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Orchestrating special education during the COVID-19 lockdown. A mapping study of the technologies and challenges

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***Abstract*—The COVID-19 lockdown entailed changes at all levels. Particularly, closing schools and moving to online education from one day to another revealed limitations in the education system and difficulties to approach remote learning and assistance, particularly, in the case of special education needs. In order to collect how special education was orchestrated along the pandemic, what technologies were involved and the impact they had, we run a survey in which a total of 295 teachers, specialists and relatives of people with autism spectrum conditions participated. This paper contributes analyzing the orchestration of remote special education and provide applicable solutions to build a learning platform adapted to people with special needs, which covers the challenges encountered. In addition, a mapping of technologies is provided that can serve as an ICT selection criteria and benefit people on the spectrum.**

***Index Terms*—Engineering education, Autism Spectrum Disorder, COVID-19, Digital transformation**

I. Introduction

COVID-19 outbreak and related mitigation measures have had deep implications for people's daily lives, work and education [1]. Particularly, the shift to online learning posed great challenges for the population with special needs and further exposed the inequalities in access and use of Information and Communication Technologies (ICT) derived from digital divide.

In the case of people with Autism Spectrum Disorder (ASD), some factors such as lack of technological resources from both family members and specialists, inexperience in their use, and low knowledge about assistive technologies caused a disruption of their education. It is essential to analyze how special education was orchestrated, both school learning and support therapies, when in-person interventions were not possible to guarantee the availability and improvement of learning in future similar scenarios. In addition, we must assess technology support to the teaching methodology followed in these conditions. Therefore, we will analyze the teaching experience of ASD professionals and the tools they used during the health crisis.

This paper contributes answering:

- What was the teaching methodology followed for remote education and assistance for people with ASD during the COVID-19 pandemic?
- What applications were used to support learning and what areas of special needs they were focused on?
- What solutions could be considered to build tools to enhance teaching orchestration oriented to special needs?

II. Background

The term "Autistic Spectrum Disorder" (ASD) derives from the identification of the formerly called "autism" as a wide group of heterogeneous neurodevelopmental disorders [2]. The most recent diagnostic classification from the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) [3] highlights two main aspects to determine the presence of an autism spectrum disorder in an individual: on the one hand, deficits on communication and social interaction; on the other hand, presence of repetitive patterns of behaviour, activities and interests, which manifest through several symptoms. These aspects affect people diagnosed with ASD in different ways, such as social isolation, lack of communication possibilities or developing limitations. Moreover, these issues influence a specific aspect of their development that has attracted attention in the recent years, due to the popularity and relevance of the self-determination theory [4]: their personal independence.

In the literature, we can find relevant works carried out to explore the suitability and validation of technological ecosystems to improve the learning process of people with ASD. If we look for evidence-based educational interventions the most common practices are [5]: visual supports, video modelling, reinforcement, Discrete Trial Training (DTT) and self-management.

Despite of the individual efforts and practices, comprehensive programs are usually valued as one of the best intervention methods [6]. Therefore, a combination of some of the interventions to cover the whole learning process of the user seems to be the next step.

In this sense, we have been researching on different approaches and exploring mechanisms to help people with ASD

(and other intellectual disabilities) to become more independent by means of technology. Examples of this are the AssisT-Task mobile system, a DTT system based on visual cues to help people with cognitive disabilities in their work-related activities by delivering ubiquitous support and guidance [7] . We also explored the self-management support by developing a smartwatch-based system to monitor users' inner status, which could predict possible behavior outburst and provide the assistance to the user to recover to a calmed state [8].

The first wave of the COVID-19 pandemic had an impact on the education and autonomy of people on the spectrum due to the preventive measures of isolation and quarantine against the contagion and spread of the virus. In order to continue developing their daily activities, such as education and work, people have relied on technology to a great extent. However, this situation entailed additional challenges for some populations, such as people with autism spectrum disorders, whose relationship with technology is more complex.

III. Methodology

We focused on the impact of technology by people with autism spectrum disorders and their caregivers during the lockdown. In order to collect solutions, preferences, feelings and reflections on the role of technology during this period, we run a survey among professionals and relatives of people with ASD.

The questionnaire was made on Microsoft Forms and shared by email. It was structured in two different sections. The first one consisted of a set of questions related to demographics: age, location, experience with technology in their daily environment, experience with technology in relation to special needs and profile. While the second section covered the topics of interest for our study. A total of 295 teachers, specialists and relatives of people on the spectrum participated in the study. According to their profile (relatives or professionals), they were handed different questions regarding their perspectives on the following matters:

- Communication: questions about the use of technology to communicate with the teachers, family and friends, or with the families and individuals with ASD, respectively.
- Online learning: questions about the use of technology to continue the education of individuals with ASD during lockdown.
- Leisure time: questions about the use of technology for leisure time.
- Emotional management: questions about the use of technology to train skills related to emotion regulation, self-awareness, stress management, etc.
- Cognitive skills: questions about the use of technology to train cognitive skills such as reading, writing and calculation.
- Executive function: questions about the use of technology to train skills related to the cognitive function, such as organization, planning, memory, etc.
- Physical activity and motor skills: questions about the use of technology to train skills related to movement and to motivate to do exercise.
- Daily activities: questions about the use of technology to assist in activities like chores, maintenance, cooking, etc.

For the purpose of the present study, we analysed the applications cited in the answers and mapped them into the technological categories that we identified as relevant in the remote education of people with ASD: attention, authoring tools, calculation, e-learning, emotions, entertainment, experience of self, language and communication, memory, planning and time management, social networking, and social skills. This mapping could benefit individuals with autism spectrum conditions and help understand the role of technology and its opportunities and challenges in each of these technological categories as a method for the comprehensive education of people with ASD. We ran a two level study: first, we collected all the applications and matched with a category (where they were cited in the questionnaire). Then we reviewed them in order to check whether they belonged to the cited category or another one (e.g. Microsoft Teams appeared in e-learning category but also as a social networking application).

IV. Results

According to the responses provided by relatives and caregivers of people with ASD, special education was orchestrated online and, particularly, the interchange of educational activities through different tools such as email, instant messaging or virtual classrooms was the most popular approach. Video calls, activities proposed by relatives and the use of specific apps were also popular among the answers (Fig. 1). In order to monitor these learning activities, ASD professionals used video calls, email, WhatsApp and Telegram applications, virtual classrooms, and other means such as traditional phone calls (Fig. 2).

This learning methodology was conditioned on the availability and collaboration of family members, necessary both for the learning process and for its follow-up, since it relied on the feedback provided by relatives and caregivers.

Although ASD specialists made a huge effort to provide the maximum support and intervention to family nucleus, by giving recommendations of applications, creating user manuals, making custom materials with authoring tools and, overall, guiding family members in education, the switch to home schooling was not an easy task. Also, the lack of a common strategy by the institutions, added to the large number of different applications available and the network saturation due to its increased use at home, seemed to cause even more confusion in the transition [9].

In Table I, we can see the resources and applications used to meet the learning needs of people with ASD. Most of them were tools adapted to be used in special education and less than 20% were actually special needs-oriented. These 212 applications have been categorized using 12 technological categories that have emerged as a result of this study and that cover the specific needs of people with ASD for remote learning

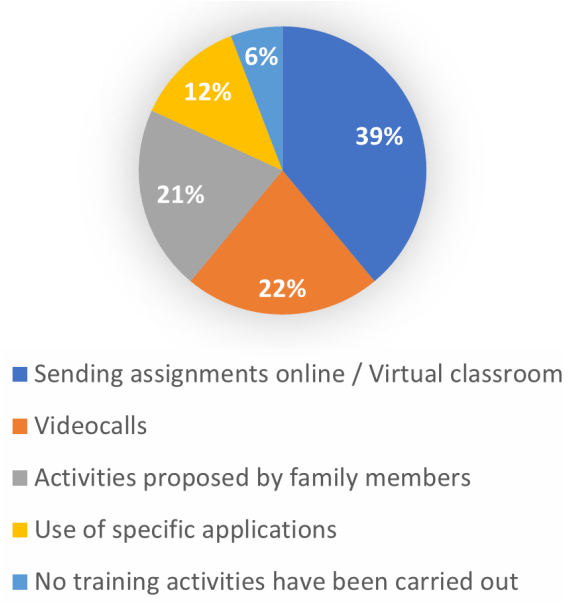

Fig. 1. Special education orchestration.

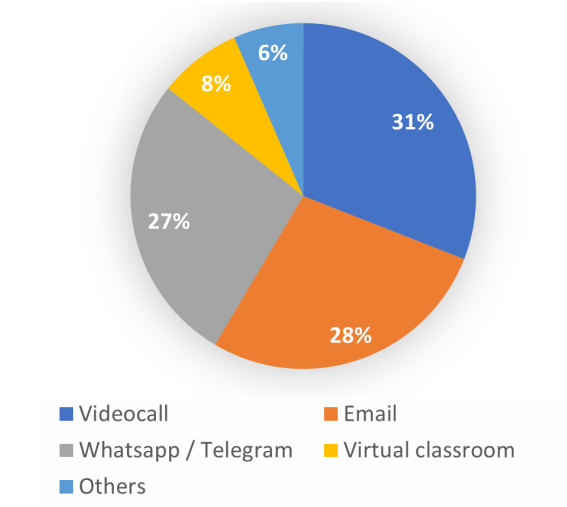

Fig. 2. Tracking of learning activities.

and support: attention, calculation, emotions, experience of self, planning and time management, memory, language and communication, social skills, e-learning and authoring tools.

Finally, our results exposed the major challenges new online learning methodology and ICT used for it had:

- Digital divide. This key factor indicated how many family members and specialists did not have enough experience with new technologies and did not have either the necessary resources to continue working [10].
- Assistive technology limitations. We found out that either there are not enough applications to assist special needs, or users do not have enough knowledge of them.
- Customization options. The customization options in ICTs are essential for its use with people with autism.
- Interaction limitations. People with ASD need face-to-face interaction, both with their teachers and with their classmates, and ICTs still have limited options for interaction [11].
- Attention and concentration. People with autism struggle maintaining attention and concentration on screens for a long period of time.
- Monitoring and tracking. Along the pandemic, it was difficult to monitor the learning tasks performed since many applications did not count with tracking options, and paper activities depended on the feedback provided by relatives and caregivers.
- Home support. Learning process was highly dependent on the availability and collaboration of the families of people with ASD.

V. Discussion

We can see how there was not a big innovation in class orchestration along the health crisis as ICTs were used to simulate the previous special education methodology. There was not a digital transformation but a digital domestication. However, this approach may have been the simplest considering the role switching between relatives and professionals that homeschooling brought about. The collaboration between family members and professionals was crucial to continue with the educational process along pandemic, despite some inconveniences. For instance, some relatives suggest that there was an over-reliance in them when switching to homeschooling, without considering that they could not have enough pedagogical skills and that they had to balance that task with full-time childcare and their employments [12]. Consequently, the stress and susceptibility suffered by relatives of people with ASD to a greater extent, in comparison to parents of children with other special needs [13], increased. As a result, some families could not continue supporting the learning development at home. Digital training programs would likely have helped both to bridge the digital divide and to overcome the overwhelming feeling of relatives.

Regarding the tools used to orchestrate special education on remote, we observe that, despite the existence of a considerable number of assistive technologies, there is some ignorance about them, some targeting specific areas are still needed, or there is no metric to indicate which ones work best. Because of this, specialists largely used authoring tools to create custom content specific to the needs they needed to meet. It is necessary to create a learning ecosystem adapted to people with special needs that can serve as an integrating platform for assistance applications and helps increase the visibility of the most useful ones. To do this, the mapping of technologies obtained as a result of this study could be used as a base metric. Likewise, this tool should also include other applications frequently used in education and allow the creation of custom resources, that is, it should also act as an authoring tool. In this way, we would have an environment that would allow both the creation and integration of resources, without having to resort to several different tools.

TABLE I
MAPPING OF TECHNOLOGIES

Areas	Applications
Attention	Sígueme, Sequence it!, El Buho Boo, Las Series Lógicas de Lucas, Match It Up, Busy Shapes, Comida divertida, Flow Free, Botones y Tijeras, MarcoPolo Recall, VirTEA, Smile and learn, NeuronUP, Lumosity, Teachers' Pack, Árbol ABC, NeuroNation, Encadena, Simon Says Nice!, Find It: Juego de objetos ocultos para niños, MyFirstApp, Smart Shapes, Trace & Share, Maxiloto Vida cotidiana, Bitsboard Flashcards & Games, Step by Step, Guttmann, NeuroPersonalTrainer
Authoring tools	Liveworksheets, Genial.ly, Make it, Wordwall, Powerpoint, Book Creator, Kahoot, JClic, TinyTap, Toontastic 3D, Scratch, ChooseIt! Maker 2, Canva, iMovie, iLovePDF, HP Reveal, Edpuzzle, Boom Cards, MiniTool MovieMaker, Quizzer, Quizizz: Juega para aprender, PDFescape
Calculation	Matemáticas con Grin, Smartick, Minecraft, Edelvives Digital, iCuadernos, ABC Autismo, 123 Numbers, Rey de las Matemáticas, Flow Free, Botones y Tijeras, Traffic Rush, Achtung Deep, Smile and learn, Lumosity, 10monkeys, Árbol ABC, Cuenta con tus dedos!, Encadena, Tella, Pet Bingo, Todo Math, MyFirstApp, 10 dedos, Tren de las matemáticas de Lola, Rey de las Matemáticas Jr, Crazy Math, Step by Step
E-learning	Zoom, Google Classroom, Webex, Microsoft Teams, Seesaw, ClassDojo, iEduca TokApp, Skype, Kahoot, Whatsapp, Educamos, Blogs, Schoology, Aula virtual, Snappet, Espacio Onda, Rayuela, Padlet, Smartia, Dinantia, Moodle
Emotions	José Aprende, Youtube, AutisMIND, #Soyvisual, Dictapicto, Breathe, EmoPLAY, Make it, Powerpoint, InShot, Pepi Play, iCuadernos, Pictoaplicaciones, iSecuencias, PictoSelector, Respira, piensa, actúa, Leo TEAyuda, Inference Pics, Tempus Lite, Adiós Enfados, Autismo - Descubra emociones, Proyecto Emociones, PictoDroid, Aprende las emociones, Stopwatch Timer, Aprendices Visuales, Padlet, VirTEA, NeuronUP, Qué tal estás?, SuperEmociones, BabyBus, Puppet Pals HD, Partes del Cuerpo para Niños, Magic Fluids Free, Plasma Sound, Conversation Therapy Lite
Entertainment	Proyecto Azahar, Piano Kids - Música y Canciones, #Soyvisual, Dr. Panda, Los Sims, Pepi Play, Busy Shapes, Comida divertida, TinyTap, Flow Free, Botones y Tijeras, MarcoPolo Recall, Toontastic 3D, Scratch, ChooseIt! Maker 2, iMovie, Traffic Rush, Achtung Deep, Smile and learn, Fantasma , Hanoi Tower, Árbol ABC, Sorter, My PlayHome, Toca House, Tap the Frog, Masha y el oso - juegos educativos, Slide & Spin, Juegos de bebés, Dot 2 Dot - Animal Series, ChatterPix Kids, Bitsboard Flashcards & Games, Kindergarten, Step by Step, Colors & Shapess
Experience of self	LudiTab, EVA Facial Mouse, José Aprende, #SoyVisual, iSecuencias, Mefacilyta, iDo Hygene, VirTEA, My PlayHome, Partes del cuerpo para niños
Language and communication	MITA, Niki Talk, José Aprende, Powerpoint, #Soyvisual, Grid 3, Leo con Lula, Proloquo2Go, Talking Pocoyó, Conversation Therapy Lite, Aprender a leer - Mario Abc, Proyecto Azahar, Sequence it!, Make it, LetME talk, Leeduca, E-mail, AutisMIND, Plaphoons, Leo con Grin: aprender a leer, Duolingo, Minecraft, AbaPlanet, Edelvives Digital, Prime reading, Skype, Araword, Niki Words, Dictapicto, iCuadernos, Basic Sounds, ABC Autismo, Match It Up, Pictoaplicaciones, ClinkPlay, Snappet, PictoSelector, EmoPLAY, Inference Pics, PictoDroid, 9 letras, Toontastic 3D, Día a Día, Pictoeduca, Smile and learn, NeuronUP, Teachers' Pack, Árbol ABC, Logopedia, Mínimo, Hitziki: Aprende jugando!, Pictosonidos, Aprende a Leer - Silabario, La mesita, Dic Dic, MyABCKit, Aprende a Deletrear y Escribir, eCasals, L'Escapadou, Cursive Writing Wizard - Handwriting, Smart Shapes, Animal Card Matching, El Tren del Alfabeto de Lola, Maxiloto Vida cotidiana, LudiTab, Pocoyo Trazos y Líneas para Niños, Conciencia Fonológica, GALEXIA Mejora Fluidez Lectora, Bitsboard Flashcards & Games, Kindergarten, Things to Learn - Study Tools, Yo Leo Lite, Jocs de lectura, Guttmann, NueroPersonalTrainer
Memory	9 letras, MarcoPolo Recall, iMimic Dice, NeuronUP, Lumosity, Árbol ABC, NeuroNation, Para los niños: KIDS match'em, Simon Says Nice!, MyFirstApp, Maxiloto Vida cotidiana, LudiTab, Bitsboard Flashcards & Games, Guttmann, NeuroPersonalTrainer
Planning and time management	iSecuencias, Tempus Lite, Pictoagenda, Sort It Out 1, José Aprende, Google Drive, Youtube, Aprende la Hora, Secuencias, Tempus Lite, Pictoagenda, Sort It Out 1, Dictapicto, Comida divertida, Stopwatch Timer, Mefacilyta, Google Slides, iDo Hygene, Día a Día, CmapTools, Symbaloo, Time timer, Achtung Deep, Fun Time Timer, In-TIC Agenda, Time in - Smart timers, Pictorario, Mouse Timer, CronoDroid, Proyecto Azahar, TEAyudo a jugar
Social networking	Skype, Whatsapp, Google Meet, Microsoft Teams, E-mail, Zoom, Hangouts, Snappet, Jitsi Meet, TokApp School, Google Duo
Social skills	Trace & Share, TEAyudo a jugar, Google Drive, AutisMIND, Pepi Play, PictoSelector, TinyTap

This new proposed ecosystem will also have to deal with the interaction limitations present in ICT, mainly in the area of communication. Possible solutions to improve interaction and communication could be to simplify the user interface design and take care of the arrangement of the elements on the screen to avoid overstimulating the user. Simulation of a real environment could improve participation and decrease the fatigue caused after a prolonged display device use.

For attention and concentration issues, an educational platform could include visual timers to support time management during activities development. Similarly, it is necessary a mechanism to detect periods of inactivity and generate a stimulus that regains attention, such as an alert, sounds, vibrations, etc. Regarding monitoring and tracking of activities, a tool that generates reports on the tasks performed, the time spent on them, the amount of distractions that have occurred, the results, etc. is desirable. In addition, this information must be accessible to both professionals and family members. It is also important to add options for self-assessment and self-perception of progress, so that people with ASD are aware of their own evolution.

Finally, an improved learning ecosystem should maintain

or, at least, allow the involvement of caregivers and relatives in the educational process, by allowing them to see the activities carried out, their status, results and statistics. Family involvement had a positive impact during COVID-19 crisis as it enabled relatives and caregivers to both support people with ASD and further understand their needs. Therefore, a key factor is to maintain this collaborative learning scenario.

VI. Conclusions

Lessons learned along COVID-19 pandemic should be a turning point in the learning model. Although special education continues or not with an online or hybrid modality, it is essential to maintain the inclusion of ICT in the educational system and daily life of people with ASD, so that a transition to a non-face-to-face methodology in adverse scenarios is possible and more bearable.

Our goal is to work on a solution that helps changing the previous learning paradigm of not introducing ICT in education on a regular basis or of using it only in a complementary way, so that a disruption of educational services is not repeated. Thus, this paper intends to analyze the challenges of remote learning and to propose recommendations to build a learning platform for people with autism that can enhance and enable the orchestration of teaching in a collaborative setting.

In addition to this analysis of the challenges faced in special education along the pandemic and their possible solutions, this study results in a list of applications, focused or adapted to special needs, mapped according to the needs they cover, to offer a selection criterion for the ICT that support skills development of individuals with ASD.

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