Behaviour & Information Technology

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tbit20

Towards more supportive ICT for children with autism spectrum disorders: lessons learned from COVID-19 pandemic

Yussy Chinchay, Juan C. Torrado, Javier Gomez & Germán Montoro

To cite this article: Yussy Chinchay, Juan C. Torrado, Javier Gomez & Germán Montoro (18 Oct 2023): Towards more supportive ICT for children with autism spectrum disorders: lessons learned from COVID-19 pandemic, Behaviour & Information Technology, DOI: 10.1080/0144929X.2023.2268734

To link to this article: https://doi.org/10.1080/0144929X.2023.2268734

BEHAVIOUR & INFORMATION TECHNOLOGY
https://doi.org/10.1080/0144929X.2023.2268734

Taylor & Francis
Taylor & Francis Group

Towards more supportive ICT for children with autism spectrum disorders: lessons learned from COVID-19 pandemic

Yussy Chinchay[a]*, Juan C. Torrado[b]*, Javier Gomez[a]* and Germán Montoro[a]*

[a]Department of Computer Engineering, Universidad Autónoma de Madrid, Madrid, Spain; [b]Norwegian Computing Center, Oslo, Norway

ABSTRACT

COVID-19 pandemic has disrupted daily routines, causing isolation and quarantine. Technology has emerged as a crucial tool for sustaining essential activities, but children with autism spectrum disorders have faced distinct challenges due to their intricate interaction with it. We employed an online survey to analyse the impact of technology use in online learning, remote assistance and daily life of children with autism along COVID-19, and we have identified benefits and challenges with assistive technology exposed by the pandemic. Findings are divided in (1) seven themes where COVID-19 impacted this population the most and their relationship with technology (remote communication, learning, emotional management, entertainment management, executive functions, activities of daily living, and physical activity and motor skills), and (2) a mapping of technological categories that define the working areas specifically aimed to cover the special needs of children with autism whenever face-to-face interactions are not possible (attention, authoring tools, calculation, e-learning, emotions, entertainment, experience of self, language and communication, memory, planning and time management, social networking, and social skills). These results help provide a more well-rounded knowledge of how to improve technology to make it accessible to autistic children, to handle and avoid services interruption in similar scenarios.

ARTICLE HISTORY
Received 10 December 2022
Accepted 2 October 2023

KEYWORDS
Digital intervention; autism; COVID-19; assistive technologies

1. Introduction

On 30 January 2020, the World Health Organization (WHO) declared a public health emergency due to COVID-19, that reached the global pandemic category in March (WHO 2020). To contain the pandemic, many governments decreed the State of Alarm, which included lockdown, social isolation and quarantine measures. One month later, schools closure nationwide in 189 countries (Unesco 2021), limiting the access to important resources to vulnerable populations such as people with disabilities, which represent an estimated 15% of world population (WHO 2011). Outbreak's restrictions specially affected them in comparison with other students (Kaden 2020), as remote education and assistance systems require not only a proper access to IT resources but also access to specific tools and special education methods that fit people with disabilities needs (Martins et al. 2020).

Challenges of online learning and remote assistance, plus a disruption in routines, and the consequential COVID-19 uncertainty can prove to be a hard issue for children with Autism Spectrum Disorder (ASD) (Patel 2020). According to Diagnostic and statistical manual of mental disorders: DSM-5 (American Psychiatric Association, A., Association, A.P. 2013), people with ASD are characterised by having deficits in social communication and restricted behaviour patterns, interests, or activities. In addition, a third of people with ASD have associated intellectual disabilities (Maenner et al. 2020) and require multimodal treatments with specialised professionals to acquire autonomy and have an independent and empowered life (Bodison et al. 2022). This individualised attention from specialists was also affected by shifting to remote both education and assistance, as caregivers had to deal with technology limitations and because some individuals with ASD struggled to understand the pandemic situation (Courtenay and Perera 2020).

While some studies have analysed the general factors that affected e-inclusion and the impact of the pandemic on the physical, clinical and mental health of people on the spectrum (Dahiya et al. 2021; Doenyas and Shohieb

CONTACT Yussy Chinchay yussy.chinchay@uam.es Department of Computer Engineering, Universidad Autónoma de Madrid, Madrid 28049, Spain
*These authors contributed equally to this work

2021; Rosli et al. 2022), there is scarce specific information focused on technology's performance in assisting children with ASD during the health crisis. It is also important to acknowledge the growing body of literature concerning the use of ICT-based support for individuals with ASD within occupational settings (Kim, Crowley, and Lee 2022). Nevertheless, this aspect falls beyond the purview of the current study. The goal of this paper is, therefore, to provide an answer on how technology should be changed in order to adapt to children with ASD in the scenarios opened by the new normality for online learning, remote assistance and daily life. Thus, we aim at answering the following research questions:

- What was the role of ICT in the daily life of children with ASD during the COVID-19 pandemic?
- What challenges did children with ASD face during the shift to online education due to the COVID-19 pandemic?
- What should be improved to increase the opportunities provided by ICT as assistive technology for children with ASD?

The paper is organised as follows: after this introduction, the research methods followed in the study are described. After that, the sample demographics are detailed. Then, the results obtained from the data analysis are presented and, in the following section, discussed. The paper finishes summarising the conclusions and providing a set of future work lines.

2. Research methods

We decided to collect first hand information by running a survey among people related to ASD, in a phenomenological, proxy-based manner. We decided to use a survey, as it allows us to capture the big picture of an unknown phenomenon (Babbie 1990). Therefore, the purpose of the survey is to serve as a baseline data for future work that implements solutions to the challenges found in ICT for children with ASD, allowing them to continue their learning without interruption of services in crisis scenarios similar to the current pandemic.

2.1. Data collection

2.1.1. Online survey

We used as a data collection method an online survey (Best and Harrison 2009) which was developed and revised based on the authors' experience with research on ASD and assistive technologies. The survey, built as a questionnaire, targeted teachers, caregivers, and relatives of children with ASD. The reason behind inquiring them, instead of people with ASD, was to be able to capture the experiences of a wider set of them, not only from those with the cognitive skills to answer about their own situation. Additionally, even among those who would be able to answer the survey, there is a significant risk for acquiescence bias, that is to say, the tendency to select or indicate positive answers, regardless of the real situation.

We included a total of 29 choice-based questions and 21 open-ended (among both categories). The survey consisted of a variable number of questions, depending on the profile (relative or professional). Both profiles shared a common section to gather demographics, and then each profile had a set of questions related to:

- Relatives: Remote communication, homeschooling, leisure and emotions' management.
- Professionals: Remote communication and tracking, cognitive functions, executive functions, motor and physical capabilities, daily live activities development, and emotions.

As the survey is self-administered mechanism, we also included a way to be able to explore deeply the results by including a last question to ask respondents if they wanted to participate in a later interview and provide more detailed information. The platform chosen for the survey was Microsoft Forms, and the data was stored in Microsoft OneDrive.

2.1.2. Selection of participants

Survey was sent by email to a community around an online course about assistive technologies for individuals with ASD that was taught partially by the authors. Participants were additionally encouraged to extend the invitation to their personal networks, thereby facilitating the amalgamation of both purposive and snowball sampling methodologies. Consequently, the survey was disseminated to specialised educational institutions, families, and organisations actively engaged in addressing ASD and intellectual disabilities, mostly in Spain.

Both the dissemination of the survey and the responses collection happened in July 2020. We were able to collect data, experiences and reflections after a whole semester of lockdown and remote learning, through the first wave of the COVID-19 pandemic.

We ended up with a total of 295 survey respondents, which provides a strong base for current and upcoming research.

2.1.3. Ethics

Along with the invitation to participate in the survey, we attached a text introducing the nature of the study, its purpose and the targeted participant profile. The survey did not ask for names or personal identifiers of the respondents. We stored the data in OneDrive, only accessible using the credentials of the authors of the paper.

2.2. Data analysis

2.2.1. Mapping of technological categories

We included several questions related to technology use before and along the pandemic in the survey, which allowed us to create a mapping of technological categories focused on the needs of individuals with ASD. For the process, we used codes derived from Gillespie research (Gillespie, Best, and O'Neill 2012) which have an established validity and we also added new categories codes emerged from our study. Predefined codebook was: Attention functions, memory functions, planning and time management, emotional functions, calculation functions and experience of self.

2.2.2. Thematic analysis

We opted for a qualitative analysis due to the complex nature of caregiving and education for children with ASD, which requires tailored approaches. Our first step in this analysis was data preparation. We reviewed our questions and filtered the 21 open-ended ones where to apply thematic analysis. We used thematic analysis (Boyatzis 1998) to identify associations in the data and put forward propositions. Process consisted in observe each of our selected open-ended responses or verbatim, identifying themes, encoding these themes and start the codes development. Coding is the action of labelling each verbatim with one or more category. We followed a manual inductive approach for it: all codes arose from survey's responses directly, except for the case of technology mapping where we also used a predefined codebook. Our code development process was:

(1) Create a summary for each verbatim.
(2) Create meta-summaries by comparing previous results and identifying themes between them.
(3) Create preliminary codes that cover the meta-summaries to generate an initial codebook.
(4) Apply codes to the first open-ended response ($S_{n=1}$), creating new codes if needed.
(5) Read next open-ended sample (S_{n+1}) and code applying the previously updated codebook.
(6) Verify the intercoder agreement and whether we need additional codes for that sample. If so, create them and start over recoding all responses again from step 4.
(7) Iterate from step 5 until all answers are fully coded.

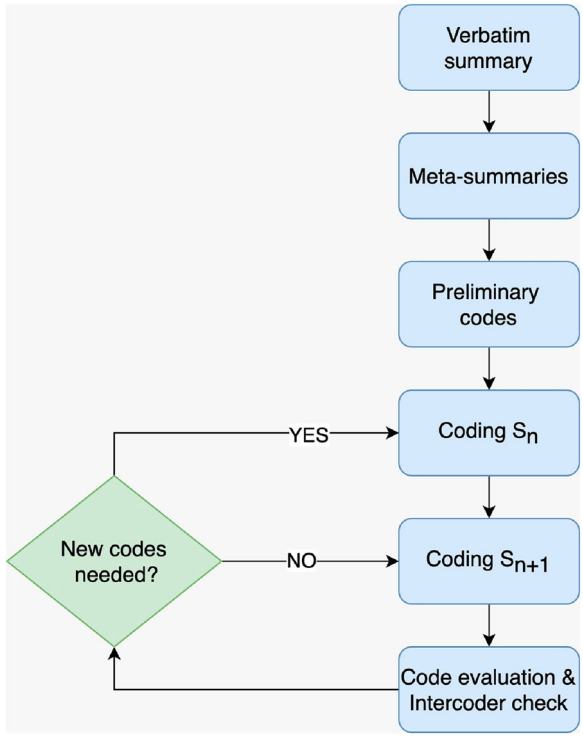

Figure 1. Thematic analysis process.

This iterative process can be seen in Figure 1.

Intercoder agreement was obtained through periodical meetings between the co-authors in step 6, as well as an initial and final round review of the codes. The first author was the main coder, and the rest of the co-authors reviewed, edited and proposed new codes to be added to the analysis in every iteration.

We have used MAXQDA software, version 20.3.0, to facilitate our codebook creation and assure having high quality codes provided with labels, definitions, inclusion and exclusion criteria, occurrence's frequency and examples.

3. Sample demographics

The ages of the 295 respondents ranged from 22 to 64 ($\bar{x} = 40.85$, $\sigma = 8.5$), from which 270 were women and 25 men. 147 (50%) of the participants were teachers, 75 (25%) were close relatives of children with ASD, 47 (16%) were ASD clinical staff, and 26 (9%) were non-educational experts in ASD. Related to their ICT experience, 168 participants (57%) reported to have basic computer skills, whereas 113 (38%) mentioned they have advanced computer skills, and 14 (5%) reported no computer skills. When asked about their experience

with assisitve technology, 204 participants (69%) reported a basic experience, 72 (24%) said they have advanced experience, and 19 (6%) reported no experience. Regarding occupation, 171 (58%) worked in educational centres, 61 (20%) worked in employments not related to ASD or special needs, 50 (17%) in health centers, 11 (4%) in centres of employment for people with special needs, and 2 (<1%) in research institutions.

Our online survey split the results into two groups from sample: a) the answers from the 75 relatives of children with ASD (25%), and b) answers from the 220 experts on ASD from the clinical, educational or research point of view (75%).

4. Results

We obtained a total of 212 technological applications mapped into 12 categories, whose distribution indicates in which categories there is more support of applications and in which more work could be done. Results are presented in Section 4.1 and discussed in Section 5.1.

Our thematic analysis identified the themes related to education, assistance and daily life, in which COVID-19 had the greatest impact for children with ASD and their use of ICT: (1) remote communication, (2) learning, (3) emotional management, (4) entertainment management, (5) executive functions (EF), (6) activities of daily living (ADL), and (7) physical activity and motor skills. This theme selection emerged from the answers and has also been informed by the previous research of the group on ASD (Torrado, Gomez, and Montoro 2020), which highlighted these aspects of the relationship between assistive technologies and ASD. The results of the analysis for each of these themes are presented in the Sections 4.2 to 4.7 and discussed in the Sections 5.2 to 5.7.

4.1. Mapping of technological categories

The obtained applications used for assistance are about both desktop and mobile environments, as well as platforms, websites and other software such as virtual reality and augmented reality. Many of these applications are actually not assistive but adapted to be used for special education (more than 80%). Similarly, various respondents adapted the use of some applications for areas other than those for which they were designed, making them match more than one category. For its mapping, we took as a starting point Gillespie's classification of assistive technology for cognition (Gillespie, Best, and O'Neill 2012) and we coded new categories that emerged from data as important factors for children with ASD.

Table 1. Mapping of technological categories.

Category	Number of applications
Language and communication	75
Emotion	37
Entertainment	36
Attention	27
Calculation	27
Planning and time management	27
Authoring tools	22
E-learning	21
Memory	15
Social networking	11
Experience of self	10
Social skills	7

Table 1 presents the technology mapping according to the following 12 categories:

- Language and communication: Ability to effectively communicate and share thoughts, feelings and desires. It includes the four basic skills of language: listening, speaking, reading and writing.
- Emotion: Ability of regulating feelings, thoughts and behaviours, as well as to identify own emotions and empathise with other people's ones.
- Entertainment: Activities associated with amusement and leisure.
- Attention: Cognitive function of attending a target external stimulus, internal experience or activity for a certain period of time.
- Calculation: Ability of performing and understanding math operations, and to apply logical thinking for problem solving and strategic thinking.
- Planning and time management: Cognitive skill of organising time and resources between tasks to achieve a goal in the most effective way.
- Authoring tools: Programs that allow to design, create and edit custom content.
- E-learning: It refers to the education that is performed through electronic devices.
- Memory: Capacity of holding on information in a short and long-term, making connections between this information and using it when needed.
- Social networking: Technology that allows users to interact with others and stay connected with family and friends.
- Experience of self: Processes related to own consciousness and the experience as an autonomous being. Awareness of identity and body perception.
- Social skills: Social-cognitive functions for interacting competently in a specific social situation. This includes verbal and non-verbal communication and being able to predict and interpret other people's behaviour.

Language and communication, and social skills have been included as additional categories to those that came from Gillespie's classification, as people with ASD often show issues in those areas, and therefore it is important to provide a specific classification for them. The remaining categories of e-learning, authoring tools, social networking and entertainment were chosen due to their relevancy to the ongoing situation. A complete list of applications mapping found in the study is provided by Chinchay, Gomez, and Montoro (2022).

In addition to this mapping, we have also analysed the preferences of survey participants on the type of device used for assistive technologies, as depicted in Figure 2.

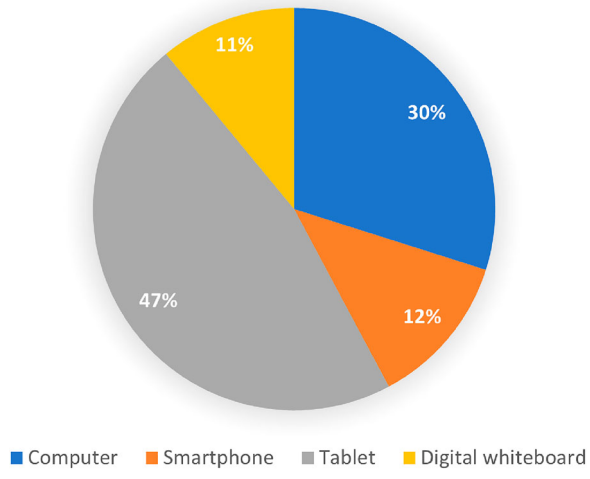

Figure 2. Preference of devices used for assistive technologies.

4.2. Remote communication

Remote communication refers to how technology allowed to keep contact not only with family and friends but with educational institutions and related professionals. According to our results, relatives and caregivers preferred to use during the pandemic emails (75%), video calls (60%), messaging applications (40%) and phone calls (35%), while professionals prioritised video calls (83%), emails (72%), phone calls (70%) and messaging applications (69%). As a last option, other media were chosen such as teaching platforms and educational blogs (by 18% relatives and 10% specialists). When addressing the online communication difficulties faced in this period, relatives and caregivers highlighted people with ASD struggled to focus on the communication tool (65%), they experienced bad image or sound quality issues (33%) and miscellaneous technical problems like logging in or managing the applications (13%), they hampered by a lack of technical resources (11%), they stated communication tools were too complex (5%), and 13% reported they did not have any difficulties. For their side, professionals detected as a main issue the lack of technical resources (66%), followed by bad audio or video quality (30%), technical difficulties (22%), complexity of communication tools (13%) and 14% stated no difficulties were experienced.

Overall, remote communication has been classified in 3 main categories according to the 295 respondent's feedback: positive (41%), neutral (17%) and negative (42%). We will focus on analysing the relation of the positive and negative categories with other codes as they concentrate the more information. In Figure 3 we found out that the most remarkable positive codes are

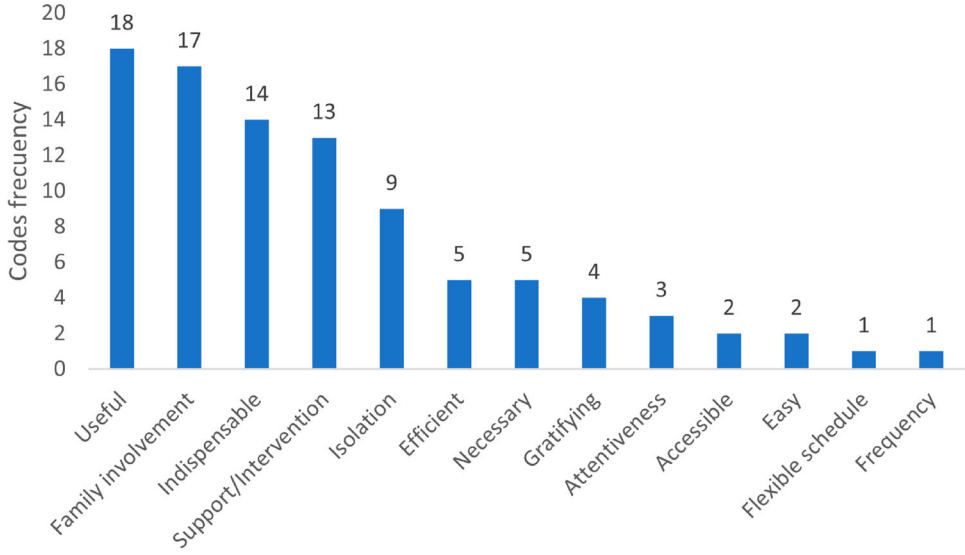

Figure 3. Frequency of codes with positive category for remote communication.

highly related to how useful and indispensable online communication has been for homeschooling, family involvement while using this resource, and the support and intervention provided by specialists. Results also show that, after a first adaptation needed in the use of chat platforms and applications, online interaction became crucial to avoid the isolation caused by the lockdown measures. In Figure 4, coded as 'negative', we came to the issue of how complex and difficult technology was for the end users. This was mainly due to digital divide, lack of knowledge about which tools to use, inexperience with the new learning methodology, dependency on caregivers' resources and availability, network connection issues, among other reasons. It was also highlighted that most online communication platforms were not special needs oriented and some users struggled to hold their attention to the screens. The participants pointed out that technology is still limited in terms of interaction options and that makes it sometimes unusable to some individuals with ASD.

4.3. Learning

We analysed how the learning situation of children with ASD was managed from a technological point of view, based on the category mapping proposed in our study.

In Table 2, we can observe the technological categories distribution of at-home learning performed by relatives before lockdown. Language and communication, and calculation are the most practiced with 50% of total dedication, while remaining areas are relegated in a second place by relatives and caregivers. We also observe how there is no use of e-learning, social networking and authoring tools at home for educational purposes. However, categories distribution changes when we analyse the ASD specialists' responses for the same period (Figure 5). Language and communication category continues to be in the forefront, but remaining areas are worked on in a more homogeneous way. Likewise, professionals do make use of authoring tools, although the use of applications for e-learning and social networking remains scarce before the pandemic. In the same Figure 5, we can see how this situation

Table 2. Family at-home learning per technological categories before lockdown.

Areas	Percentage
Language and communication	40,68
Calculation	16,95
Social skills	8,47
Experience of self	8,47
Entertainment	8,47
Planning and time management	6,78
Emotional	5,08
Attention	3,39
Memory	1,69
Author tools	0,00
E-learning	0,00
Social networking	0,00

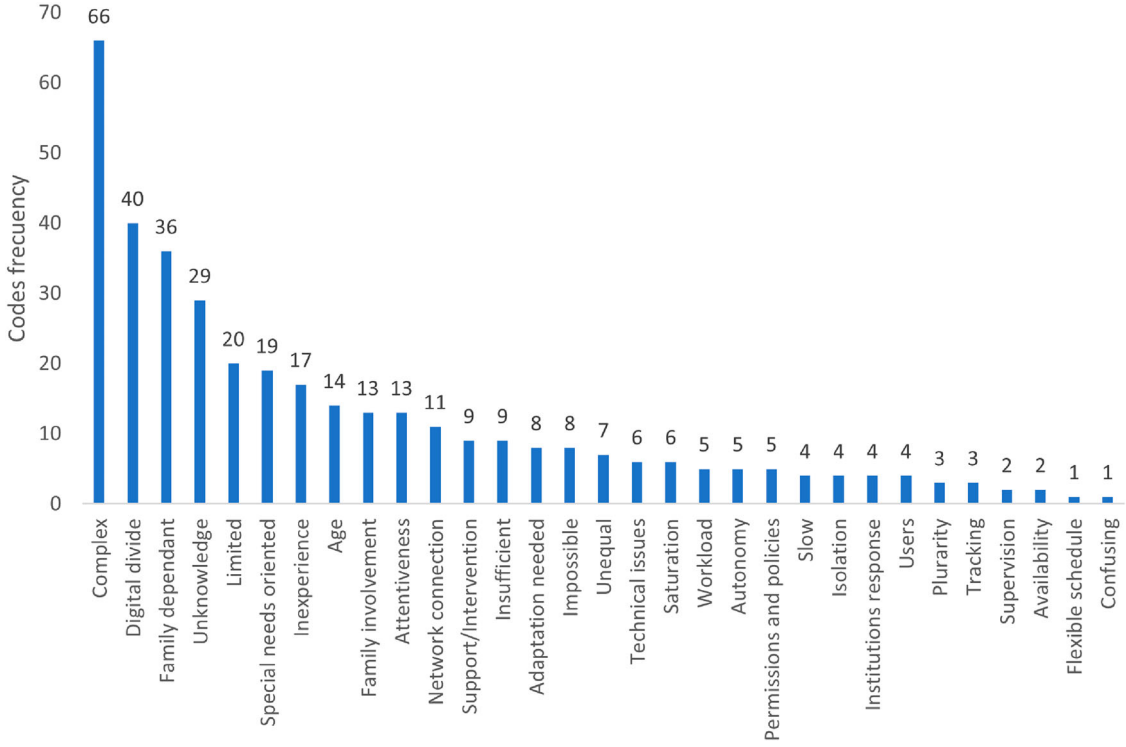

Figure 4. Frequency of codes with negative category for remote communication.

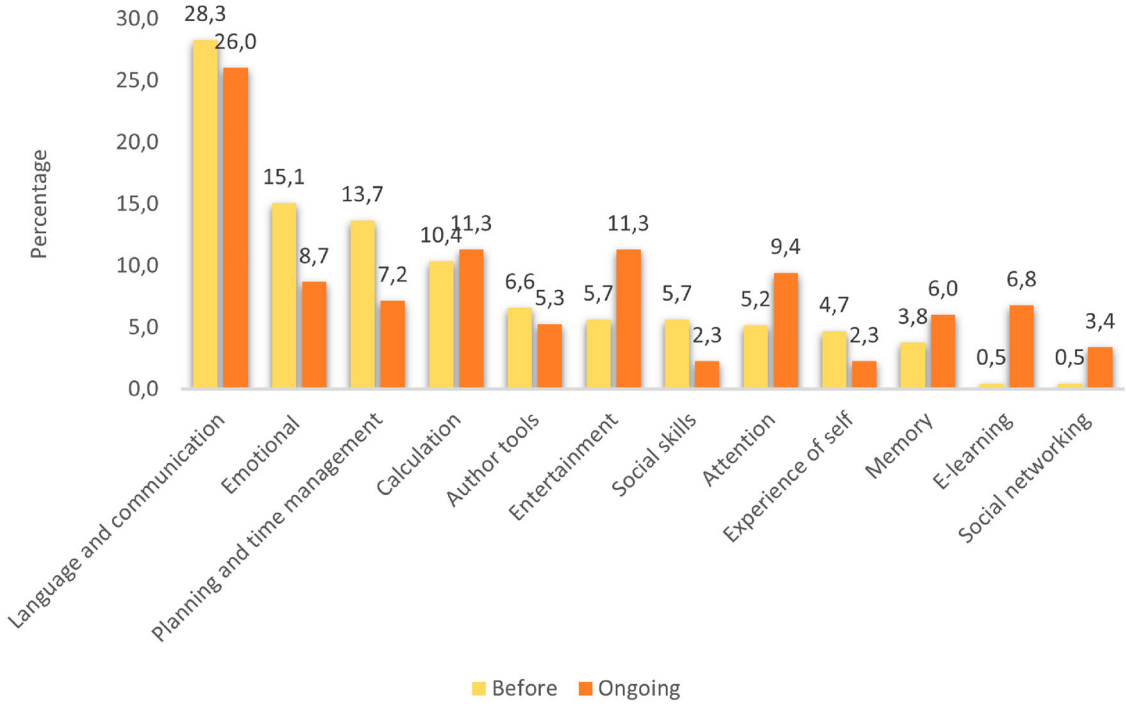

Figure 5. Technological categories evolution before and along lockdown period.

changes along lockdown. The e-learning (+6,3%) and social networking (+2,9%) applications presented the more marked change, due to the shift to remote education. Some areas such as language and communication (−2,3%), calculation (+0,9%), and authoring tools (−1.3%) remain stable, while others are reduced in practice, such as experience of self (−2,5%), social skills (−3,4%), emotional management (−6,4%), and planning and time management (−6,5%). There is also an increase in memory (+2,3%) and attention (+4,2%) areas and we can see how the percentage dedicated to entertainment doubles (+5,7%). This last phenomenon will be discussed in depth in the next sections.

For this same period, relatives and caregivers indicated that they arranged the educational activities mainly by exchanging them through e-mail and educational platforms (79%), they also proposed their own activities (39%) and 9% stated they were not able to continue with homeschooling. Communications tools were used by specialists to monitoring the learning process which was developed delivering paper-based activities to relatives (60%), using specific applications (38%), recording videos (39%), through live lessons (28%), online work groups (22%) and 19% described other methods such as sharing presentations or giving support by phone calls in the cases where there was a lack of technical resources at home. Among the issues related to this new learning approach, relatives commented they faced similar ones as with remote communication, but also adding the need of constant supervision (52%). Professionals indicated as a problem the lack of knowledge about applications by individuals with ASD and their relatives (70%), and from their own side (16%). They also reported an increased workload (66%), limitations of technology in comparison to face-to-face tracking (59%), lack of technical resources from the family's side (62%), lack of technical resources from their own side (14%), other difficulties such as poor family involvement and feedback (5%) and only 4% specialists reported no difficulties. Aside from these general learning drawbacks, professionals also reported challenges while developing emotional management, executive functions, and ADL skills, such as difficulty monitoring the student's progress (69%), limitations of video-based education (33%), technical issues (26%), difficulties derived from dependence on families to continue with education (16%) and only 7% did not indicate any problem. Concerning global advantages of this new situation, specialists highlighted time flexibility (54%), an overall positive impact on end users (26%), improved self-organisation (25%), better overview of student's progress with online tracking (17%), other advantages such a greater family cooperation and collaboration (12%) and 22% of professionals found no advantages. As specific learning benefits for emotional management, executive functions, ADL, physical activity and motor skills, they stated the fact that online sessions could be recorded

(30%), there were less behavioural issues when working online (17%), individuals with ASD focused better this way (12%), 16% indicated other advantages that will be described in the thematic analysis, and 40% of specialists found none.

Regarding the use of ICT for education, results display a low usage of it before the pandemic. Only 25% of family members integrated applications in at-home learning, compared to 43% of the specialists. However, this statistic changes during the time of online learning, reaching 78% of ICT use.

4.4. Emotional management

We obtained 511 codes correspondent to the emotional management theme, both before and along the application of COVID-19 restrictions. Results showed that in 52% of the cases no ICT was used for developing this skill before the health crisis. Emotional management was mainly carried out through activities such as game dynamics, relaxation exercises, workshops, role-playing, among others. There was also a big use of manipulative materials, such as pictograms to express emotions, and sensory toys to self-regulate behaviours and regain calm. Technological resources were used in a complementary way in 26% of the sample (music, videos, projectors), and only 22% of the specialists used specific ICT applications to work on emotions.

Changing to homeschooling, specialists used videos recorded (30%), live lessons (27%), applications (23%), online work groups (30%), and 7% could not continue these activities. 32% of the professionals mainly chose to entrust the task of emotional management to relatives and caregivers, providing them with both guidelines and personalised materials to be used. Other than the new communication approach, there were no big changes from an ICT point of view. It did not really change the way of managing emotions, but the emotions to be managed as new negative ones emerged. In Figure 6 we display these concepts related to the emotional impact that declaration of the state of alarm and, later, the so-called 'new normality', had on children with ASD.

4.5. Entertainment management

Some digital media can become too attractive for people with ASD and one of the biggest families' concerns along lockdown was the possible rise in

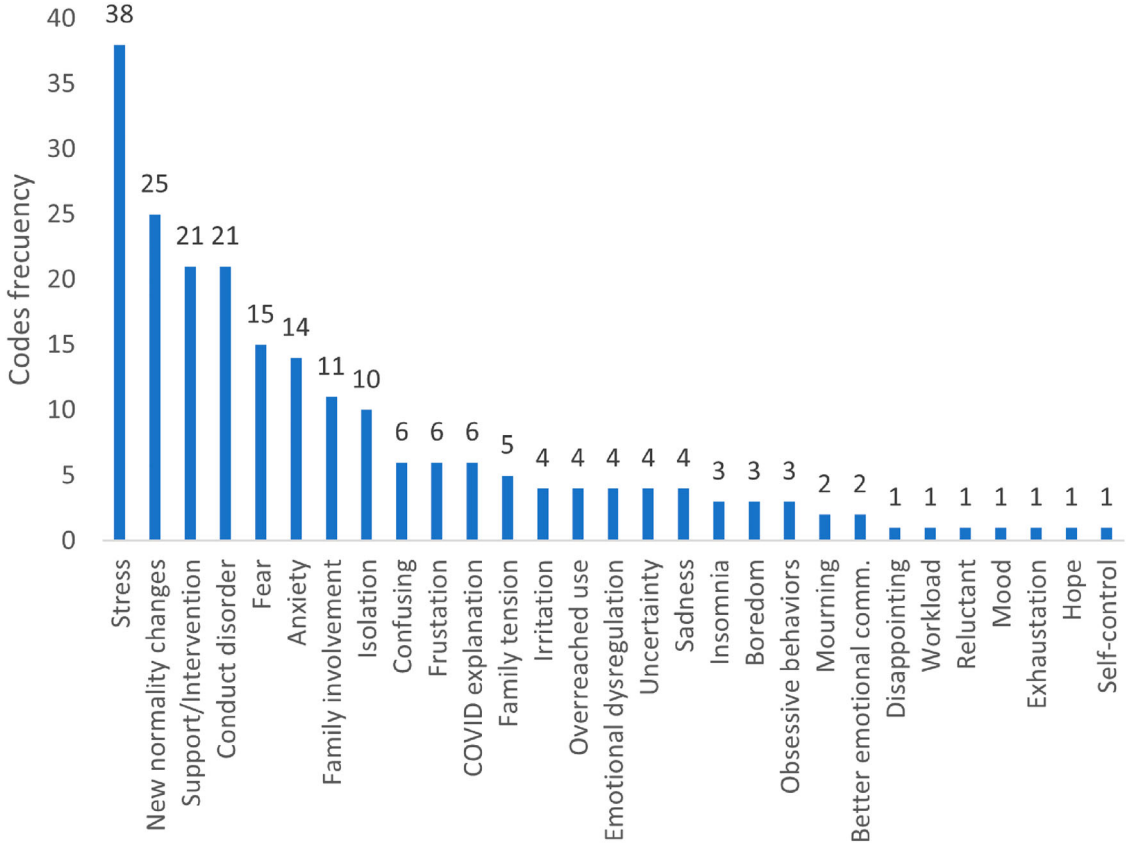

Figure 6. Frequency of codes related to emotional management.

problematic ICT use and the addiction they may cause (Kawabe et al. 2020). We observed that children with ASD mainly used video streaming (88%) and gaming applications (36%) in their leisure time, which are the technology-based activities where they spend more hours per day compared to neurotypical individuals (Mazurek and Wenstrup 2013). In a minor percentage, they also used social media (9%). All this ICT for entertainment were mostly used on mobile devices (83% on tablets and 63% on smartphones), computers (53%) and game consoles (21%). Respondents also reported perception of spare time increased due to disruption of routines and quarantine measures, and time spent at entertainment doubled consequently (Figure 5). Furthermore, some family members faced difficulties managing the ICT use for leisure, due to their workload. As one of our respondents commented:

> [···]*during lockdown, we both parents have worked, that's why we could not control the hours of technology [that our children] used.*

In fact, only 55% of the surveyed relatives and caregivers reported to take action in managing a responsible ICT use for entertainment along the pandemic. From this percentage we have obtained 42 responses where we analysed (1) the cases where there was excessive use of technology (mostly in tablet), and (2) the strategies followed to avoid a dysfunctional ICT use (Figure 7).

4.6. Executive functions

Prior to the pandemic, ASD specialists detailed that EF training was performed preferably through non-screen activities and by using manipulative materials. Less than the half of our respondents (44%) included technology as a visual aid for the learning activities. They incorporated online resources such as virtual agendas, presentations, videos and timers. Only 22% of the professionals used specific ICT applications for executive functions or applications indirectly associated to it such as the ones focused on memory, planning and time management, attention, and language and communication.

Specialists maintained this use of manipulative materials during lockdown by sending paper materials to relatives and caregivers (56%). Although they used authoring tools to create these custom resources (29%), and incorporated video applications for e-learning (29%), they did not report major changes in ICT use for EF. Regarding the issues faced with this methodology, professionals highlighted the digital divide, a high family dependence, lack of learning resources, attention issues and 3% stated they stopped developing these skills. Among the advantages of EF online learning, 11% of the specialists mentioned an increased family involvement in their children's education, flexible therapy schedule and a greater motivation of students with the media, which also led to some improvement in communication.

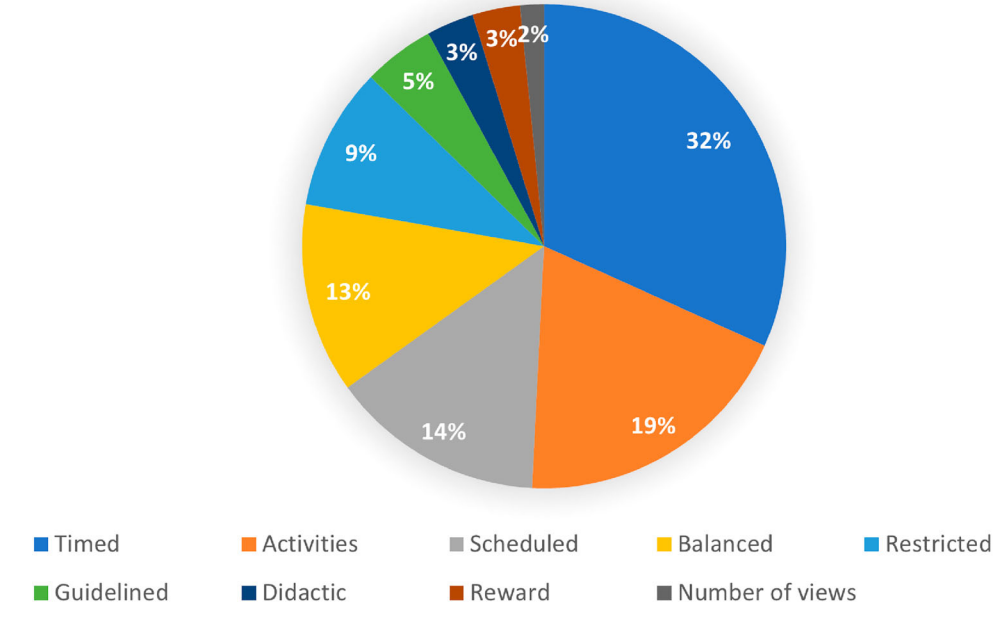

Figure 7. Strategies for managing ICT use for entertainment during lockdown.

4.7. ADL, physical activity and motor skills

ASD specialists responses corroborated that these trainings were carried out through practical experiences before the pandemic. ADLs were improved mainly through workshops, social stories and role plays, while physical activities and motor skills were performed through psychomotor exercises, physical therapy, sports, among others. Our results show that only 20% of respondents used technology for ADL development and 16% for physical activities. In both cases, low technology was used as a complement such as presentations, music, videos, digital calendars, visual clocks and digital whiteboards. ADL skills were also reinforced through few ICT applications of planning and time management, experience of self, and social skills.

Along lockdown, professionals' support became online and outdoor activities were restricted. Training of ADL, and physical and motor activities were managed through recorded videos (38% and 45%), live sessions (16% and 21%), activities carried out by relatives (32% and 24%), online work groups (11% and 13%) and a small use of ICT applications (14% and 6%). In 14% and 16% of the cases, ADL and motor activities, respectively, stopped during this period. Professionals also supported relatives and caregivers by sending sequence of activities to be carried out at home (39% COVID-19 associated).

5. Discussion

In this section, we will discuss the results of our study, starting with the mapping of the 12 technological categories and continuing with the 7 themes where COVID-19 impacted people on the spectrum the most and their relationship with technology. These themes are encompassed in the area of education, assistance and daily life of people on the spectrum, given that these aspects are the most relevant when it comes to designing, developing, and evaluating ICT for and with them.

5.1. Mapping of technological categories

Assistive technologies are those that meet the needs of people with all types of functional diversity. For our proposal of technological categories that cover the specific needs of people with ASD for remote learning and support, we have used as a basis a study on the relationship between assistive technology for cognition and cognitive functions (Gillespie, Best, and O'Neill 2012), according to the International Classification of Function: attention, calculation, emotional regulation, experience of self, memory, and organisation and planning. Then, based on our thematic analysis, we have detected the most important areas that support skills development of people with ASD: Language and communication, social skills, e-learning, authoring tools, social networking and entertainment. The 212 applications cited in the survey responses have been categorised using these 12 technological categories. This mapping of technological categories could benefit children with ASD and help understand the global vision of the areas in which it is necessary to improve or create new ICT assistance solutions to support both education and daily life of children with ASD, also considering crisis scenarios in which face-to-face support is not possible. For instance, we can see in Table 1 how the number of tools for language and communication stands out, followed by entertainment applications and by others related to more common cognitive processes such as emotional functions, calculation, attention, planning and time management, and memory. However, we found few examples related to other competences such experience of self or social skills.

We also observed how applications not intended for assistance have been adapted to different areas related to special education, since only less than 20% of them are focused on special needs. This could indicate that more awareness about existing assistive technologies is needed by users, or that there is a lack of applications targeting the specific needs of children with ASD.

Regarding the devices used as assistive technology, we can see in Figure 2 that tablet's use is prominent, followed by computers, smartphones and digital whiteboards. Tablets as a preferred option is likely to be due to their characteristics and advantages for education: they are portable wireless devices that can be used when and where it is required, it allows customisation to fit specific needs, it increases motivation and attention, and it offers a satisfactory screen size compared to smartphones (Algoufi 2016). We also got some answers related to the use of virtual reality and augmented reality, but they did not have a significant presence in the results (<1%). Reasons for this could be that there are still few projects using 3D graphics oriented to people with special needs used in everyday life, and because that solutions are usually more expensive and have some negative side effects (Bellani et al. 2011).

5.2. Remote communication

The role of ICT in remote communication along the pandemic has been crucial to keep people connected and avoid the isolation feeling. According to our

study, relatives and professionals stayed in touch using medias according to their experience with them, highlighting the use of emails and a minor communication through new educational platforms.

We obtained a similar percentage of positive (41%) and negative (42%) feedback about this topic, belonging most of the positive ones to the final stage of switching to online interaction. Respondents argued that, initially, some schools and special education centers were not prepared for this situation as they did not count with the necessary tools and permissions to perform remote education. There was no common strategy on which communication tool to use among the variety of available applications and, according to the technological categories mapping shown in Figure 5, children with ASD did not have enough experience with e-learning and social networking tools, which made the transition to the new communication channel tough. Furthermore, many online video platforms interfaces are not compatible with assistive technology since they saturate users with stimuli, especially when there are many students connected, make it difficult to capture non-verbal language, and generate a mental exhaustion already known as 'Zoom Fatigue' (Bailenson 2021). Some platforms such as Zoom and Microsoft Teams have recently started working on solutions to offer immersive video calls, which resemble a physical environment to improve the interaction of the participants and reduce this fatigue (Together mood and Immersive View).

If we analyse Figures 3 and 4, we can observe that there are answers that match both positive and negative feedback, such as family involvement. Family support was sometimes required while using the communication tools due to most chat applications are aimed at a young adult audience and they are not special needs oriented (Calvo, Iglesias, and Castaño 2017). Consequently, relative's interest and collaboration in the learning process of their children raised. However, their overstretched support entailed a decrease in the autonomy of the individual with ASD. There were also advantages of remote communication, after a period of change adaptation, since it can provide individuals with ASD benefits in social interaction. They feel more comfortable with it, many of them prefer it to face-to-face interactions, and they experience less social pressure by having greater control over communication (Burke, Kraut, and Williams 2010). Therefore, it is important to adapt these tools to their special needs by, for example, improving the user interface accessibility to provide more autonomy, or by expanding the videocall moderator's options so that they can regain the attention of participants to the screen, as people with ASD struggle to keep this attention (Murray 2010).

According to specialists in our study, overall, remote communication worked best for children with special needs such as high-functioning autism (HFA), Asperger's or Attention-deficit/hyperactivity disorder (ADHD). However, it was marked as impossible when dealing with young children, users with severe autism, cognitive disabilities or impaired speech, in which cases students partially lost their educational intervention services (Jeste et al. 2020).

5.3. Learning

Before lockdown, our results showed that the role of ICT was apparently complementary. It was used as an aid for teaching, to reinforce concepts or to motivate students, and not as a main source of learning. This partly explains why the percentage of ICT used both at home and in educational centers was low before the pandemic. Therapists seem to prefer using manipulative materials and face-to-face activities for education instead of ICT. Reasons for this could be the need of adapting teaching to the particular needs and preferences of each child with ASD (customisation). In addition, personal tracking of their progress and performance is desired. These requirements are, in many cases, hard to achieve through ICT, since customisation and tracking options may be limited. This may explain relatives and specialists chose to exchanged paper-based activities along lockdown. However, it was also necessary to include ICT to continue with education through videos and specific applications, having to face the challenges that they entailed. A common e-learning impediment that both relatives and specialists commented was digital divide (Van Lancker and Parolin 2020), highlighting the lack of technological resources (Parmigiani et al. 2021). According to relatives and caregivers, 15% of them were affected by this lack of technological resources, contrasting with the 62% commented by specialists in the case of families, and 14% in their own cases. This difference in percentages may be due to the global perspective of the professionals with respect to all the families they worked with, and the fact that the number of relatives who participated in the online survey had already some access to technology (the same would apply to the participating professionals). Some families were excluded from the new educative approach because of not getting these minimum required resources. Likewise, there were families who could not work remotely (essential employees such as health workers, supermarket personnel, security forces, delivery people, etc.) or that had an excessive workload at home, so they could not support home education.

Curricular adaptation along COVID-19 pandemic was complicated considering results indicate that learning process was mainly school and special center-based, with generally little parent involvement in education. Families were not prepared to face academic activities (Stenhoff, Pennington, and Tapp 2020) and their dynamics seem to have changed during the pandemic to deal with adapting to new routines and provide constant care. This impacted the learning performed through technological categories (Figure 5) and it will be discussed further in next sections.

Finally, we analysed the advantages of remote education which were mentioned by specialists in a low percentage. We believe that few advantages were obtained due to our study was carried out in the initial phase of this change to online teaching, and it will require an adaptation period to perceive all the possible opportunities ICT can provide in learning, particularly in special education (Konstantinidis et al. 2009). Likewise, it will be necessary to improve the design of e-learning platforms to include requirements aimed at people with special needs, and to increase the training of professionals, caregivers and relatives in the use of assistive technologies.

5.4. Emotional management

Even if emotional dysregulation is not included as a criterion in the formal definition of ASD, many individuals with ASD face impairments in their emotional functions and behavioural disturbance (Samson et al. 2015). Thus, therapeutic interventions are needed to develop the emotional competence. Our study shows that emotion regulation was traditionally worked in-person, using ICT as a complement. This situation did not change especially along COVID-19 pandemic since specialists decided, in most cases, to continue with face-to-face emotional development through relatives of people with ASD. However, dedication given to learn the emotional category decreased (Figure 5). This could be due previous experience and preference of relatives supporting other cognitive areas at home such as language and communication, and social skills, which are certainly associated with emotional skills but do not directly develop emotional competence (Saarni 1999). Another reason could be the main change of relatives and caregivers to home educators as they may struggle to effectively help express emotions and handle crisis situations. There were no major changes in ICT applications use, probably because parents strictly followed specialists' recommendations and did not have time or capacity to experiment with new technological resources. This change in the learning approach also emotionally affected children with ASD, as we can see in the values of Figure 6. Many of them were reluctant to parents switching roles and that caused family tensions, coexistence issues, emotional dysregulation and conduct disorders, which parents reported did not occur in the previous education at schools.

Daily routines and habits disruption due to lockdown measures, added to the general uncertainty of the health crisis, led to new emotions to be managed. It highlighted the stress, anxiety, fear, isolation, and the appearance of obsessive behaviours related to preventive measures against COVID-19 (excessive both hand washing and use of hydroalcoholic gel). Likewise, sleeping difficulties such as insomnia and nightmares also worsened as a consequence (Jiao et al. 2020; Lindor et al. 2019). Although existing emotional management applications were not intended to address all these specific new emotions, ICT played a key role in mitigating these negative feelings. Authoring tools and social story applications were instrumental in creating new material to facilitate understanding of the ongoing situation as individuals with ASD struggle with phenomenological perception (Pellicano and Burr 2012), and to help facing new scenarios such as diagnostic tests, temperature taken or, in worst cases, even mourning. Nevertheless, ICT had some limitations and professionals faced issues such as the impossibility of observing responses to spontaneous situations, and depending, to a great extent, on parents' feedback.

However, not all the emotional impact was negative. We detected in our study some ICT advantages for emotional management associated with the use of video calls. Some individuals with ASD improved emotional expression and emotional communication thanks to the online lectures. As one of the participating specialists indicates,

> [the children] enjoyed using the computer and I have even come to have a better connection with some of them than in person.

This may be because, although individuals with ASD face difficulties in direct interaction, ICT offers them a channel of communication in which they feel more comfortable (Benford and Standen 2009). We believe that, after some adaptation time to remote learning, specialists could take even more advantage of ICT to enhance emotional competence and integrate mobile applications created to improve emotion recognition and emotion regulation. Examples of these applications are Wrong Planet, LIFEisGAME, My Drama, among others (Papoutsi, Drigas, and Skianis 2018).

5.5. Entertainment management

Implications of lockdown period such as home-schooling and the absence of outdoor routines caused an increased use of technology, according to parent's report. ICT was used more frequently and for a longer duration along the day to help fill the spare time and alleviate some of the negative emotions. However, its overuse also led to adverse scenarios. In the cases in which we detected an overreached use of ICT for entertainment, a dependence and addiction to it was generated, making it hard to stop using them or switch to other activities. In those circumstances, our results show that emotions such as stress, agitation and lower tolerance increased when family members tried to remove all electronics from the children with ASD. Likewise, our qualitative analysis found a relationship between this dependence and an increased self-isolation experienced by people on the spectrum (Finkenauer et al. 2012), as well as less dedication to other non-screen activities such as physical exercise. For these reasons, it is important to monitor the responsible use of ICT for leisure time. In Figure 7, we can observe the measures taken by relatives and caregivers to manage this use, ranging from flexible strategies to more restrictive ones. According to results, timed or scheduled sessions were the preferred option to avoid excessive use of applications. Second most used measure consisted of alternating ICT use for entertainment with other non-screen activities such as family games and physical exercise. In some cases, a total replacement of technology with these activities was also chosen. On a more restrictive side, we found the complete elimination of access to ICT for leisure, control over the number of video views, or even an increased load of other activities such as homework or tasks at home to reduce spare time. Lastly, some relatives decided to guide the applications to be used, including didactic or serious games, and using the time dedicated to ICT as a reward.

Spare time is an important part of day-to-day and children with ASD could actually benefit from leisure use of ICT. Applying a well-balanced strategy and a functional use, ICT leads to improvements in expressive language skills and could also be effective for teaching social understanding (Wainer and Ingersoll 2011). In addition, the exposure to ICT can enhance learning, social language and communication thanks to the video modelling and deferred verbal imitation (Shane and Albert 2008). Therefore, it is fundamental to make a balanced use of ICT for entertainment that allows to take advantage of the offered benefits, improve their use with less overexcitation, and achieve a disengaging of them and a proper re-adaptation when COVID-19 crisis has passed (King et al. 2020).

5.6. Executive functions

Executive functions are the cognitive abilities related to organisation, planning, memorisation and decision making. They also help controlling emotions and inhibiting inappropriate responses. Children with ASD experience some EF-related difficulties (Robinson et al. 2009), therefore it was strongly recommended to continue their therapies in an online modality along the lockdown. However, there were some issues while applying this remote learning. Firstly, our study detected a dependency between executive functions during the pandemic and digital divide, which partially explains the low use of ICT for them. Secondly, specialists mentioned also a dependence on family availability and, in few cases, a certain resistance from families with some of the proposed activities because they did not completely understand their importance. Relatives and caregivers also struggled with facing the learning difficulties of their children and with using some of the recommended ICT applications. Some parents commented that an assistive technologies training would have helped them in their task of continuing with education at home. Thirdly, a lack of learning resources was reported, especially in certain languages or for a younger audience, and a low knowledge about ICT focused on executive functions as there is not much information about assistive technology solutions to support these skills (Desideri et al. 2020). Lastly, other technology-related issues were mentioned such as few customisation options to adapt content to students' needs, the struggle to maintain control, interaction and concentration of children with ASD in video sessions, and the impossibility of conducting lectures by videocalls with young children students.

5.7. ADL, physical activity and motor skills

Activities of daily living are essential for the autonomy and integration of children with ASD. However, many of them face issues with their daily living skills caused by cognitive impairment, atypical sensory responses and motor difficulties (Jasmin et al. 2009). Improving their self-care activities and structuring their ADLs is very important, especially when daily routines are broken, because people with ASD struggle with managing uncertainty, change, and novelty (Hodgson et al. 2017). Physical activity could help cope with the

emotions stemming from the uncertainties of the pandemic, but these activities were also conditional on COVID-19 restrictions.

As we saw in the results, relatives and caregivers supported with ADL training along the lockdown by developing appropriate behaviour of individuals with ASD, generating responsibilities and structuring schedules and spaces at home, which were reported as not necessary before the pandemic. As a result of lockdown measures, some families also opted for the strategy of intensifying routines and home tasks with the purpose of filling in spare time and avoid excessive use of ICT for entertainment.

ASD professionals guided the parents through this learning and provided them custom materials created with authoring tools to develop this skill and to explain the impact of health crisis on some ADL, which had to adapt to new health regulations such (changes in social distance, hand washing, masks and gloves use, temperature measurement and diagnostic tests).

Motor skills and physical activity development were managed in a similar way. Although video sessions with specialists were somewhat higher in comparison with ADL management, the use of specific applications and family support was lower. Probably, relatives and caregivers had difficulties in following the specific recommendations of physiotherapists and other professionals, and they were also limited to restrictions of carrying out outdoor activities or had limited space for indoor activities to promote physical activity. Although therapeutic walks were allowed for people with special needs during the state of alarm, in some cases fear led to remain at home.

Among the challenges for remote learning both skills, since many of the activities were done through family collaboration without ICT support, professionals reported issues such as insufficient feedback about the development and timetable dependency with parents. In addition, in a similar way as it happened with EF, some families showed resistance to some recommended activities and did not understand their objective. There were also challenges that could not be overcome, such as having highly dependent students who need direct support and with whom telematic means do not work. These severe cases also struggled with ADL adaptation as they could not tolerate the use of masks or maintain social distance.

Overall, motor and self-care skills were little explored, despite the importance they have. Poor motor skills affect autonomy of people with ASD in their ADL, and poor physical activity impacts academic performance and motor skills development (Donnelly and Lambourne 2011).

Regarding the low use of ICT for the development of these competences, it may be due to the lack of knowledge of ICT solutions, to the technology-related disadvantages found as difficulties in monitoring the activity, and the belief that if these activities are developed in person, ICT are not required. However, the use handheld devices and new technologies such as wearable devices or virtual reality can help reduce common problems experienced by many students with ASD (Karami et al. 2021). For example, video recording applications can support motor and movement analysis (Krause and Taliaferro 2015), virtual reality applications can simulate relaxing environments that motive physical activity and wearable devices can track the activities regardless of where it takes place.

5.8. Summary

ICT were the communication and learning support that allowed to maintain a certain stability in the daily life and education process of people with ASD during the COVID-19 crisis, where collaboration between specialists and relatives was also instrumental. However, its main use was focused more on remote communication, while teaching of specific areas continued to develop using traditional means, by sending back and forth paper-based materials. Professionals adapted ICT to simulate the previous existing learning system (RQ1). We found out that this may be due to the limitations of technology compared to direct interaction and the challenges found to carry out homeschooling for ASD students. Overall, digital divide, family home support, lack of knowledge of assistance applications or the excess of them without a metric that indicates their effectiveness, and the lack of consideration of special needs in the design of e-learning solutions were some of the major challenges faced. From Sections 5.1 to 5.7, we also discuss the specific issues per impact theme along the shift to online education related to monitoring, tracking, attention and customisation limited options, between others (RQ2). Thus, it is required to review and adapt ICT belonging to the mapping of technological categories proposed (attention, authoring tools, calculation, e-learning, emotions, entertainment, experience of self, language and communication, memory, planning and time management, social networking, and social skills), especially in those where we have detected a greater impact because of health crisis, to cover the deficiencies found and ensure that technology is accessible to people on the spectrum. Developing a structured learning environment by adapting ICT to special needs, simplifying user interface accessibility to

minimise unnecessary stimuli, and keeping a collaborative learning setting would also benefit children with ASD. Likewise, it is very important to understand the value of engagement in using ITC both in education and in daily life, to reduce the impact that the new normality or a future threat like the COVID-19 pandemic could entail, and to take advantage of the fact that ICT can serve to train several skills of people with ASD. We should also consider that ICT are only as effective as the learning and assistance support provided to its users. Therefore, training programs are required to increase digital competence of professionals, relatives and caregivers of people on the spectrum, and to teach relatives the necessary skills for an effective learning and assistance support. These improvement actions, along with knowledge provided by the mapping of technological categories, could help increase the opportunities that ICT provides for people on the spectrum (RQ3).

6. Limitations

Despite of the variety of our sample and the topics covered in the survey, the results are limited by three factors:

- Sample bias: part of the participants were former students of a mobile technologies and ASD course. Therefore, their previous knowledge and interest may have biased the results. Additionally, the composition of participants primarily hailing from a single country presents a constraint on the extent of the study's representational scope. Nevertheless, the contextual insights derived from this study offer valuable comprehension of the overarching phenomenon under scrutiny.
- Time frame: the study was carried out after the first wave (during the summer of 2020). During this period the information, previous experience and awareness were very limited. A comparison with the measurements and approaches taken during subsequent waves might be relevant for the audience.
- People with ASD inclusion: Their point of view might produce a better understanding of the situation, feelings, technology acceptance, etc. However, it might be also biased and difficult to acquire, as some individuals with ASD may have communication problems and a proxy would be required. We did not collect domestic environment information either, thus a possible information bias might be considered.

7. Conclusion

This paper contributes to the analysis of technology's performance in assisting children with ASD in their education, supportive therapies, and daily life during the health crisis. In particular, the topics in which COVID-19 affected them the most from a technological point of view are studied (remote communication, learning, emotional management, entertainment management, executive functions, activities of daily living, and physical activity and motor skills), their challenges and advantages. In addition, a mapping of technological categories is provided along with a distribution of applications by category, which helps identify areas where technology solutions could be improved or created, considering the context of special needs and remote learning.

Together, these results provide insights into how ICT could be improved to enhance their inclusion and accessibility for people with special needs, and reduce the impact that a future pandemic-like situation could cause.

Study results reflect the timing in which the survey was implemented, which was during the early waves of the pandemic in Europe, when people with ASD faced the initial transition to online education and assistance. Therefore, there is an opportunity for future research to analyse the long-term impact of ICT use of people on the spectrum along the pandemic, the possible rise of the advantages of using ICT in daily routine, the improvements of design and implementation of e-learning platforms, and the evolution of the ICT adoption by educational policy makers and practitioners to overcome the barriers towards an effective implementation of remote or hybrid learning and assistance. COVID-19 global emergency could be the catalyst to improve basic education and support through a strong inclusion of ICT, rather than letting current learning and assistance systems 'domesticate' new technologies. The bigger the challenge, the bigger the opportunity for a no-go-back digital transformation that allows to build a more autism-friendly ICT environment.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was co-funded by the Project Indigo! (Ministry of Science and Innovation with reference number PID2019-105951RB-I00/AEI/10.13039/501100011033) and by the Madrid Regional Government through the e-Madrid-CM Project under Grant S2018/TCS-4307, co-funded by the European Structural Funds (FSE and FEDER).

Ethics approval

Respondents were informed about the study nature and no personal information was required. Since this is a non-interventional study, it has been granted exemption according to the ethics committee of the UAM

Consent to participate All authors agreed with participate this paper

Consent for publication All authors agreed with submit this paper

Availability of data and materials

Complete survey data is available under request

References

Algoufi, R. 2016. "Using Tablet on Education." *World Journal of Education* 6 (3): 113–119. https://doi.org/10.5430/wje.v6n3p113.

American Psychiatric Association, A., Association, A.P. 2013. *Diagnostic and Statistical Manual of Mental Disorders: DSM-5*. Washington, DC: American Psychiatric Association.

Babbie, E. R. 1990. "Survey Research Methods Wadsworth Pub." *Co Belmont, Calif* 3 (9): 31–50.

Bailenson, J. N. 2021. "Nonverbal Overload: A Theoretical Argument for the Causes of Zoom Fatigue." *Technology, Mind, and Behavior* 2 (1). https://doi.org/10.1037/tmb0000030.

Bellani, M., L. Fornasari, L. Chittaro, and P. Brambilla. 2011. "Virtual Reality in Autism: State of the Art." *Epidemiology and Psychiatric Sciences* 20 (3): 235–238. https://doi.org/10.1017/S2045796011000448.

Benford, P., and P. Standen. 2009. "The Internet: a Comfortable Communication Medium for People with Asperger Syndrome (as) and High Functioning Autism (HFA)." *Journal of Assistive Technologies* 3: 44–53.

Best, S. J., and C. H. Harrison. 2009. *The SAGE handbook of applied social research methods* 2: 413–434.

Bodison, S. C., L. I. Stein Duker, B. Nakasuji, M. Gabriele, and E. I. Blanche. 2022. "Occupational Therapy for Children with Autism Spectrum Disorder and Intellectual and Developmental Disability." In *Handbook of Treatment Planning for Children with Autism and Other Neurodevelopmental Disorder*, edited by P. McPherson, 389–398. Cham: Springer.

Boyatzis, R. E. 1998. *Transforming Qualitative Information: Thematic Analysis and Code Development*. Thousand Oaks, CA: SAGE Publications.

Burke, M., R. Kraut, and D. Williams. 2010. "Social Use of Computer-Mediated Communication by Adults on the Autism Spectrum". *Proceedings of the 2010 ACM Conference on Computer Supported Cooperative Work*.Savannah, Georgia, USA.

Calvo, R., A. Iglesias, and L. Castaño. 2017. "Evaluation of Accessibility Barriers and Learning Features in M-learning Chat Applications for Users with Disabilities." *Universal Access in the Information Society* 16 (3): 593–607. https://doi.org/10.1007/s10209-016-0484-x.

Chinchay, Y., J. Gomez, and G. Montoro. 2022. "Orchestrating Special Education During the Covid-19 Lockdown. A Mapping Study of the Technologies and Challenges." In *2022 IEEE Global Engineering Education Conference (EDUCON)*, 2028–2032. IEEE.

Courtenay, K., and B. Perera. 2020. "Covid-19 and People with Intellectual Disability: Impacts of a Pandemic." *Irish Journal of Psychological Medicine* 37 (3): 231–236. https://doi.org/10.1017/ipm.2020.45.

Dahiya, A. V., E. DeLucia, C. G. McDonnell, and A. Scarpa. 2021. "A Systematic Review of Technological Approaches for Autism Spectrum Disorder Assessment in Children: Implications for the Covid-19 Pandemic." *Research in Developmental Disabilities* 109:103852. https://doi.org/10.1016/j.ridd.2021.103852.

Desideri, L., A. Di Santantonio, N. Varrucciu, I. Bonsi, and R. Di Sarro. 2020. "Assistive Technology for Cognition to Support Executive Functions in Autism: A Scoping Review." *Advances in Neurodevelopmental Disorders* 4 (4): 330–343. https://doi.org/10.1007/s41252-020-00163-w.

Doenyas, C., and S. M. Shohieb. 2021. "Leveraging Technology for the Wellbeing of Individuals with Autism Spectrum Disorder and Their Families During Covid-19." *Frontiers in Psychiatry* 12:566809. https://doi.org/10.3389/fpsyt.2021.566809.

Donnelly, J. E., and K. Lambourne. 2011. "Classroom-based Physical Activity, Cognition, and Academic Achievement." *Preventive Medicine* 52:36–42. https://doi.org/10.1016/j.ypmed.2011.01.021.

Finkenauer, C., M. M. Pollmann, S. Begeer, and P. Kerkhof. 2012. "Brief Report: Examining the Link Between Autistic Traits and Compulsive Internet Use in a Non-clinical Sample." *Journal of Autism and Developmental Disorders* 42 (10): 2252–2256. https://doi.org/10.1007/s10803-012-1465-4.

Gillespie, A., C. Best, and B. O'Neill. 2012. "Cognitive Function and Assistive Technology for Cognition: A Review." *Journal of the International Neuropsychological Society* 18 (1): 1–19. https://doi.org/10.1017/S1355617711001548.

Hodgson, A. R., M. H. Freeston, E. Honey, and J. Rodgers. 2017. "Facing the Unknown: Intolerance of Uncertainty in Children with Autism Spectrum Disorder." *Journal of Applied Research in Intellectual Disabilities* 30 (2): 336–344. https://doi.org/10.1111/jar.2017.30.issue-2.

Jasmin, E., M. Couture, P. McKinley, G. Reid, E. Fombonne, and E. Gisel. 2009. "Sensori-motor and Daily Living Skills of Preschool Children with Autism Spectrum Disorders." *Journal of Autism and Developmental Disorders* 39 (2): 231–241. https://doi.org/10.1007/s10803-008-0617-z.

Jeste, S., C. Hyde, C. Distefano, A. Halladay, S. Ray, M. Porath, R. Wilson, and A. Thurm. 2020. "Changes in Access to Educational and Healthcare Services for Individuals with Intellectual and Developmental Disabilities During Covid-19 Restrictions." *Journal of Intellectual Disability Research*64 (11): 825–833. https://doi.org/10.1111/jir.v64.11.

Jiao, W. Y., L. N. Wang, J. Liu, S. F. Fang, F. Y. Jiao, M. Pettoello-Mantovani, and E. Somekh. 2020. "Behavioral and Emotional Disorders in Children During the Covid-19 Epidemic." *The Journal of Pediatrics* 221:264. https://doi.org/10.1016/j.jpeds.2020.03.013.

Kaden, U. 2020. "Covid-19 School Closure-Related Changes to the Professional Life of a K-12 Teacher." *Education Sciences* 10 (6): 165. https://doi.org/10.3390/educsci10060165.

Karami, B., R. Koushki, F. Arabgol, M. Rahmani, and A.-H. Vahabie. 2021. "Effectiveness of Virtual/augmented Reality-based Therapeutic Interventions on Individuals with Autism Spectrum Disorder: a Comprehensive Meta-analysis." *Frontiers in Psychiatry*12:665326. https://doi.org/10.3389/fpsyt.2021.665326.

Kawabe, K., R. Hosokawa, K. Nakachi, A. Yoshino, F. Horiuchi, and S.-I. Ueno. 2020. "Excessive and Problematic Internet Use During the Coronavirus Disease 2019 School Closure: Comparison Between Japanese Youth with and Without Autism Spectrum Disorder." *Frontiers in Public Health* 8. https://doi.org/10.3389/fpubh.2020.609347.

Kim, S., S. Crowley, and Y. Lee. 2022. "A Scoping Review of Technology-based Vocational Interventions for Individuals with Autism." *Career Development and Transition for Exceptional Individuals* 45 (1): 44–56. https://doi.org/10.1177/21651434211041608.

King, D. L., P. H. Delfabbro, J. Billieux, and M. N. Potenza. 2020. "Problematic Online Gaming and the Covid-19 Pandemic." *Journal of Behavioral Addictions* 9 (2): 184–186. https://doi.org/10.1556/2006.2020.00016.

Konstantinidis, E. I., A. Luneski, C. A. Frantzidis, M. Nikolaidou, M. Hitoglou-Antoniadou, and P. D. Bamidis. 2009. "Information and Communication Technologies (ict) for Enhanced Education of Children with Autism Spectrum Disorders." *The Journal on Information Technology in Healthcare* 7 (5): 284–292.

Krause, J., and A. Taliaferro. 2015. "Supporting Students with Autism Spectrum Disorders in Physical Education: There's An App for that. Report)(Cover Story)." *Palaestra* 29 (2): 45.

Lindor, E., C. Sivaratnam, T. May, N. Stefanac, K. Howells, and N. Rinehart. 2019. "Problem Behavior in Autism Spectrum Disorder: Considering Core Symptom Severity and Accompanying Sleep Disturbance." *Frontiers in Psychiatry* 10:487. https://doi.org/10.3389/fpsyt.2019.00487.

Maenner, M. J., K. A. Shaw, J. Baio, A. Washington, M. Patrick, M. DiRienzo, and D. L. Christensen. 2020. "Prevalence of Autism Spectrum Disorder Among Children Aged 8 Years—autism and Developmental Disabilities Monitoring Network, 11 Sites, United States, 2016." *MMWR Surveillance Summaries* 69 (4): 1–12. https://doi.org/10.15585/mmwr.ss6904a1.

Martins, V. F., C. Amato, L. Tomczyk, S. S. Oyelere, M. A. Eliseo, and I. F. Silveira. 2020. "Accessibility recommendations for open educational resources for people with learning disabilities." In *Trends and Innovations in Information Systems and Technologies*. Vol. 3, 387–396. Springer International Publishing.

Mazurek, M. O., and C. Wenstrup. 2013. "Television, Video Game and Social Media Use Among Children with Asd and Typically Developing Siblings." *Journal of Autism and Developmental Disorders* 43 (6): 1258–1271. https://doi.org/10.1007/s10803-012-1659-9.

Murray, M. J. 2010. "Attention-deficit/hyperactivity Disorder in the Context of Autism Spectrum Disorders." *Current Psychiatry Reports* 12 (5): 382–388. https://doi.org/10.1007/s11920-010-0145-3.

Papoutsi, C., A. Drigas, and C. Skianis. 2018. "Mobile Applications to Improve Emotional Intelligence in Autism-a Review." *International Journal of Interactive Mobile Technologies* 12 (6): 47–61.

Parmigiani, D., V. Benigno, M. Giusto, C. Silvaggio, and S. Sperandio. 2021. "E-inclusion: Online Special Education in Italy During the Covid-19 Pandemic." *Technology, Pedagogy and Education* 30 (1): 111–124.

Patel, K. 2020. "Mental Health Implications of Covid-19 on Children with Disabilities." *Asian Journal of Psychiatry* 54: 102273.

Pellicano, E., and D. Burr. 2012. "When the World Becomes 'too Real': a Bayesian Explanation of Autistic Perception." *Trends in Cognitive Sciences* 16 (10): 504–510. https://doi.org/10.1016/j.tics.2012.08.009.

Robinson, S., L. Goddard, B. Dritschel, M. Wisley, and P. Howlin. 2009. "Executive Functions in Children with Autism Spectrum Disorders." *Brain and Cognition* 71 (3): 362–368. https://doi.org/10.1016/j.bandc.2009.06.007.

Rosli, S., N. A. Amin, S. Suryanto, and K. Ilias. 2022. "Roles of Digital Technology in Sustaining Mental Health Among Parent of Children with Autism Spectrum Disorders (asd) During Pandemic Covid-19." *Environment-Behaviour Proceedings Journal* 7 (19): 173–179. https://doi.org/10.21834/ebpj.v7i19.3257.

Saarni, C. 1999. *The Development of Emotional Competence*. New York, NY: Guilford press.

Samson, A. C., A. Y. Hardan, R. W. Podell, J. M. Phillips, and J. J. Gross. 2015. "Emotion Regulation in Children and Adolescents with Autism Spectrum Disorder." *Autism Research* 8 (1): 9–18. https://doi.org/10.1002/aur.v8.1.

Shane, H. C., and P. D. Albert. 2008. "Electronic Screen Media for Persons with Autism Spectrum Disorders: Results of a Survey." *Journal of Autism and Developmental Disorders* 38 (8): 1499–1508. https://doi.org/10.1007/s10803-007-0527-5.

Stenhoff, D. M., R. C. Pennington, and M. C. Tapp. 2020. "Distance Education Support for Students with Autism Spectrum Disorder and Complex Needs During Covid-19 and School Closures." *Rural Special Education Quarterly* 39 (4): 211–219. https://doi.org/10.1177/8756870520959658.

Torrado, J. C., J. Gomez, and G. Montoro. 2020. "Hands-on Experiences with Assistive Technologies for People with Intellectual Disabilities: Opportunities and Challenges." *IEEE Access* 8:106408–106424. https://doi.org/10.1109/Access.6287639.

Unesco. 2021. "Education: From Disruption to Recovery." Accessed May 25, 2021. https://en.unesco.org/covid19/educationresponse.

Van Lancker, W., and Z. Parolin. 2020. "Covid-19, School Closures, and Child Poverty: a Social Crisis in the Making." *The Lancet Public Health* 5 (5): 243–244. https://doi.org/10.1016/S2468-2667(20)30084-0.

Wainer, A. L., and B. R. Ingersoll. 2011. "The Use of Innovative Computer Technology for Teaching Social Communication to Individuals with Autism Spectrum Disorders." *Research in Autism Spectrum Disorders* 5 (1): 96–107. https://doi.org/10.1016/j.rasd.2010.08.002.

WHO. 2011. "World Disability Report." Malta: World Health Organisation, The World Bank.

WHO. 2020. "World Health Organization coronavirus disease 2019 (COVID-19) Situation Report".

Appendix. Online survey template

Survey on the use of technology during the COVID-19 pandemic of teachers, intervention personnel and family members of children with autism spectrum disorders.

This survey is anonymous and will be used in order to improve knowledge, research and technological solutions applied to people with functional diversity within the Autonomous University of Madrid and other collaborating research groups.

Thank you very much in advance for your participation and for helping us improve our knowledge and future work with technology for children with special needs.

A.1. Demographic profile

(1) How old are you?
(2) What is your gender?
- ○ Male
- ○ Female
- ○ Prefer not to answer
- ○ Other: _____

(3) What is your place of residence?
(4) What is your main place of work?
- ○ Educational Center
- ○ Special employment center
- ○ Health Center
- ○ Research Center
- ○ Not related to special needs
- ○ Other: _____

(5) What is your experience with technology in everyday life?
- ○ Little experience (e.g: I use the mobile in a basic way)
- ○ User level (e.g: I use various devices and configure them)
- ○ Advanced level (e.g: I know and use many applications and devices, I configure and adapt them to my users)

(6) What is your experience with technology in the field of special needs?
- ○ Little or no experience (e.g: I barely use technology)
- ○ User level (e.g: I use some specific applications)
- ○ Advanced level (e.g: I know and use many applications and devices, I configure and adapt them to my users)

(7) What is your profile?
- ○ Family member/legal guardian of child with autism
- ○ Teacher
- ○ Non-teaching ASD expert
- ○ Clinical staff

A.2. Relatives and caregivers section

(8) How did you communicate with the educational center and the teaching team?
- □ Video calls
- □ Phone calls
- □ Email
- □ WhatsApp/Telegram
- □ Other: _____

(9) How have you communicated with family and friends?
- □ Group video calls (e.g: relatives or a group of friends)
- □ Individual video calls (e.g: to a specific family member or friend)
- □ Phone calls
- □ Email
- □ WhatsApp/Telegram (e.g: voice notes, photos, videos, etc.)
- □ Other: _____

(10) If you have used applications for communication, which ones?
- □ Zoom
- □ Jitsi Meet
- □ Skype
- □ Webex
- □ WhatsApp/Telegram
- □ Microsoft Teams
- □ Other: _____

(11) What difficulties have you encountered when establishing communication?
- □ Lack of technical means
- □ Poor image and/or sound quality
- □ Complexity of the tool(s)
- □ Technical issues (registration, configuration, etc.)
- □ Difficulty for the person with special needs in my charge to remain attentive to the communication tool
- □ None
- □ Other: _____

(12) How would you rate remote communication in this situation?
(13) Before lockdown, did you work on the training of the person with special needs in your care at home? As? Did you use any kind of technology? For example, language, calculation, activities of daily living, etc.
(14) How has the person with special needs in your care continued their training during pandemic?
- □ Connection with teachers through video calls
- □ Sending tasks by email/virtual class platform
- □ Activities proposed by family members
- □ No specific training activities have been carried out
- □ Use of specific applications
- □ Other: _____

(15) If you have used specific applications, can you tell us which ones? For what tasks?
(16) What are the main drawbacks you have encountered when continuing with training during lockdown?
- □ Lack of technical means
- □ Difficulty for the person with special needs in my charge to stay attentive to the task
- □ Need for continuous supervision
- □ Very complex tools to use/configure
- □ None
- □ Other: _____

(17) What devices did the person with special needs in your care use in their free time before the lockdown?
- □ Smartphones
- □ Tablets
- □ Computer
- □ Smartwatch

- ☐ Game consoles
- ☐ None
- ☐ Other: _____

(18) What applications did the person with special needs in your charge use in their free time before lockdown?
- ☐ Video player (eg: Youtube, Netflix, HBO)
- ☐ Video game
- ☐ Social networks (eg: Instagram, Twitter, TikTok, Facebook)
- ☐ None
- ☐ Other: _____

(19) To what extent has confinement affected the use of technologies for leisure?
- ○ Has decreased quite a bit
- ○ Has slowed down a bit
- ○ Hasn't changed
- ○ Has increased a bit
- ○ Has increased a lot

(20) Have you taken any measures to manage the use of technologies in their leisure time during lockdown?
- ○ Yes
- ○ No

(21) Which ones?

(22) What kind of technologies did the person with special needs in your charge use to work on managing emotions before confinement? (e.g: specific applications, entertainment or relaxation devices)

(23) Has the use of technologies to manage emotions in lockdown changed? If so, how?

A.3. ASD professionals section

(24) How have you communicated with students and their families?
- ☐ Video calls
- ☐ Phone calls
- ☐ Email
- ☐ WhatsApp/Telegram
- ☐ Other: _____

(25) If you have used applications for communication, which ones?
- ☐ Zoom
- ☐ Jitsi Meet
- ☐ Skype
- ☐ Webex
- ☐ WhatsApp/Telegram
- ☐ Microsoft Teams
- ☐ Other: _____

(26) What difficulties have you encountered when establishing communication with students and their families?
- ☐ Lack of technical means by families
- ☐ Poor image and/or sound quality
- ☐ Complexity of the tool(s)
- ☐ Technical issues (registration, configuration, etc.)
- ☐ None
- ☐ Other: _____

(27) How would you rate remote communication in this situation?

(28) How did you keep track of the students?
- ☐ Virtual classroom
- ☐ E-mail
- ☐ Whatsapp/telegram
- ☐ Video call
- ☐ Other: _____

(29) What difficulties have you found when using the monitoring tools?
- ☐ Increased workload
- ☐ Lack of knowledge of the tools by students and their families
- ☐ Own lack of knowledge of the tools
- ☐ Limitation of follow-up by direct observation
- ☐ Lack of technical means by families
- ☐ Own lack of technical means
- ☐ None
- ☐ Other: _____

(30) What advantages have you found when doing this remote monitoring?
- ☐ It allows me to have a global and objective vision
- ☐ It allows me to better organise my time
- ☐ Reduced workload
- ☐ Flexible hours
- ☐ Positive impact on users
- ☐ None
- ☐ Other: _____

(31) How did you work on cognitive skills before the pandemic? Did you use any kind of technology for it?

(32) How have you worked on cognitive skills during confinement?
- ☐ Pre-recorded videos
- ☐ Live videos
- ☐ Group work via video call
- ☐ Specific applications
- ☐ Paper materials sent to families
- ☐ Other: _____

(33) If you have used specific applications, can you tell us which ones?

(34) What are the difficulties you have encountered when working on cognitive skills during confinement?
- ☐ Lack of options when it comes to two-way video transmission
- ☐ Technical problems
- ☐ Few possibilities for supervision/monitoring and correction of students
- ☐ None
- ☐ Other: _____

(35) What are the advantages you have found when working on the development of cognitive skills remotely?
- ☐ Possibility of recording sessions for later viewing and analysis
- ☐ Less behaviour problems (conflicts in class, etc.)
- ☐ Higher degree of concentration on the part of the students
- ☐ None
- ☐ Other: _____

(36) How did you work on executive functions (e.g: organisation, planning, memorisation) before confinement? Did you use any kind of technology for it?

(37) How have you worked on executive functions during confinement?
- ☐ Pre-recorded videos
- ☐ Live videos
- ☐ Group work via video call

- ☐ Specific applications
- ☐ Paper materials sent to families
- ☐ Other: _____

(38) If you have used specific applications, can you tell us which ones?

(39) What are the difficulties you have encountered when working on executive functions during confinement?
- ☐ Lack of options when it comes to two-way video transmission
- ☐ Technical problems
- ☐ Few possibilities for supervision/monitoring and correction of students
- ☐ None
- ☐ Other: _____

(40) What are the advantages you have found when working on the development of executive functions remotely?
- ☐ Possibility of recording sessions for later viewing and analysis
- ☐ Less behaviour problems (conflicts in class, etc.)
- ☐ Higher degree of concentration on the part of the students
- ☐ None
- ☐ Other: _____

(41) How did you work on physical and motor activity before confinement? Did you use any kind of technology for it?

(42) How have you worked on the skills related to physical and motor activity during confinement?
- ☐ Pre-recorded videos
- ☐ Live videos
- ☐ Group work via video call
- ☐ Specific applications
- ☐ Other: _____

(43) If you have used specific applications, can you tell us which ones?

(44) How did you practice activities of daily living (e.g: cleaning, using electrical appliances, cooking, laundry, etc.) before confinement? Did you use any kind of technology for it?

(45) How have you worked on the skills related to activities of daily living during confinement?
- ☐ Pre-recorded videos
- ☐ Live videos
- ☐ Group work via video call
- ☐ Specific applications
- ☐ Other: _____

(46) If you have used specific applications, can you tell us which ones?

(47) What are the difficulties you have encountered when working on activities of daily living?
- ☐ Lack of options when it comes to two-way video transmission
- ☐ Few possibilities for supervision, follow-up and/or correction of students
- ☐ Missing session record
- ☐ None
- ☐ Other: _____

(48) What are the advantages you have found when working on activities of daily living remotely?
- ☐ Recording of sessions for later supervision
- ☐ Less behaviour problems (conflicts in class, etc.)
- ☐ Higher degree of concentration on the part of the students
- ☐ Better tracking
- ☐ None
- ☐ Other: _____

(49) Has the confinement meant that you have to work on activities of daily life that are different from those that were traditionally worked on (eg: wearing a mask, washing hands, social distancing, etc.)? Which ones?

(50) How did you work on managing the emotions of the person with special needs before confinement? Did you use any kind of technology for it?

(51) How have you worked on the skills related to emotional skills during confinement?
- ☐ Pre-recorded videos
- ☐ Live videos
- ☐ Group work via video call
- ☐ Specific applications
- ☐ Other: _____

(52) If you have used specific applications, can you tell us which ones?

(53) What are the difficulties you have encountered when working on emotional skills?
- ☐ Lack of options when it comes to two-way video transmission
- ☐ Few possibilities for supervision, follow-up and/or correction of students
- ☐ Missing session record
- ☐ None
- ☐ Other: _____

(54) What are the advantages you have found when working on emotional skills?
- ☐ Recording of sessions for later supervision
- ☐ Less behaviour problems (conflicts in class, etc.)
- ☐ Higher degree of concentration on the part of the students
- ☐ Better tracking
- ☐ None
- ☐ Other: _____

(55) Has the confinement made it necessary to work on different emotional skills (eg: stress due to isolation, change in routine, return to normality, etc.) to those that were traditionally worked on? Which ones?

(56) In which center/association/foundation do you work?

(57) What is your current position?

(58) Finally, would you like to participate in a short, online interview?
- ○ Yes
- ○ No

(59) Leave us your email and we will contact you to arrange the date, time and means of the interview

(60) What technologies used during confinement will you continue to use after it?

(61) In this space you can leave us any other reflection that you want to share with us, and that you have not been able to include previously.