR "teaching" OR "training") AND ("technology" OR "tool") were used in the process of thinning (69936 results). The "primary school" combination was chosen to specify the subject and to narrow down the scope of the literature searched. It is a relevant combination of words because most of the studies found during the previous phases of the literature search,

were focused on primary school children. All found papers were filtered by the year published (2018, 2019, 2020, 2021).

The combination "technology" AND "primary school" AND autism gave 12 results (see Appendix A) that were manually sorted out and limited to 9 relevant research papers. 3 papers were excluded during the review process as they did not meet the inclusion criteria. One paper studied the gaze behaviour of autistic people, without any technologies in use; the second paper referred to the study of home education in Covid-19 lockdown, and the third paper discussed the results of the survey about the support of children with autism in their transition to elementary school. The literature review process is shown on Figure 2 below.



Figure 2: The literature review process

## 2.3 Results: Themes in studies

Four main themes were found in the research papers: gamified learning, Virtual reality and Augmented reality, self-expression, and behavioural training. The four mentioned themes reflect the types of assistive technologies used for educating children with autism, the process in studies' focus and the purposes of using technological tools by children with autism or by adults when interacting with autistic children in an educational environment.

An overview of the themes and the literature is shown in Table 3 below.

Theme	Author	Number of studies
Gamified learning	<ul> <li>Kang, YS., and Chang, YJ. (2019).</li> <li>Using game technology to teach six elementary school children with autism to take a shower independently. Developmental Neurorehabilitation</li> <li>Mohd, C. K. N. C. K., Shahbodin, F., Sedek, M., and Samsudin, M. (2020).</li> <li>Game-based learning for autism in learning mathematics. International Journal of Advanced Science and Technology</li> <li>Faria, D. R., Bird, J. J., Daquana, C., Kobylarz, J., and Ayrosa, P. P. S. (2020). Towards AI-based Interactive Game Intervention to Monitor Concentration Levels in Children with Attention Deficit. International Journal of Information and Education Technology</li> </ul>	3
Virtual Reality and Augmented reality	Yuan, S. N. V., and Ip, H. H. S. (2018). Using virtual reality to train emotional and social skills in children with autism spectrum disorder. London Journal of Primary Care Tokarskaya, L., Bystrova, T., and Aguilera, G. R. (2020). An augmented	2

#### Table 3. Overview of reviewed articles and identified themes

	reality book for training a child with autism spectrum disorders: Towards an inclusive primary school education. Kidmore End: Academic Conferences International Limited	
	Wilson, C., Brereton, M., Ploderer, B., and Sitbon, L. (2018). MyWord: enhancing engagement, interaction and self-expression with minimally verbal children on the autism spectrum through a personal audio-visual dictionary. Proceedings of the 17th ACM Conference on Interaction Design and Children	
Self-expression	Wilson, C., Sitbon, L., Ploderer, B., Opie, J., and Brereton, M. (2020). Self- Expression by Design: Co-Designing the ExpressiBall with Minimally- Verbal Children on the Autism Spectrum. In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems, Association for Computing Machinery	3
	Ozdowska, A., Wyeth, P., Carrington, S., and Ashburner, J. (2021). Using assistive technology with SRSD to support students on the autism spectrum with persuasive writing. <i>British Journal of Educational</i> <i>Technology</i>	
Behavioural training	Hashim, R., and Yussof, H. (2018). Preparation for adulthood: Benefits of assistive technologies in social skills training of children with autism. 2017 IEEE International Symposium on Robotics and Intelligent Sensors (IRIS)	1

## 2.3.1 Gamified learning

Two studies focus on teaching children with autism such a personal skill like taking a shower independently, and on teaching them mathematics, and one study focuses on monitoring the level of concentration through gamification.

Kang and Chang (2019) have investigated the effectiveness of video game intervention in training children with ASD taking a shower. Children with ASD may have difficulties in performing such daily tasks as independent showering or taking a bath. For this reason, the researchers gamified the process of taking a shower to train children. The study describes an experiment, where the Kinect sensor was applied. Kinect is Microsoft's motion sensor add-on for the gaming console. The device provides a natural user interface that allows users to interact intuitively and without any intermediary device (What Is Kinect?, 2011).

Six elementary school children with ASD participated in the study. They attended a special education class at school where they could play the game. Then the children took a shower independently in their own bathroom at home. The shower taking was video recorded and later examined by the special education teachers for evaluating correctness according to task analysis.

The study showed that training through the game improved the real process of taking a shower. Besides, the experiment resulted in higher motivation among the participants. Kang and Change (2019) suggest that a technically robust system combined with additional attractive games will likely result in higher participant motivation and superior task performance.

Mohd et al. (2020) developed a game for autistic children in teaching them the basics of mathematics. The researchers designed a point-and-click game that meets educational and entertaining purposes. The basic math operations with numbers are taught through showing the flash cards. The players must click the right sea creature that shows the right answer to the question. According to the researchers, the combination of such multimedia elements as short animation and graphics help autistic children to learn mathematics in a structured and easier way. A short animation is presented before the game to gain the children's attention. The systematic technique and repetitions in the game can make children learn at their own pace and time.

Primary school children between the ages of 5 and 8 participated in testing the product. The results showed that game-based learning attracts autistic children and helps them learn and focus during the educational process. Besides that, game-based learning can motivate children to learn new things because the game-based learning acts as both education and entertainment for the children. Autistic children tend to accept educational material that is presented in an interesting way rather than straightforward lessons. According to Mohd et al. (2020) the game is beneficial for

both autistic children and their parents or teachers, who can use the game for teaching children.

Faria et al. (2020) monitored attention levels of children with autism. They developed Artificial intelligence-based games for educational therapy to monitor the progress of children's concentration levels during specific cognitive tasks: a spelling game, and an aircraft controlled by hand. In the first game the interface randomly selects images of animals and their sound, separated into categories of easy, medium, and complex. In the aircraft controlled by the hand the position and orientation of the aircraft is defined by the hand position, and the acceleration is controlled by moving the hand towards the screen or backwards, also allowing left and right directions. When the concentration drops while playing one of the games, the players are stimulated through some visual or auditory stimuli on the interface to keep their attention and focus on the training session.

30 children from 3 different public primary schools participated in the study. During the playing session the children's brainwave patterns were measured to monitor their concentration level.

The use of the games showed higher engagement and motivation during the training sessions. The authors argue that intelligent games can be used by children with special needs towards improving their cognitive abilities and concentration.

#### 2.3.2 Virtual Reality and Augmented reality

Yuan and Ip (2018) in their study examined the efficacy of the virtual reality enabled training programme on emotional and social skills of children with autism. The programme contained six VR scenarios depicting the daily lives of typical children in Hong Kong. The programme allowed interaction in virtual scenarios covering reallife situations. During the training, a group of 3 to 4 children were tested to review previously learnt social skills. Then with the support of the trainer, the children had a one-hour VR training session to experience and generalise their learnt skills within emotion expression, regulation, and social interaction into real life. 94 primary school children participated in the study.

The study revealed that the use of virtual reality scenarios of daily life by autistic children improved their emotion expressions, social interaction, and adaptation. The results also showed a higher level of engagement. The authors conclude that Virtual reality can be used as an asset in training and therapy for children with autism.

Children with ASD often require social skills training while VR provides a safe, controllable environment to practice skills repeatedly.

Tokarskaya et al. (2020) designed and tested a prototype of augmented and virtual reality elements on a training book "Journey into Space with Laika". Laika is a virtual dog that explains to children about the space and helps them explore the subject. The physical book is integrated with augmented reality (AR) and virtual reality (VR) technologies to offer a different level of complementing learning and interaction. In the book children can see an illustration of a subject (for example, the moon), and in an augmented reality application accompanying the book, they can see the object (the moon) in three-dimensional geometric form on a smartphone or a tablet. These technologies offer additional information that is difficult to verbally explain in ordinary books.

Two groups of 30 children with autism participated in the study. The results showed an increase in the efficiency of mastering the proposed topic, as well as motivation growth.

#### 2.3.3 Self-expression

Wilson et al. (2018) investigated the use of an interest-based, child-led technology MyWord. MyWord is an audio-visual dictionary app supporting autistic children to build their own personalised catalogue of favourite words, images, and audio over time.

12 minimally verbal primary school children with autism between the ages of 5 and 8, their teachers and speech therapists participated in the study. The results of the study indicated that creating dictionary entries involved processes of personal choice, representation of the self and interests, and dynamic action and play, and that the use of personally and contextually relevant words enhanced engagement, interaction, and self-expression.

Wilson et al. (2020) also undertook co-design research with autistic children with a purpose to understand how children with ASD express themselves, how technologies can encourage self-expression, and how to better recognize instances of self-expression. The authors undertook co-design research of a tangible ball prototype, the ExpressiBall, which through voice, sounds, lights, and motion sensors explores how tangible technologies can support the range of expressive modalities.

For minimally verbal children with autism, self-expressing in the traditionally verbal context of co-design may be challenging. However, they can express their design needs and opinions through physical, playful, creative, tactile, or sensory activities. The ball prototype was designed so that children could record expressions. The ball produces audio, light and vibrations which enable audio/visual/sensory feedback.

20 minimally verbal children with autism between the age of 4 and 8 participated in the study. The study explored their self-expression in everyday autism-specific school context over the course of one school year. According to Wilson et al. (2020) matching physical control and digital response can be motivating.

Ozdowska et al. (2021) evaluated the impact of using self-regulated strategy development in combination with assistive technology on the quality and length of written compositions of children with autism. They evaluated an app for iPad that was developed to provide support for the difficulties that children with autism often experience with writing tasks.

Self-regulated strategy development is the practice designed to improve academic skills of school children, especially those with learning disabilities. It is also used for planning and organising ideas before writing an essay. The practice involves six steps: providing background knowledge, discussing the strategy with the students, modelling the strategy, helping the student memorise the strategy, supporting the strategy and watching as the student independently performs while using it. (What Works Clearinghouse, 2017).

Children with autism often experience difficulty with two key aspects of writing: the skills required for handwriting (fine motor and perceptual) and the conceptual and language skills required for written composition. Therefore, the research examined the quality and length of writing outcomes for children with autism during three stages: when handwriting, when using assistive technology, and after learning SRSD. The research also investigated how children felt about using the SRSD writing strategy.

Eight primary school children with autism between the ages of 9 and 12 participated in the study. Research has shown that the use of self-regulated strategy development (SRSD) writing strategies can improve the writing abilities of autistic children. The results of this research suggest that such assistive technologies as writing-support software have the potential to help children with ASD better express themselves through writing. Such technologies can also be used by teachers in developing strategies for integration of autistic children in the class environment.

#### 2.3.4 Behavioural training

Hashim and Yussof (2018) studied the socio-economic benefits of humanoid-assisted social skills training of children with autism in Malaysia. According to the authors humanoid and social robots are needed to assist children with special needs, including the ones with autism, to recognize nonverbal social cues in the context of social scenarios and can be reinforced in play-based activities. Children with autism respond more to computers, robots, and machines than they do to people. Therefore, the authors conducted interviews with 10 teachers from primary school and 10 parents of the schoolchildren. The purpose was to understand how effective humanoids are in assisting autistic children, and why it is important to have humanoid intervention in the skill-based improvements of autistic children.

The findings showed that teachers, parents, and guardians of autistic children are not ready for humanoids to train their children. It may be possible in future, though, as it is important to prepare the children for adulthood and independence.

#### 2.4 Conclusion

The literature review is performed through finding, sorting through the building blocks strategy, and systemising previous research on using technologies that help children with autism at schools during the educational process. As found studies have different goals, they were divided into themes and sub-themes to better understand the potentials, goals, and challenges for further research.

It can be concluded that modern technological tools such as Virtual reality and Augmented reality, and games have the potential to assist children with autism in an educational environment. The use of assistive technology can also be beneficial for teachers and parents. Primary school children with autism have different challenges in the class environment. These challenges are mostly connected with expressing themselves through communication and writing and learning social skills. The goal for further research is to find the best possible technological solution that can be used by parents, teachers, and the children with autism in the education process.

## 3 Methods

This chapter gives an overview and description of the methods used for the research, analysis of the data, and the design. Design-based research is used as a framework for the project, interview and survey methods are used for data collection, thematic analysis is applied to the analysis of the qualitative data, and prototyping is a method chosen for showing the design of the found solution.

### 3.1 Design-based research

The whole workflow of this master's thesis lies within the Design-based research framework. Design-based research is "a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories" (Wang and Hannafin, 2005). Design-based research is a framework for integration of different methods in different phases of development and research (Barab and Squire, 2004).

Unlike the educational research that is often detached from practice and conducted in controlled, laboratory-like settings, the Design-based research blends empirical educational research with the theory-driven design of learning environments (The Design-Based Research Collective, 2003). Learning processes must be studied in the context in which they take place - not in isolated laboratory studies (Lave and Wenger, 1991).

Even though the design-based research was originally formulated in educational research setting as a "research approach that engages in iterative designs to develop knowledge that improves educational practices" (Armstrong et al., 2020), it can be used for developing and analysing learning designs in different contexts.

Design-based research can lead to an understanding of relevant design knowledge and practices as they apply to naturalistic settings. In design-oriented fields, design knowledge is often characterised by common examples, patterns, and principles, and by the expertise required to apply these generalities in specific settings (The Design-Based Research Collective, 2003).

The design-based research model used for this study is shown in Figure 3 below.



Figure 3: Design-based research model

The Problem statement and Research question is the phases where the problem is formulated, and the research question and sub-questions are made. This phase is based on the prior desk research.

The research lies within the educational context and is made in tight collaboration with participants. The literature review helps to understand which design has already been made as a solution to the current or similar problems. The research phase includes such methods as interview and survey for data collection and understanding the problem in the educational context. To understand the problems of children with autism, people who participate in the educational process or have a close relation to it, need to be interviewed or asked for collaboration. In this project the children with autism cannot be interviewed directly to the specifications of the disease. Instead, parents and teachers can participate in the phase of data collection.

Analysis of the collected data is performed at the next stage through the thematic analysis and analysing quantitative data. Based on the analysis, the design principles are made and shown in a prototype, which can be further tested and elaborated.

### 3.2 Interview

According to Goodman et al. (2012), "no matter what the research, there are two things you're always going to be doing: looking for people who will give you the best feedback and asking them questions". Three people were chosen to be interviewed for this research: two mothers of children with autism and a teacher's assistant from an institution for people with special needs. These interviewees have direct contact with autistic primary school children and have a better understanding about the needs of such children in an educational context.

The qualitative research interview attempts to understand the world from the subjects' points of view, to unfold the meaning of their experiences, to uncover their lived world prior to scientific explanations (Kvale and Brinkmann, 2015).

By using the interview method, it is possible to collect information about the main challenges children with autism experience at school, how the educational environment looks like for them, and how different technologies are helpful or can be helpful for them. Interview as a method is chosen because this method allows many open-ended questions and questions to elaborate on some answers. The interview as a method can also help "raise and explore issues that they find to be relevant and allow their voices to be heard" (Foley, 2012).

Such methods as field trip, observation and focus group were considered at the beginning. Field trip and observation were rejected by the interviewees who had access to schools where children with autism studied. According to the interviewees, the access to the class with autistic children is limited, parents do not have close communication with each other, and children are brought to and back from school by cars, specially arranged by the school. Focus group as a method does not seem ethically appropriate due to sensitivity of the subject of the research: not all people are ready to have open conversation about autism and an autistic child. It is especially difficult to discuss it in the group.

The main purpose of interviews is to understand which problems and challenges primary school children with autism have, which tools are used to cope with some challenges, which technologies, if any, are used at school, and how technological tools can be helpful in educating children with autism. The interview method provides a deep insight into the studied subject and helps to formulate questions for the survey.

#### 3.3 Survey

As it was not possible to find more people to interview, and knowing that autism has a large spectrum, which means that children with autism might have different needs and challenges, interviews were not enough for gathering as much necessary data as possible. Therefore, an online survey was chosen as a logical method to continue data collection.

According to Marsden and Wright (2010), the survey is the "heart" of any study. "The results of the research largely depend on it, which is why it is necessary to approach its compilation with the necessary attention" (Marsden and Wright, 2010).

The questionnaire in a form of online survey was made in Google Forms (see Appendix B). Google Forms automatically collects and summarises responses. Data can be presented in forms of graphs and pie-charts, as a list of responses from each separate respondent, and can be sorted out when needed.

The survey consists of seven questions, one of which is a verification question to confirm that the survey is answered by the relevant people (teachers, parents or close relatives of a child with autism), four questions are open-ended questions for gaining qualitative data from the respondents, one multiple choice question about the type of education the child is involved in, and one checkbox question about special digital tools that are used in the educational institution.

Questions contained the "Other" field to provide respondents with an option to give an answer, differ from the given ones, and to increase the possibilities for a better insight.

The survey was published on Autism Speaks website with prior permission from the website administration. The platform was chosen for the reason that Autism Speaks is a large organisation dealing with problems of autism, and they study this subject. Other communities for autistic people denied the permission to publish a survey on their website.

#### 3.4 Thematic analysis

Qualitative approaches are incredibly diverse, complex, and nuanced (Holloway and Todres, 2003), and thematic analysis should be seen as a foundational method for qualitative analysis (Braun and Clarke, 2006). Thematic analysis is a method for identifying, analysing, and reporting patterns (themes) within data. It minimally organises and describes the data set in detail (Braun and Clarke, 2006). However, frequently goes further than this, and interprets various aspects of the research topic (Boyatzis, 1998).

The interviews (see Appendixes C, D, E) are analysed by implementing the thematic analysis. This analysis includes both the machine and manual analyses. The machine analysis was automatically made by the online software Otter.ai<sup>2</sup>. The programme transcribes audio recordings of the interviews, finds the frequently used words in an interview transcript, and tags them. The most relevant words were chosen manually

<sup>&</sup>lt;sup>2</sup> https://otter.ai/signin?r=%2Fhome

afterwards and checked how often and in which context they were used. When choosing the relevant words, the words in the interviews that described the behaviour of autistic people, their challenges, and special characteristics, were in focus. For example, such words as "autism", "autistic", "person", "people", "good" were excluded from the analysis, as they are commonly used in the interviews.

When the keyword is chosen in Otter.ai, the programme highlights all sentences and sections in the transcript where this keyword is used. This allowed to have an overview of the context and to group these keywords, into themes.

Qualitative data gained through the survey, is manually analysed. The most repeated answers are combined into themes, and afterwards are added to the themes found in the interviews. Each theme is divided into sub-themes for a deeper analysis.

## 3.5 Prototyping

The design of the digital solution is presented in the form of a prototype. "A prototype is a simplified but functional model of a system, used to explore, communicate, and test a design. Users can move directly through a prototype, with pages following each other in chronological order" (Bowles and Box, 2011). According to Bowles and Box (2011), in comparison with the wireframe, the prototype gives the user testing participants the opportunity to see the interface of the future solution.

According to Lidwell et al. (2010) concept prototyping is a good way to test out basic design concepts rapidly and cheaply. Concept drawings are used to define the appearance and personality of characters in animated films prior to the time-consuming process of animation and rendering. This method aids in the communication of thoughts to others, discloses design needs and issues, and enables for audience evaluation (Lidwell et al., 2010).

The concept prototyping is used to show the main features and the functions of the digital solution. Though the design phase is usually an iterative process, this thesis does not include the user testing. Only the first version of the design is presented. The main idea is to present the solution based on the thematic analysis and give a description of the most important functions needed. For further development the user testing and redesigning phases are needed.

## 4 Analysis

This chapter of the master's thesis includes the analysis of the collected data. The data was collected by means of survey in the form of a questionnaire and three interviews with people who have a close relation with autistic children. The survey was published at the Autism speaks online platform, where the members of the community were invited to fill in the survey to share their knowledge and opinions about primary school children with autism, their daily challenges at school, and how these challenges could be met with the help of technological tools. The survey allowed to collect both qualitative and quantitative data.

Three interviews were conducted to gain an understanding of problems and challenges of children with autism in an educational environment. The interviews also helped understand the problems of parents and teachers when helping autistic children to learn. The use of the technological tools was also discussed during the interviews.

The interviews were conducted with three different participants. One interview was held with a current teacher's assistant at the activity centre for people with special needs. The teacher's assistant has experience in working with primary school children with autism, and this person shared the knowledge about autistic children in the interview. The last two interviews were conducted with two mothers, each of whom has a child with autism. Each child attends a special class at the public school.

The overall focus of the analysis is to find the major themes in the collected data and sub-themes that reflect the biggest challenges for children with autism in the educational environment. These challenges are seen from the perspective of parents and teachers, as they are the main respondents to the survey questions. As the respondents were also asked about the use of technological tools that assist children with autism at school, themes and sub-themes belonging to this subject also need to be defined.

The quantitative data provides insight into the type of educational environment where children with autism study. The respondents could have experience from different types of schools. The types of educational environment could be a special school for children with special needs, a special class in an ordinary school, or a class or a school with integrated education, where children with autism study together with other children.

Information about the relation to a child with autism was also collected. Answers to the question "What is your relation to a child (children) with autism?" from teachers, parents, close relatives, and autistic people who have experience of studying at school

can allow to look at the same subject from different perspectives. The challenges experienced by the parents can be different from challenges experienced by the teacher or people who have autism. This kind of data may allow to see different patterns in the way everyday challenges can be handled at school.

Information about special digital tools that the children use at an educational institution was also collected as quantitative data. It helps to understand which types of technology have already been used and how these technologies can assist children with autism in the learning environment.

The qualitative data provides an insight into the challenges that children with autism experience daily while at school, and the existing technological and non-technological tools that have been specially designed for autistic children. For this reason, the respondents were asked about any special non-technological tools for autistic children that help them at school. The wishes for any educational assistive technologies for primary school children with autism were also expressed by respondents.

The qualitative method of collecting information is used to better understand the educational environment surrounding children with autism, and to get more insightful open answers to these questions. Besides, all multiple questions of the survey allowed to elaborate on the given answer or to give a different answer, which means that the quantitative data is supplemented by qualitative data and provides a better insight into the studied subject.

The qualitative data collected by means of the survey and the three interviews allow to make an analysis and divide the gathered information into themes. The themes provide a better insight into the collected data allowed to make an analysis and get an insight into the subject of the research.

#### 4.1 Analysis of the survey

Data that was gathered by means of the survey helps to have an overview of the educational context for children with autism. It also gives an understanding of how autistic children's challenges and problems can be seen from different perspectives, and whether there are any special patterns in responses from different people who have relation to a child with autism. This data is based on answers from 33 respondents. All these respondents visited the Autism Speaks website, as the survey had been published there.

Most of the answers (66.7%) were given by parents whose child or children have autism. 21.2% of respondents were close relatives, and 12.1% - teachers. The question did not allow to elaborate on the relation of close relatives to the autistic child. In total there were collected responses from 33 people after the validation. Figure 4 visually presents the categories of respondents to the survey.



## What is your relation to a child (children) with autism? 33 responses

100% of the children, whose parents, relatives, or teachers answered the survey questions, study in a special class or school for children with autism (see Figure 5). There are no respondents whose children would receive home education or who would study in integrated class. Therefore, the further research and analysis is focused on the educational environment of the class with children with autism.



Which type of education is the child (children) involved in? 33 responses

Figure 4: Pie chart

As for any special technological tools, such as apps, games, videos, or websites designed for autistic children, and used at the educational institution (see Figure 6), most of the respondents stated that there are no special technologies in use (more than 33.3%). Other respondents (24.2%) stated that there are games used at school, but none of them could provide a specific name. For this reason, it is difficult to understand which skills the games teach, and whether they are educational games at all.

The same number of respondents (15.2% respectively) stated that a website and educational videos are used at their school. Nevertheless, no name of the games were provided to understand the purpose of use. As for the websites, a few respondents referred to the school website as a special technological tool.

3% of respondents chose a special app as a digital tool used in school, but no name was provided.



Which special digital tools are used at your educational institution? <sup>33 responses</sup>

#### Figure 6: Bar chart

The information collected about the use of technologies at special classes and schools for autistic children allows to conclude that there are technological tools used at school (stated by more than 57% of respondents), or they are not used at all, during the educational process to assist children with autism. As nobody could give a specific name of the technological tools, it makes it impossible to conclude what these

technological tools are used for, and how exactly they help children with autism in the learning environment.

As Tokarskaya et al. (2020) developed an ordinary book for children into an interactive Augmented reality book for children with autism, it seems that there are opportunities in developing non-technological tools into technological ones. For this reason, the question "Which other special non-technological tools are used at your educational institution?" was asked. Non-technological tools used in classes for children with autism are cards with pictures to stimulate verbal communication, pictures, posters, books, and toys (without a clear explanation about their use), headphones without music, and a toy to relieve stress. Teacher's gesture was mentioned as a tool to help autistic children in class.

## 4.2 Thematic analysis of the survey and interviews

By applying the thematic analysis, all the qualitative data received by means of survey and interviews can be categorised into themes and sub-themes. These themes and subthemes are shown in Table 4. The examples are taken from the interviews and from the answers to the questions of the survey. These questions are: "What do you think is the biggest challenge for children with autism in an educational environment?" and "Please, state which special tool or technology you wish could be developed to help teachers, parents and children with autism". When answering the second question, most of the respondents focused not on specific types of technologies, but on the problems and challenges that children with autism, their parents and teachers have during the educational process and that can be solved by using technological tools. These answers allowed to find specific themes and sub-themes, as well.

Themes and sub-themes	Examples from the survey	Examples from interviews
Skills related to social situations:		"They have difficulty processing <b>social</b> <b>situations</b> , the social cues of people's feelings, what people want, like, what they want." <sup>3</sup>

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<sup>&</sup>lt;sup>3</sup> Some interview citations have been edited because of grammar mistakes and language mix.

• Understanding norms and rules	"understanding norms and rules"	"It is hard for him to learn the <b>rules</b> ."
	"obedience and following the <b>rules</b> " "social <b>rules</b> "	"He just does not have the understanding of the situation with the <b>rules</b> of the game."
		"But when he is outside on a trip with the family, in nature, outside the <b>rules</b> , he says something or starts to act."
		"It is simply difficult to understand the <b>rules</b> ."
• Communication	"something that can help them actively and peacefully <b>communicate</b> with each other"	"The problem is that these kinds of kids can't find out how to <b>communicate</b> sometimes."
	" <b>communication</b> with others"	"Even though they can't <b>communicat</b> e properly, they still need it."
	"willingness to communicate"	they still need it.
• Interaction with others	"i <b>nteraction</b> with each other"	"It is more about his <b>interaction</b> with others, that he has problems with."
	" <b>interaction</b> with children with the same problems"	
Decode others	"interact with others"	
	"to <b>decode</b> other children" "to decode social behaviour/feelings"	
• Express themselves		
	"express themselves"	
Aggression and fights	"helping to <b>express</b> <b>themselves</b> , translate feelings into words"	"And they can never
	"not to <b>fight</b> with each other"	agree It causes aggression and they start fighting."

	"to relieve stress and aggression"	<ul> <li>"He can't explain what he wants, and he starts to fight."</li> <li>"They need a signal to make them stop fighting."</li> <li>"Sometimes he has fun, but he can get a little bit aggressive."</li> <li>"The problem with the high level of autism is that the risk of becoming aggressive increases."</li> </ul>
Skills related to school educational situations:		
• Learning and focus	"to <b>learn</b> what they don't like or understand" " <b>focus</b> on the subject" " <b>learning</b> together"	"Even when you talk to him, he is on his own. You ask him a question, but he is not <b>focus</b> ed." "These kids are different: some are very <b>focus</b> ed on what they do, and can stay quite for hours, others like ours, needs to be active and to talk."
• Applying the knowledge	"to <b>apply the knowledge</b> "	
• Understanding	" <b>understanding</b> " "to <b>understand</b> the material"	"You have pictures and you show them to him. And then he does it because he has trouble <b>understanding</b> what he has to do. It's easier. So you show him a picture and then he understands." "He just does not have the <b>understanding</b> of the situation with the rules of the game."

<ul> <li>"technology to teach basic skills (how to tie shoe laces, how to eat, etc)"</li> <li>"plan activities, follow the schedule"</li> <li>"app to plan the day"</li> </ul>	"Maybe a <b>planner</b> . Some digital schedule. I don't think they use anything at school."
<b>Technology</b> to teach basic skills (how to tie shoe laces, how to eat, etc)	"It could be good to have something as a <b>tool</b> for use."
	"He can play with <b>iPad</b> , and he likes it."
	"They have different apps on the <b>iPad</b> ."
	"He uses this <b>iPad</b> , where he sits by himself and just watches what he wants."
" <b>app</b> to plan the day"	"Maybe the <b>apps</b> can have some pictures and you can
"an <b>app</b> to help them switch between time to learn and	just slide this."
time to relax"	"But no, they don't have any <b>apps</b> designed especially for them."
	"technology to teach basic skills (how to tie shoe laces, how to eat, etc)" "plan activities, follow the schedule" "app to plan the day" Technology to teach basic skills (how to tie shoe laces, how to eat, etc) "app to plan the day"

#### 4.2.1 Skills related to social situations

Skills related to social situations are a central theme in both the qualitative data in the surveys and the data from the qualitative interviews with teachers and relatives. It was mentioned as one of the major challenges faced by the children with autism by many respondents, including the interviewees. According to the data received, the social skills that are challenging for autistic children are understanding norms and rules, communication, interaction with others, decoding people's behaviour, and expressing themselves. These challenges can become the reason for aggression and fights.

Understanding norms and rules mean that children with autism have difficulties understanding social norms and rules, which, according to the interviews respondents, is challenging and can become the reason for their aggressive behaviour. According to the responses from both the survey and the interviews, children with autism have problems with following the common social rules and understanding them and the reason to make and follow these rules. As the teacher's assistant says, the so-called conflict with the world is caused by not understanding the meaning of rules: "They translate the world from another perspective. So sometimes social rules don't work, from their perspective. For them it seems stupid to follow these rules. And it causes conflict with the society", "Society rules that he needs to follow do not really have meaning. If there are some rules he understands, that have meaning for him, he follows them". However, as it is mentioned by the same interviewee, autistic children can obey the rules if they know that being disobedient will have negative consequences on them: "He took a picture of the other person, who did not like it. So, I had to say to him "Sorry, the rule is that you need to delete the picture". So, he deleted it because of that person. He was a bit upset, but he had to do it. Because he could not come anymore there (to the after-class activities) if he did not respect the rules." One of the mothers also talks about problems with following the rules: "- Is it hard for him to learn rules? -Yes, he has problems with being obedient. It is simply difficult to understand the rules. - How do you explain them to him? - Oh, just trying to talk again and again".

The inability to understand the rules also applies to the rules of playing with other children. Children with autism have problems when playing together, and one of the reasons is that they cannot either agree on their own rules or follow the rules of the game. For example, one of the mothers talked about the situation when two autistic children wanted to play together: "He wants to play with toy cars. He wants to move the car this direction, and the other boy wants to move it the other direction. And they can never agree on it".

Communication is another sub-theme in the data analysis, and it reflects another problem of autistic children. According to the interviews, the problem of the children who have speech difficulties is how these children can "communicate with the world" because communication with other people requires the same language that people around speak, as the interviewed teacher's assistant says: "He knows how to follow the way to communicate with a teacher. And even if he has a good education, how can he communicate with the world? Because you need to communicate with the world with the world language". The teacher's assistant gives an example of how a child with autism does not use enough words to communicate: "-Do you want some tea?" -" Maybe". And then how am I supposed to translate it? I mean, I think it's only the close family who understands his "maybe", and what it means".

As the interview results show, children with autism who do not have speech difficulties, still have problems with communication with other people. "The problem is that these kinds of kids can't find out how to communicate", says the mother of one autistic child.

Interaction with others is another sub-theme, closely related to the problem with communication. According to the interviews, the problem with interaction is a result of the lack of communication and communicational skills. Because autistic children cannot properly communicate and agree on anything, for example, the rules of the game, as described above, they have difficulties playing together. According to one mother, who was interviewed, the inability to interact with each other can also sometimes cause aggressive behaviour: "The problem is that these kinds of kids can't find out how to communicate sometimes. Most of the time, actually... He wants to move the car this direction, and the other boy wants to move it the other direction. And they can never agree on it. It causes aggression and they start fighting". According to Hashim and Yussof (2018), children with high functioning autism were found to have difficulties in engaging with social interaction.

Decoding others is the sub-theme in the social situations skills theme. Autistic children often have problems with understanding behaviour of other people, which makes it difficult for them to decode others. One of the interviewees talked about the necessity of using the cards with pictures when trying to explain to the child what he has to do: "We use small pictures. If we want him to do something, we just show him: you have to do this. Like, get dressed. You have pictures and you show them to him. And then he does it because he has trouble understanding what he has to do. It's easier. So, you show him a picture and then he understands".

One more challenge with social skills for autistic children is expressing themselves. Together with problems with communication and decoding others, described above, they have problems with expressing their needs, wishes and emotions: "I could see many times when he says nothing, he has a feeling inside. But sometimes if something funny happens, and he hasn't expected it, he smiles. Then suddenly he closes again because he doesn't want to show his feelings". One of the frequent answers to the survey question about the biggest challenge for school children with autism is self-expression and translating feelings into words.

According to Wilson et al. (2018), children on the autistic spectrum can be minimally verbal and may communicate with no spoken language at all, can use atypical non-speech sounds only or a few words or phrases in limited contexts, or use echolalic language, when the child repeats language of others but does not generate it. As verbal communication is used throughout school curricula, it may provide challenges for

minimally verbal children to engage in typical verbal and written language tasks. Researchers suggest that using the child's own personal interests and individual choices of communication can motivate engagement in the classroom. Communication can occur through an app for language learning by focusing on using the children's own content to encourage attention to and engagement with new words. It can also happen through tangible tools that can help them express themselves through sensorimotor skills (Wilson et al., 2020).

According to Ozdowska et al. (2021), children with autism are not motivated to express themselves through handwriting, and write as little as possible. Many children on the autism spectrum struggle to develop both the physical fine motor skills required to handwrite, and the conceptual skills required for written expression (Ozdowska et al., 2021). Ozdowska et al. (2021) suggest the use of assistive technologies like keyboards and writing-support software in combination with special teaching strategies to improve the writing outcomes of autistic children.

Aggressive behaviour, anxiety and fighting are named as challenges in the educational environment for children with autism. According to all interview participants, children experience aggressive behaviour and fights at school. It happens because of poor communication skills, inability to understand each other and to express themselves. These mentioned things are united in the sub-theme "Aggression".

Aggression happens in different situations. "He can't explain what he wants, and he starts to fight." The teacher's assistant in his interview states that "the higher the level of autism is, the higher is the risk of becoming aggressive." Children need "a signal to make them stop fighting", according to one of the mothers of the autistic child. "-They have a "Pyt" button at school. It is such a red plastic button. When they start fighting, and it becomes too much, someone has to press that button. - Who presses it? A teacher? - One of the kids. They are trained to do it. When the child feels it is getting too much, it is overwhelming with aggression, they press it. - Does it help? - Yes, it is a psychological method, and it helps". More serious forms of aggressive behaviour need medical treatment, according to the teacher's assistant: "I think it's very difficult to decide whether they really need medicine or not. Of course, for the violent ones, sometimes a pill is needed to make them quiet. But before we do it, we should understand why they become aggressive sometimes, what's happening around them".

Tokarskaya et al. (2020) give an example of a child with autism who can develop an aversion to glue or other material during a drawing class and becomes aggressive or tries to leave the class. "A teaching professional should be prepared for these

manifestations, not only psychologically, but also methodologically" (Tokarskaya et al., 2020).

Anxiety as a result of too much information received during the day was mentioned by one interviewee: "The child can have a lot of problems with the noise and impressions, they get a lot of impressions each day, and they have to process it. And that's why they get too anxious".

According to Yuan and Ip (2018), social skills can be trained by implementing Virtual reality: "Children with ASD often require social skills training while VR provides a safe, controllable environment to practice skills repeatedly". Yuan and Ip (2018) proved the efficacy of the reality training program on emotional and social skills. "Other than social and emotional skills, VR can also be applied to other disorders, such as anxiety, or as a medium to raise public concerns such as reducing stigma" (Yuan and Ip, 2018).

#### 4.2.2 Skills related to school educational situations

Skills related to school educational situations are mentioned many times by the respondents and therefore are united in one theme. Learning ability, ability to apply the knowledge received in class, and problems with understanding are the sub-themes in this theme. The absence of some skills needed when receiving education is one of the biggest challenges for children with autism in the educational environment, as seen by the respondents. Applying the knowledge received in class is also mentioned as a challenge by a survey respondent.

According to some survey respondents, the autistic children have problems with learning something that they do not like or do not understand. It is difficult for them to focus on a subject, and to learn together. There is no further elaboration on this subject in the survey responses. The interview respondents, on the contrary, talk about the interest in learning: "He doesn't have problems with learning. He is quite clever and has logic. Sometimes he surprises us with his knowledge. He likes learning different things. It is more about his interaction with others, that he has problems with". The mother of the other autistic child explains how the children in their class can focus on the learning process: "- At school they have separate tables that are covered by such a screen from both sides. - Like a booth? - Exactly. So, they each stay in their own world. - Does it help to focus on the learning process? - It does. It helps both the kids and the teacher at the same time".

Nevertheless, there is an assumption that other children with autism might have problems with learning: "I would say that the teacher has to do a lot of adapting to each child. So maybe that could be a challenge for the teacher because they have unique needs. And someone is cleverer, or someone is less", says the mother of the child who has autism. "These kids are different: some are very focused on what they do, and can stay quiet for hours, others like ours, need to be active and to talk", says the other mother.

The mothers of autistic children talked about the strong need of children with autism to isolate. One mother says: "When it is too much for him, we just leave him alone. He also has headphones with him all the time, so he can isolate from others. It helps, these children have a need in being isolated, they often can't stand loud sounds and voices". For this reason, such appliances as headphones without music and the plastic screens between the desks are used in class: "He also has headphones with him all the time, so he can isolate from others. They just cover the ears, like making a sound barrier. There are no cables or anything in them", "At school they have separate tables that are divided by such a screen from both sides... So, they each stay in their own world". The use of headphones as a tool for isolation is also discussed with the other mother, who was interviewed: "My child uses the earphones to make some noises go away". Such need in isolation explains why children with autism cannot collaborate with each other during the learning process and cannot study in teams.

Faria et al. (2020) state that the learning abilities of children who have autism can be improved through engagement and focus. When children are engaged, they get more focused on the subject, and their motivation to learn increases. The researchers also state that the challenge in more traditional educational settings in learning is boredom. Therefore, they suggest gaming as a solution for children with autism to motivate these children to learn and increase their engagement. Education can then be customised for the individual based on brain activity in order to raise the concentration level and improve the educational experience.

Special explanations are needed by autistic children, as they have problems with receiving and processing information. As it has been described earlier, one of the interviewees uses cards with pictures, depicting daily life situations, to explain to the child with autism what he needs to do: "It's easier. So, you show him a picture and then he understands." These kinds of cards can be used both at home for daily skills, and in class when planning the classroom activities.

Instructional strategies that incorporate visual supports such as pictures or video modelling are helpful tools for children with autism, according to Kang and Chang (2019). These tools can help students with autism "become more independent and better prepared for adulthood by learning a variety of life skills" (Kang and Chang, 2019).

Yuan and Ip (2018) state that teaching children with autism through virtual reality minimises potentially confusing instructions by providing direct social information, followed by new skills practices.

Tokarskaya et al. (2020) state that children with autism require special support during the entire period of education, and often after their graduation from school. As the range of differences in ASD (autism spectrum disorder) is very wide, it should be considered when designing programs and teaching aids for such children. "This kind of work requires the involvement of specialists who can take into account the whole variety of factors affecting the educational product" (Tokarskaya et al., 2020).

Wilson et al. (2018) suggest that learning autistic children by building on the children's own interests and motivations would engage them in learning to read and spell words. "For example, typically in word games or digital dictionaries, "A" is for "Apple", but if a child on the spectrum were enabled to choose what "A" stood for, their specific interests may lead them to choose, for example, "Air Conditioner" instead" (Wilson et al., 2018).

According to Mohd et al. (2020), autistic children need to learn slowly and systematically. The researchers state that the traditional explanations by the teacher cannot be understood by children with autism because they cannot focus for a long time. Through a game-based education, specially made for them, they can learn and overcome their challenges. Through their research, Mohd et al. (2020) proved that immersion into a game and curiosity can motivate the autistic children to finish the game, which would lead to better results in learning. The researchers state that up to now it is difficult to find underlying mechanisms for the success of playing games. "Emotional engagement is hypothesised to play a crucial role among other factors. "Though the idea of using games in educational settings has been around for decades, as a research field it is still in its early stages. As such, there is still unclear underlying mechanism by which games or game elements involve learners and promote learning" (Mohd et al., 2020).

#### 4.2.3 Basic daily skills

Basic daily skills are the subject that has been mentioned by several respondents as one of the challenges for children with autism. Daily routine and planning their day and following a schedule can be difficult for autistic children. One interview participant mentions that it is a difficult task for the autistic child to tie shoelaces: "When we saw he could not tie his shoelaces, we thought we were bad parents. It was not obvious that something was wrong with the son". The survey respondents mention such things as planning activities, following the schedule, being able to sit still and quiet as a problem that the autistic children face in the class environment. The respondents also share an idea of having a digital tool that would support school children with autism in planning their day, send reminders, and help to switch between time to study and time to relax.

According to Tokarskaya et al. (2020) children with autism express discomfort with unexpected changes, the cancellation of planned events, changes in their usual schedule, etc (Tokarskaya et al., 2020).

According to Kang and Chang (2018), one of the biggest concerns of parents of children with autism is whether their child will live a safe, productive, and independent life. This concern derives from the inability of many autistic children to manage their everyday tasks. The difficulties in verbal reasoning and short-term memory present pedagogic challenges in teaching children with autism basic living skills. Therefore, these skills are difficult to teach properly through traditional methods such as verbal instruction and memorization tasks.

Kang and Chang (2019) studied such an important daily living task as taking a shower or a bath. "Even simple tasks can present complex challenges for some individuals with ASD" (Kang and Chang, 2018). The researchers suggest that organising tasks into a sequence of smaller steps or actions is a way for teaching autistic children new skills. "Having an understanding of all the steps involved for a particular task can assist in identifying those steps that require extra training and can help teach tasks in a logical progression" (Kang and Chang, 2018).

Nevertheless, the researchers state that basic daily skills can be trained through gaming: "Individuals acquiring independence early in life have more potential to thrive in domestic and vocational settings" (Kang and Chang, 2018). Technological interventions can help autistic children become more independent and better prepared for adulthood by learning a variety of life skills. For example, learning to take a shower through gamification helps children with autism familiarise themselves with all the task steps involved in the process of taking a shower and assists them with the task steps where they need extra practice (Kang and Chang, 2018). "Additionally, the game-based intervention can benefit children with ASD for the learning of other functional skills such as shopping, pedestrian safety, and food preparation" (Kang and Chang, 2018).

Though taking shower is not a skill related to the class educational environment, the study by Kang and Chang (2019) proves that basic daily skills can be trained with the

help of games. Planning, scheduling, and following the plan can be assisted by using technological tools. This was also confirmed by one of the interviewees, who said that an app that helps to plan the daily routine would be useful for the autistic child: "There's something to pop up to show them: it's dinnertime. And then another pop-up: "I need to sleep" or something".

#### 4.2.4 Technologies in autism education

Technologies in autism education theme arises as the result of discussion during the interviews and investigation in the survey. This is the last theme in the analysis that has the following sub-themes: technological tools, iPad and apps. Technologies were discussed as tools to assist children in their daily school life. IPads and different apps were mentioned by the respondents as the most used technological tools.

Interview respondent talks about iPads as tools used by the children with autism to calm down and isolate themselves from the surroundings: "The child can have a lot of problems with the noise and impressions... He uses this iPad, where he sits by himself and just watches what he wants." The same respondent talks about the use of iPads at school: "When the child needs to get away from the noise and the social interactions, they use the iPad with different apps and games... It helps. Because otherwise, they couldn't handle the impressions in school each day. Impressions from other children, the teacher, the surroundings.". The sub-theme of the analysis is called iPad as the conversation was about iPad. However, the positive use of such technological tools can be generalised to tablets.

Apps are mentioned as digital tools used by autistic children, as well. According to the interviewees, children with autism can use apps designed for all users, and not specifically for autistic children: "he can have an app in the same way as a normal person", "they use the iPad with different apps".

Technological tools, as seen by majority of the respondents, can be used in the following areas:

- teaching children with autism basic daily skills like eating, tying shoelaces,
- to help the child relax,
- to control behaviour,
- to express themselves,
- to understand their wishes,
- to make them relax,
- to plan the day,

- to track the child's condition,
- to control aggression,
- to communicate,
- to decode social behaviour/feelings,
- to translate feelings into words,
- to learn the rules,
- to help switch between time to learn and time to relax.

The information above is based on the answers to the survey, which were not elaborated. Therefore, it is impossible to conclude which technological tools would be preferred by the survey respondents.

Nevertheless, the studied literature confirms the positive effect of using assistive technological tools in education of children with autism. Video modelling is efficient in teaching daily living, as well as functional, vocational, academic, and social skills (Kang and Chang, 2019). Video modelling includes using a video recording as a model. Video self-modelling is when a child views a video recording of themselves performing the behaviour or skill successfully (Merrill, 2022).

Video games engage children with autism in a target behaviour and makes them subsequently imitate it in real life. "Gameplay demands focus and attention, motivates the user to practise, and provides the user with a sense of achievement, even if the user cannot perform that task in the real world" (Kang and Chang, 2019). According to Kang and Chang (2019) augmented reality-based games help train students with autism in different tasks. Faria et al. (2020) state that Artificial Intelligence-based interactive games can be applied in training cognitive skills. The child-machine interaction facilitates adaptive learning-related coping and focuses on helping children with autism (Faria et al., 2020). Augmented and virtual reality, according to Tokarskaya et al. (2020) maximise mental, communicative, and motor skills of children with autism.

Wilson et al. (2018) designed an app for autistic children to make their personal dictionary. A child initially takes their own photos to insert into a dictionary format and then can add an audio recording, such as the sound of the word. It enables autistic children to build a personalised catalogue of words over time.

Ozdowska et al. (2021) states that the use of assistive technologies like keyboards and writing-support software on an iPad can improve the writing outcomes of children with autism.

"Writing-support software includes additional functions other than simply providing a keyboard to overcome handwriting challenges. These include word prediction and word choices during word construction, homophone detection, text-to-voice feedback, and meaning/dictionary support" (Ozdowska et al., 2021).

Autistic children are known to respond more to computers, robots, and machines than they do to normal people (Hashim and Yussof, 2018). "Humanoids as a form of assistive technologies have been shown to have positive effects on the social-cognitive behaviour" (Hashim and Yussof, 2018). Humanoid and social robots are needed to assist children with autism to recognize nonverbal social cues in the context of social scenarios and to be taught to use their cognitive skills to better understand emotions.

Nevertheless, the study by Hashim and Yussof (2018) also shows that not all parents and teachers are ready for assistive technologies, especially humanoids. Findings of the study indicated that the teachers, parents, and guardians of children with autism are not ready for humanoids to train their children, though it is seen by the respondents as a positive tool to use in future (Hashim and Yussof, 2018). Humanoids can be put to use for assistive measures for children with autism. According to the researchers, conservative parents may want a trained human to handle their children's therapy sessions rather than trusting "an object". This situation warrants further research on parents' acceptance of humanoids in therapies. Hashim and Yussof (2018) suggest that more promotions should be done by healthcare entities to promote the advantages and uptake of robots in assistive applications.

However, there is no full agreement between the parents and teachers' about the use of technology. For example, the teacher's assistant, who gave the interview, does not see technological tools at school as the necessary things to be used: "If they decide to use technology, they can use it like other people use it", "YouTube, SIRI, he could use it without problems. He was having fun with his phone. I could see he was much better than me at using technology", "I also think, sometimes we, modern society, focus too much on categorising the sickness. I think now an autistic person should feel like a normal person. If he has a potential to use an app, so use the app".

## 4.3 Theoretical approach to the learning process

To be able to understand how children with autism can learn, and how the process of learning can become more efficient, Kolb's Experiential learning theory (1984) is applied.

Experiential learning theory by Kolb (1984) offers a fundamentally new perspective on the learning process that differs from traditional educational cognitive and behavioural methods. It demonstrates the influence primarily of experience, rather than cognitive processes, on learning. "From this different perspective emerge some different prescriptions for the conduct of education, the proper relationships among learning, work, and other life activities, and the creation of knowledge itself" (Kolb, 1984). This learning theory is called "experiential" because Kolb's theory is based on the summary of the elements of previous theories by Dewey, Lewin, and Piaget. These original theories were related to experiential learning. The second reason, according to Kolb (1984) is to emphasise the central role that experience plays in the learning process.

As the literature review revealed, the teaching of autistic children should be conducted through experience. Gamified learning (Faria et al., 2020; Kang and Chang, 2019; Mohd et al., 2020), tangible materials (Wilson et al., 2020), and self-designed learning tools (Wilson et al., 2018) create the experience that helps children with autism learn and perform better. Kolb's theory helps to better understand and visualise the way knowledge is perceived by children with autism, which can be used when developing technological solutions for them.

The process of experiential learning by Kolb (1984) can be described as a four-stage cycle involving four adaptive learning modes – concrete experience, reflective observation, abstract conceptualization, and active experimentation. The bases of the learning process lie in the transactions among these four adaptive modes (see Figure 7).



Figure 7: Kolb's Experiential learning model

The concrete experience and abstract conceptualization, and active experimentation and reflective observation are two distinct dimensions, each representing two opposed adaptive orientations. They represent two different and opposed processes of grasping or taking hold of experience in the world, either through reliance on conceptual interpretation and symbolic representation, a process called comprehension, or through reliance on the tangible, felt qualities of immediate experience, what is called apprehension.

The active experimentation and the reflective observation are one of transformation, representing two opposed ways of transforming that grasp or "figurative representation" of experience – either through internal reflection, a process called intention, or active external manipulation of the external world, here called extension. The central idea of the Experiential learning theory is that learning, and therefore knowing, requires both a grasp or figurative representation of experience and some transformation of that representation. "Either the figurative grasp or operative transformation alone is not sufficient. The simple perception of experience is not sufficient for learning; something must be done with it. Similarly, transformation

alone cannot represent learning, for there must be something to be transformed, some state or experience that is being acted upon" (Kolb, 1984). From these three fields there emerges a consistent picture of the structure and functioning of these two basic dimensions of the learning process.

The learning process, according to Kolb (1984) can start from any dimension depending on students' personal style and needs. Experiential learning for autistic children can only start from the active experimentation phase. "Physicality is an essential component in learning. Thus, children must be supported to freely "play out" feelings and experiences in physical and imaginative play" (Wilson et al., 2020). Through playing educational games and gaining experience, the autistic children move to the concrete experience phase. The already gained experience makes it easier for them to move to the reflective observation phase as they cannot "readily learn by observing others, and they show deficits in skills that may be associated with observational learning, such as attending and imitating" (Taylor et al., 2012).

Starting the learning process from the abstract conceptualisation phase is not possible as "an abstraction of thought in the context of autism can be challenging" (Wilson et al., 2020). Moreno and O'Neil (2020) also state that people with autism have problems with abstract and conceptual thinking. "When abstract concepts must be used, use visual cues, such as drawings or written words, to augment the abstract idea. Be as concrete as possible in all your interactions with these students" (Moreno and O'Neil, 2020), which brings the abstract conceptualisation to the active experimentation phase.

Therefore, it can be concluded that the learning experience for children with autism lies between the phases of active experimentation and concrete experience, and the main learning style for these children is through the accommodative knowledge (see Figure 8). The main characteristics of the accommodative knowledge (Kolb, 1984) that can be applied to the learning process of children with autism are:

- learning abilities are dominated by concrete experience and active experimentation;
- the ability to learn is manifested primarily through practical experience;
- reliance on a sense of own intuition instead of logical analysis.



Figure 8: Learning style for children with autism (Modified from Kolb's Experiential learning model, 1984)

The learning style based on accommodative knowledge means that children with autism take hold of experience through apprehension, or reliance on the tangible, felt qualities of immediate experience. The grasp or "figurative representation" of experience happens through the extension, or the active external manipulation.

## 5 Designing and Prototyping

In this chapter the design of the educational platform for children with autism is discussed. Based on the research and the analysis of user needs, the educational platform is the technological solution for the problems and challenges of children with autism, and their parents. As these problems and challenges differ from each other and require different solutions, the platform for parents and children, that provides different informative, educational, and assistive tools, is needed. Though the research and analysis phases revealed that apps are popular among children, one app cannot solve the complex of challenges that the autistic children face every day in the educational context. With more homogeneous problems one specific app or a video game could be a solution. As the research and analysis revealed multiple problems within the educational context, the web platform can be designed to help children with autism and their parents to cope with these problems. The web platform can target different users with different needs, and guide parents through the usage of different solutions presented on it.

### 5.1 General intro design

As it was discussed in the previous chapter, different themes and sub themes arose during the analysis of the information received through interviews and the survey. Design principles for the educational platform, based on the discussed themes and sub themes are shown in Table 5 below. These principles need to be considered when creating content for children.

Theme	Hypothesis	Design principle	
<ul> <li>Skills related to social situations</li> <li>Understanding norms and rules</li> <li>Communication</li> <li>Interaction with others</li> <li>Decode others</li> <li>Express themselves</li> <li>Aggression and fights</li> </ul>	Assistive technology can be designed to help children cope with some social situations.	The design of the platform should support children in coping with social situations through gamification, and user- friendly interface.	

 Table 5. Design principles based on the found themes (modified from Kanstrup and Bertelsen, 2011)

<ul> <li>Skills related to school educational situations</li> <li>Learning and focusability</li> <li>Applying the knowledge</li> <li>Understanding</li> </ul>	The user group has difficulties in situations related to school education. Learning through games can help motivate children to learn and stay focused on the subject.	The design should support easy and motivating learning through entertaining content and graphics. The platform should support children in school educational situations through games.
Basic daily skills <ul> <li>Planning</li> </ul>	A schedule can be designed to help children learn basic daily skills and plan their routine.	The design should allow to plan the day through an interactive schedule with pictures for easy planning.
Technologies <ul> <li>Technological tools</li> <li>iPad</li> <li>Apps</li> </ul>	The user group uses different technological devices.	The content has to be designed for both tablets and smartphones. Design should support responsive interfaces for different devices, including smartphones and tablets.

The platform helps to solve such problems as skills related to social situations, skills related to school educational situations and basic daily skills. It aims to serve both parents of children with autism and autistic children themselves. Due to different needs of the two target user groups, the platform is divided into two main parts: one for the parents of children with autism and one for the autistic children. Content designed for the parents can serve as guidelines for managing different life situations with autistic children (see Figure 9), and content for the children with autism can help them express themselves and communicate, manage aggression, learn through gaming, and plan their day.



Figure 9: Page for parents

Each user can have their own account and can use the website either as a parent or as a child. The example of the website's front page is shown in Figure 10 below.



Figure 10: Front page

Parents can get access to the information on the website by clicking the field "For parents", and children can get excess to the games by clicking the field "For children". There is a possibility to create an account on the website and save the favourite content in the personal collection.

Interactive helper in the form of a cartoon character is used as a part of gamification. Gamification is "a term for the use of video game elements (rather than full-fledged games) to improve user experience and user engagement" (Deterding et al., 2011). By clicking on the figure of the character the child will hear the voice guidelines with instructions on how to use different functions of the website, how to play a game, etc. Such an approach proved to be effective in the study of Tokarskaya et al. (2020), where a virtual dog is used to instruct children. "The dog is also a friendly educational assistant, relying on the strategies of humour that activate the learning process" (Tokarskaya et al., 2020). For the platform design Sponge Bob is chosen as the guidelines character, as this character appears among the first popular cartoon characters on Google, when searching for "the most famous cartoon character". The example of the page with the interactive helper and menu is shown in Figure 11.



Figure 11: Interactive helper and the site menu

The four design principles need to be considered when creating the learning platform. Three of these principles are in focus when creating the content of the platform, and the last design principle has to be applied when presenting this content on different devices. The further description of the platform design is given based on the design principles described above.

#### 5.2 Design for skills related to social situations

The design principle for skills related to social situations is that the design of the platform should support children in coping with social situations through gamification, and user-friendly interface. According to the research children with autism have problems with such social skills as understanding norms and rules, communication, interaction with other people, decoding behaviour of others, self-expression, ability to cope with aggression to avoid fighting with other children.

As the analysis of the data received during the research phase showed, learning skills related to social situations through gamification is seen as a skill-developing approach for children with autism (Kang and Chang, 2019). The gamification of training involves the child playing a video game, which stimulates the child to develop a target behaviour and certain skills through subsequently imitating them in real life (Kang and Chang, 2020). Games are already used at school, according to some survey and interview respondents.

Among other games that can be added to the platform, can be the following existing free games:

- Minecraft ("Minecraft," 2022) is not specifically designed for autistic children, but it can be used for teaching communication skills and helping children interact with each other.
- Life Skills winner can teach norms and rules, and explain why and how skills, such as brushing teeth, getting dressed, and packing a backpack, are important (Miller-Wilson, 2022);
- MyTalkTools (MyTalkTools, 2022) helps children to communicate and interact with each other with sequences of words, sounds, and images.
- If ("IF," 2022) can train skills to manage aggression and frustration, help decode other people and understand their emotions, and interact with others;
- FaceSay helps to recognize and interpret facial expressions and directly targets the skill of decoding other people (Miller-Wilson, 2022).

Communication and self-expression can be performed through drawing and typing (by children who can write). Interactive cards showing different life situations can be also used to express the needs and wishes of a child.

The "Pyt" button that helps autistic children manage aggression, and that was described in one of the interviews, is used as a digital button on the platform (see Figure 12). The advantage of the digital button is that it is available for each child any time compared to the physical one, and it can have more functions. By pressing the button, the child can activate the music or a cartoon that would help the child to relax.

The interactive helper explains to the user how to choose a category, a game, and guide. The instructions can sound as follows: "Hi! If you want to learn how to talk to your friends, choose a game from here (pointing to the block with games for communication skills)". "If you are angry, click here (points to the icon with the angry boy). Now press the button and enjoy the music!".

The user can go to the personal account, change the screen settings, go to home page or one page back.



Figure 12: Social situations games page

#### 5.3 Design for skills related to educational situations

The design principle for developing this module is that the design should support easy and motivating learning through entertaining content and attractive graphics. The platform should support children in school educational situations through games. The school educational situations that can be challenging for the children with autism, are learning and focusability, applying the knowledge, and understanding the explanations of the teacher. This module contains games and videos that help to manage educational situations at school. Games and videos are chosen as the analysis revealed that autistic children are interested in playing video games (24.2% stated that there are games used at school) and like watching videos (15.2% stated that educational videos are used at school). Gamification of education does not only engage users but also helps develop motor skills and cognitive abilities through problem solving skills (Faria et al., 2020)

According to Faria et al. (2020), games can also help to raise motivation to study and learn new things, and to make children with autism better understand the material learnt in class. The authors argue that games can be used by children with special needs towards improving their cognitive abilities and concentration (Faria et al., 2020). "Additionally, the game-based intervention can benefit children with ASD for the learning of other functional skills such as shopping, pedestrian safety, and food preparation" (Kang and Chang, 2018).

According to the literature review and the performed analysis, gamified learning proved to be an effective solution when teaching children with autism. As Mohd et al. (2020) state, the positive effects of game-based learning led to the creation of educational games in supporting the teaching and learning development in schools in general. Autistic children are more attracted to playing educational games rather than learning by listening to the teacher (Mohd et al., 2020). For this reason, learning through gamification can be beneficial for autistic children in learning new skills, and in understanding the explanations within the study curricula. Once the autistic children get interested in the game, they immerse themselves in the process of playing the game. They try to solve the problem and their curiosity makes them try to finish the game until the end to know the result of the game (Mohd et al., 2020). Games can provide a better and more efficient learning environment as they introduce a "fun" element to education which makes the whole experience more appealing for students. Gamification of education does not only engage users but also helps develop motor skills and cognitive abilities through problem solving skills (Faria et al., 2020). "There is a strong association between engaging in computer-based learning activities and cognitive development in children" (Faria et al., 2020).

Kang and Chang (2019) state that game-based training is an alternative approach to developing skills in children with autism. This strategy became possible with the recent advancements in human–computer interaction technology. The gamification of training involves the child playing a video game, which stimulates the child to develop a target behaviour and certain skills through subsequently imitating them in real life. Gameplay demands focus and attention, motivates the user to practise, and provides the user with a sense of achievement, even if the user cannot perform that task in the real world. Gamification has become a new strategy to successfully teach children with autism a variety of skills (Kang and Chang, 2019).

Gamification can also enhance the learning experience for children with autism. It provides active experimentation that leads to concrete experience, which is the main learning style for autistic children, based on Kolb's Experiential learning theory.

Excess to different existing games and videos would be provided on one platform and be updated by the site administration. Parents can also add games and videos to the personal collection and share with others.

Among games that can be added to the platform, can be the following existing free games:

- Minecraft ("Minecraft," 2022) can be used in teaching maths, besides teaching communication skills and helping children interact with each other. Though the game is not specifically designed for children with autism, it is recommended to use when teaching autistic children (Watkins, 2015);
- Reader rabbit is a game teaching and helping to learn the alphabet, practise reading skills and improve vocabulary. It is specifically designed for children with autism (Miller-Wilson, 2022);
- Earobics is a two-player game designed to improve auditory processing. "Since auditory processing, or the ability to understand and integrate material that is presented through spoken words, can be a challenge for kids on the spectrum, this game is a popular therapy tool" (Miller-Wilson, 2022). The game slightly increased phonological awareness in kids who played the game (Miller-Wilson, 2022);
- Mathmateer is a game for learning maths (Kulman, 2020).

The module for training skills related to school educational situations is divided into categories. There are two categories: one for learning and one for practising. Sub themes learning, focus and understanding are not separated into different categories as there are no games for each separate sub-theme.

The prototype of the page with the game divided into categories, is shown in Figure 13. Some games can belong to both categories, as they can help to learn new things and to practise.



Figure13: Educational situations games page

The interactive helper explains to the user how to choose a category and a game. The instructions can sound as follows: "Hi! If you want to learn how to write, read, or count, choose a game from here (pointing to the block with games for learning). If you want to write, read, count better and have fun, choose a game from here (points to the block with games for exercising)".

When the user has clicked on the game icon, the game starts. The game Earobics is taken as an example and can be seen on Figure 14. The purpose of the game is to teach children mathematics, where students are launching a rocket and trying to keep it in space by correctly choosing numbers based on a corresponding math category. Success is based on how long students can keep their rocket in the air and how high it can go before it returns to earth. As they go through the levels, the math required increases in complexity: children can practise even numbers, fractions, etc.



Figure 14: Earobics game

The user can scroll the page down, go to the personal account, change the screen settings, go to home page or one page back.

#### 5.4 Design for basic daily skills

The design principle for developing this module is that the design should allow planning the day through an interactive schedule with pictures for easy planning. To teach children with autism to better plan their day and to know when it is time for different activities, the planner is needed. The website needs to include an online daily planner that can also be used in offline mode and can be saved as a desktop version.

The important thing when designing a planner for children with autism is that they have difficulties with writing (Ozdowska et al., 2021). Therefore, the design of the planner should include graphic elements instead of text. As it was discussed in one of the interviews during the research phase, children with autism better understand when they need to perform their daily tasks by being shown cards with pictures: "We use small pictures. If we want him to do something, we just show him: you have to do this. Like, get dressed. You have pictures and you show them to him. And then he

does it because he has trouble understanding what he has to do. It's easier. So, you show him a picture and then he understands". The same approach can be used in developing a planner: pictures representing such daily routines as brushing teeth, taking a shower, having mealtime, etc can be understood better. By dragging a card to the specific time slot or slots on the calendar, the user can plan the daily schedule. With the better developed platform there can be a possibility of setting a reminder for different activities on mobile devices. The cards can also be copied and used multiple times.

Wilson et al. (2018) gives an example of how children with autism are different in making their own associations: "For example, typically in word games or digital dictionaries, "A" is for "Apple", but if a child on the spectrum were enabled to choose what "A" stood for, their specific interests may lead them to choose, for example, "Air Conditioner" instead" (Wilson et al., 2018). Therefore, it should also be possible for a child to choose the picture referring to a concrete situation, so that the child can use the picture that is mostly liked by them. By clicking the library icon on the picture, the child will be redirected to the database with different pictures to choose from.

The planner can be used by both parents and children. An example of the planning page is presented in Figure 15.



Figure 15: The planner page

As in the other modules, previously described, the interactive helper will guide the user through the process of making a schedule, making changes, and setting reminders.

#### 5.5 Design for different technological tools

The design principle for developing the whole platform is that the platform content has to be designed for both tablets and smartphones. Moreover, the design should support responsive interfaces for different devices, including smartphones and tablets.

As it was earlier revealed in the research phase, children with autism use different devices for playing games and using the internet. Two devices, a smartphone, and an iPad, were mentioned in both interviews and the survey. As different types of tablets are often named iPad, different types of tablets should be considered when developing the website.

As not all devices support different games, the content of the platform can vary depending on the device in use. For example, games involving drawing are better suitable for a tablet, while Augmented reality games are better to use on a smartphone. Thus, parents should consider using a tablet for a child who needs to learn how to express themselves through drawing and using a smartphone for Augmented reality where a child can better understand the explained material.

To develop a website with user -friendly content, responsive design is needed, as well. Responsive design is the approach that suggests that design and development should respond to the user's behaviour and environment based on screen size, platform, and orientation. As the user switches from their laptop to iPad, the website should automatically switch to accommodate for resolution, image size and scripting abilities (Friedman, 2018). It will allow both parents and children with autism to use the website on different devices.

## 6 Discussion and Conclusion

This Master's thesis aimed to answer the research question *How to design an educational technological tool for children with autism between the age of 6 and 11 years old?* Through the literature review, research, and the analysis of the received data the answer to the question was found and the design of the digital solution presented.

The research was aimed to answer several sub-questions. One of them is: *Which technological tools have been already designed to assist children with autism and what are the potentials and challenges with these tools?* The literature review revealed that such technological solutions as Virtual and augmented reality (Yuan and Ip, 2018; Tokarskaya et al., 2020), educational video games (Kang and Chang, 2019; Mohd et al., 2020; Faria et al., 2020) , apps (Wilson et al., 2018), humanoids (Hashim et al., 2018), and tangible tools with integrated technology (Wilson et al., 2020) have been designed to help children with autism in an educational context. These tools have a big potential to motivate children with autism to learn, make them more focused and interested either in learning things within school curricula or learning social skills. The challenges with the tools are that not all of them are still accepted by parents and teachers, and some of them require further development and testing.

To answer the sub-question "*What is the biggest challenge that children with autism and their surrounding experience in school?*" qualitative methods were applied. The research in the form of interviews and a survey, and thematic analysis of the gained data revealed that the biggest challenges for children with autism are developing skills related to social situations, skills related to educational situations, and the ability to plan their day.

The challenges mentioned above can be coped with by using technological tools mentioned earlier. According to the research, children with autism like and use tablets. Therefore, the answer to the sub-question "*How can primary school children with autism and people related to them benefit from using technologies in the educational process*?" is that primary school children with autism can use tablets to develop skills that are challenging for them. As the literature review and the research showed, these skills can be trained through gamification. Parents can control and guide their children in using assistive technologies and be informed how to help an autistic child train certain skill.

The last sub-question is: How to design a technological tool for primary school children with autism? This sub-question was answered by showing the prototypes of the digital solution in the form of a web platform for both children and parents.

The presented solutions target primary school children with autism and their parents, and this solution is based on the analysis of data gained during the research phase. With more time allocated to the research, more data could be gained, and more information about the challenges and problems of autistic children collected. As the studied subject is delicate, and some communities, and parents of autistic children refused to provide data on the topic, there was no possibility to gain more information within the given timeframe.

The subject of autism is very complex: "If you've met one person with autism, you've met one person with autism" (Flannery and Wisner-Carlson, 2020), which means people on the autism spectrum can differ from each other. Further study of this subject would allow a deeper insight and better understanding of problems of autistic children.

Moreover, other age groups of children might have other difficulties. With the deeper study of different age groups, the web platform can be expanded and divided into more categories depending on the age of the children with autism.

As the performed research was not geographically limited due the difficulties with the access to communities and people related to children with autism, it is difficult to say whether there is any difference in the educational system for children with autism in different countries. The interviews were performed in Denmark, and the survey was published on the USA online community for autistic people. As even the interviewed parents have limited knowledge about the school curricula and the educational process, it is difficult to compare educational systems, and make special solutions for the current educational system in Denmark.

The provided solution can be used by both children with autism and parents. Games are essential part of the web platform. Due to the complexity of the web platform, no specific game design was suggested. Instead, it is suggested to use the already existing games on the platform. With further development and the auditory growth, there can be developed games for this web platform. Videos and self-modelling videos can be used for training certain skills and are seen as a way to teach autistic people some skills. Video-modelling is a helpful tool that is efficient in teaching daily living, as well as functional, vocational, academic, and social skills for children with autism (Kang and Chang, 2019). As video-modelling has not been in a great focus in the papers studied during the literature review, and during the research process, it needs a more thorough research and better understanding.

Considering the opinion of the teacher's assistant who gave the interview, no special solution for children with autism is needed: "I also think, sometimes we, modern

society, focus too much on categorising the sickness. So, if you want an autistic person to find some special app for autism, maybe someone can produce something like that, but without it people with autism are good. I think now an autistic person should feel like a normal person. If he has a potential to use an app, so use the app". As there was no possibility to gain information from more teachers, it is impossible to conclude what the perspective from other teachers would be, and whether the presented solution is needed in the educational context.

All in all, the educational platform designed for children with autism between the ages of 6 and 11, can help them cope with some challenges they have at school. These challenges are related not only to the school curricula and the learning process, but also to the social behaviour. As problems within the autism spectrum can vary, the platform should target different users' needs, and serve as an assistive tool in the educational context. The platform needs to contain information for parents of autistic children, too, as parental guide is often needed by children with autism.

## References

Abu-Akel, A., Webb, M. E., de Montpellier, E., Von Bentivegni, S., Luechinger, L., Ishii, A., and Mohr, C. (2020). Autistic and positive schizotypal traits respectively predict better convergent and divergent thinking performance. Thinking Skills and Creativity, 36, 100656. <u>https://doi.org/10.1016/j.tsc.2020.100656</u>

Armstrong, M., Dopp, C., and Welsh, J. (2020). Design-Based Research. The Students' Guide to Learning Design and Research. https://edtechbooks.org/studentguide/design-based\_research

Autism Speaks. (2017). Autism and health: a special report by Autism Speaks. Advances in Understanding and Treating the Health Conditions that Frequently Accompany Autism. Autism Speaks.

Autism Speaks. (2022). In Wikipedia. https://en.wikipedia.org/w/index.php?title=Autism\_Speaks

Barab, S., and Squire, K. (2004). Design-Based Research: Putting a Stake in the Ground. Journal of the Learning Sciences, 13(1), 1–14. https://doi.org/10.1207/s15327809ils1301\_1

Boren, S. A., and Moxley, D. (2015). Systematically Reviewing the Literature: Building the Evidence for Health Care Quality. Missouri Medicine, 112(1), 58–62. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6170102/

Bowles, C., and Box, J. (2011). Undercover user experience: learn how to do great UX work with tiny budgets, no time, and limited support. New Riders.

Boyatzis, R. E. (1998). Transforming qualitative information: thematic analysis and code development. Sage Publications.

Braun, V., and Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

CDC. (2021, December 2). Data and Statistics on Autism Spectrum Disorder | CDC. Centers for Disease Control and Prevention. <u>https://www.cdc.gov/ncbddd/autism/data.html</u> CDC. (2022). Basics About Autism Spectrum Disorder (ASD) | NCBDDD | CDC. Centers for Disease Control and Prevention. <u>https://www.cdc.gov/ncbddd/autism/facts.html</u>

Cronin, P., Ryan, F., and Coughlan, M. (2008). Undertaking a literature review: A step-by-step approach (p. 25). School of Nursing and Midwifery, Trinity College.

DCCINC. (2013). Disability Tax Credit for Autism: Help Your Loved Ones. *Disability Credit Canada | Disability Tax Credit & CPP Disability Services*. https://disabilitycreditcanada.com/disability-tax-credit-eligible-conditions/autism/

Deterding, S., Sicart, M., Nacke, L., O'Hara, K., and Dixon, D. (2011). Gamification. using game-design elements in non-gaming contexts. Proceedings of the 2011 Annual Conference Extended Abstracts on Human Factors in Computing Systems - CHI EA '11, 2425. <u>https://doi.org/10.1145/1979742.1979575</u>

Faria, D. R., Bird, J. J., Daquana, C., Kobylarz, J., and Ayrosa, P. P. S. (2020). Towards AI-based Interactive Game Intervention to Monitor Concentration Levels in Children with Attention Deficit. International Journal of Information and Education Technology, 10(9), 641–648. <u>https://doi.org/10.18178/ijiet.2020.10.9.1437</u>

Flannery, K. A., and Wisner-Carlson, R. (2020). Autism and Education. Psychiatric Clinics of North America, 43(4), 647–671. <u>https://doi.org/10.1016/j.psc.2020.08.004</u>

Foley, L. J. (2012). Constructing the Respondent. In J. Gubrium, J. Holstein, A. Marvasti, and K. McKinney, The SAGE Handbook of Interview Research: The Complexity of the Craft (pp. 305–316). SAGE Publications, Inc. https://doi.org/10.4135/9781452218403.n22

Friedman, V. (2011, January 12). Responsive Web Design - What It Is And How To Use It. Smashing Magazine.

https://www.smashingmagazine.com/2011/01/guidelines-for-responsive-webdesign/

Goodman, E., Kuniavsky, M., & Moed, A. (2012). *Observing the User Experience a Practitioner's Guide to User Research*. Elsevier Science & Technology Books. http://international.scholarvox.com/book/88809579 Greaves, N., Prince, E., Evans, D. W., and Charman, T. (2006). Repetitive and ritualistic behaviour in children with Prader-Willi syndrome and children with autism. *Journal of Intellectual Disability Research*, *50*(2), 92–100. https://doi.org/10.1111/j.1365-2788.2005.00726.x

Hart, C. (1998). The literature review in research. In Doing a literature review. Releasing the Social Science Research Imagination. SAGE Publications.

Hashim, R., and Yussof, H. (2018). Preparation for adulthood: Benefits of assistive technologies in social skills training of children with autism. 2017 IEEE International Symposium on Robotics and Intelligent Sensors (IRIS), 374–378. https://doi.org/10.1109/IRIS.2017.8250151

Holloway, I., and Todres, L. (2003). The Status of Method: Flexibility, Consistency and Coherence. Qualitative Research, 3(3), 345–357. https://doi.org/10.1177/1468794103033004

IF... iPad Game review. (2022). LearningWorks for Kids. https://learningworksforkids.com/playbooks/if/

Kang, Y.-S., and Chang, Y.-J. (2019). Using game technology to teach six elementary school children with autism to take a shower independently. Developmental Neurorehabilitation, 22(5), 329–337. https://doi.org/10.1080/17518423.2018.1501778

Kanstrup, A. M., and Bertelsen, P. (2011). User Innovation Management: a handbook (1st edition). Alaborg University Press.

Kolb, D. A. (1984). Experiential learning: experience as the source of learning and development. Prentice-Hall.

Kulman, D. R. (2020, November 23). Video Games to Help Kids with Learning Disabilities Cope with Remote Learning. LearningWorks for Kids. <u>https://learningworksforkids.com/2020/11/video-games-to-help-kids-with-learning-disabilities-cope-with-remote-learning/</u>

Kvale, S., and Brinkmann, S. (2015). InterViews: learning the craft of qualitative research interviewing (Third edition). Sage Publications.

Lave, J., and Wenger, E. (1991). Situated learning: legitimate peripheral participation. Cambridge University Press.

Lidwell, W., Holden, K., and Butler, J. (2010). Universal principles of design: 125 ways to enhance usability, influence perception, increase appeal, make better design decisions, and teach through design; [25 additional design principles] (rev. and updated). Rockport Publ.

Marsden, P. V., and Wright, J. D. (Eds.). (2010). Handbook of survey research (Second edition). Emerald.

Merrill, A. (2022). Implementation and Effectiveness of Using Video Self-Modeling with Students with ASD. Indiana Resource Center for Autism. https://iidc.indiana.edu/irca/articles/video-self-modeling.html

Miller-Wilson, K. (2022). Software Games for Children with Autism. LoveToKnow. https://autism.lovetoknow.com/software-games-children-autism-pdd

Minecraft. (2022). LearningWorks for Kids. https://learningworksforkids.com/playbooks/minecraft/

Model Me Going Places: Community Social Skills for Children with Autism. (2022). <u>https://www.modelmekids.com/community-social-skills-autism.html</u>

Mohd, C. K. N. C. K., Shahbodin, F., Sedek, M., and Samsudin, M. (2020). Game Based Learning for Autism in Learning Mathematics. International Journal of Advanced Science and Technology, 29(05), 4684–4691. http://sersc.org/journals/index.php/IJAST/article/view/13849

Moreno, S., and O'Neal, C. (2020). Tips for Teaching High-Functioning People with Autism. Indiana Resource. <u>https://iidc.indiana.edu/irca/articles/tips-for-teaching-high-functioning-people-with-autism.html</u>

MyTalkTools > Products. (2022). http://www.mytalktools.com/dnn/2/Products.aspx

Nyhuus, H. (2018). Omfang — Vidensportalen på det sociale område [Socialstyrelsen]. Vidensportal. https://vidensportal.dk/handicap/born-medautisme/omfang, https://vidensportal.dk/handicap/born-med-autisme/omfang

Ozdowska, A., Wyeth, P., Carrington, S., and Ashburner, J. (2021). Using assistive technology with SRSD to support students on the autism spectrum with persuasive writing. British Journal of Educational Technology, 52(2), 934–959. <u>https://doi.org/10.1111/bjet.13063</u> Parner, E. T., Thorsen, P., Dixon, G., de Klerk, N., Leonard, H., Nassar, N., Bourke, J., Bower, C., and Glasson, E. J. (2011). A Comparison of Autism Prevalence Trends in Denmark and Western Australia. Journal of Autism and Developmental Disorders, 41(12), 1601–1608. https://doi.org/10.1007/s10803-011-1186-0

Scopus. (2022). Elsevier. https://www.elsevier.com/solutions/scopus

Social Story Speech App for Teaching Emotions to Children. (2015). Touch Autism. http://touchautism.com/app/emotions-and-feelings-autism-social-story/

Socialstyrelsen. (2020). Socialstyrelsens egne beregninger vedrørende børn og unge med autisme. <u>https://vidensportal.dk/filer/handicap/socialstyrelsens-analyse-af-born-og-unge-med-autismespektrumforstyrrelser.pdf</u>

Taylor, B. A., DeQuinzio, J. A., and Stine, J. (2012). Increasing observational learning of children with autism: a preliminary analysis. Journal of Applied Behavior Analysis, 45(4), 815–820. <u>https://doi.org/10.1901/jaba.2012.45-815</u>

The Design-Based Research Collective. (2003). Design-Based Research: An Emerging Paradigm for Educational Inquiry. Educational Researcher, 32(1), 5–8. <u>https://doi.org/10.3102/0013189X032001005</u>

The original visual timer. (n.d.). Time Timer. Retrieved January 28, 2022, from <u>https://www.timetimer.com/</u>

Tokarskaya, L., Bystrova, T., and Rodrigez Aguilera, G. (2020). An Augmented Reality Book for Training a Child - ProQuest. <u>https://doi.org/10.34190/EEL.20.081</u>

Wang, F., and Hannafin, M. J. (2005). Design-based research and technologyenhanced learning environments. Educational Technology Research and Development, 53(4), 5–23. <u>https://doi.org/10.1007/BF02504682</u>

Watkins, L. (2015, April 7). 5 Popular Games That Help Children with Autism Spectrum Disorders. LearningWorks for Kids. <u>https://learningworksforkids.com/2015/04/5-popular-games-that-help-children-with-autism-spectrum-disorders/</u>

What is Kinect? - Definition from WhatIs.com. (2011). SearchHealthIT. https://www.techtarget.com/searchhealthit/definition/Kinect What Works Clearinghouse. (2017). Self-Regulated Strategy Development (p. 44). Institute of Education Sciences. <u>https://ies.ed.gov/ncee/wwc/EvidenceSnapshot/680#</u>

Wilson, C., Brereton, M., Ploderer, B., and Sitbon, L. (2018). MyWord: enhancing engagement, interaction and self-expression with minimally verbal children on the autism spectrum through a personal audio-visual dictionary. Proceedings of the 17th ACM Conference on Interaction Design and Children, 106–118. https://doi.org/10.1145/3202185.3202755

Wilson, C., Sitbon, L., Ploderer, B., Opie, J., and Brereton, M. (2020). Self-Expression by Design: Co-Designing the ExpressiBall with Minimally Verbal Children on the Autism Spectrum. In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (pp. 1–13). Association for Computing Machinery. <u>https://doi.org/10.1145/3313831.3376171</u>

Yuan, S. N. V., and Ip, H. H. S. (2018). Using virtual reality to train emotional and social skills in children with autism spectrum disorder. London Journal of Primary Care, 10(4), 110–112. https://doi.org/10.1080/17571472.2018.1483000

## List of appendixes

Appendix A - Results of the literature search on Scopus

Appendix B – Questionnaire

Appendix C - Transcript of the interview with the school teacher's assistant

Appendix D - Interview with the mother of a child with autism

Appendix E – Interview with the mother of a child with autism