UNIVERSIDAD DE GRANADA

FACULTAD DE CIENCIAS DE LA EDUCACIÓN

Departamento de Didáctica y Organización Escolar

TESIS DOCTORAL

ANÁLISIS Y EVALUACIÓN DE APPS DESTINADAS A PERSONAS CON TEA Y SU EMPLEO POR PARTE DE PROFESIONALES

PROGRAMA DE DOCTORADO EN CIENCIAS DE LA EDUCACIÓN

DOCTORANDA

CARMEN DEL PILAR GALLARDO MONTES

DIRECTORES

DR. ANTONIO RODRÍGUEZ FUENTES

DRA. MARÍA JESÚS CAURCEL CARA

Granada, 2022

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PRESENTADA POR

CARMEN DEL PILAR GALLARDO MONTES

Para optar al Grado en Doctor Internacional por la Universidad de Granada

DIRECTORES

DR. ANTONIO RODRÍGUEZ FUENTES

DRA. MARÍA JESÚS CAURCEL CARA

Trabajo de investigación financiado por el Ministerio de Universidades del Gobierno de España en el Marco del Plan de Formación del Profesorado Universitario (FPU) con referencia FPU19/00026

Granada, 2022

Editor: Universidad de Granada. Tesis Doctorales
Autor: Carmen del Pilar Gallardo Montes
ISBN: 978-84-1117-486-2
URI: https://hdl.handle.net/10481/76845

Hay dos formas de vivir la vida -comentó Einstein en una ocasión-: como si nada fuera un milagro y como si todo lo fuera. Vivir con atención o conciencia plena es experimentar cualquier cosa como un milagro. Si te preguntas con curiosidad qué queremos decir con esto es que, de alguna manera, ya lo sabes.

AGRADECIMIENTOS

A ti mamá, mami, por ser mi luz y guía en todo este camino de aprendizaje y crecimiento. Porque sin estar, te he sentido más cerca que a nadie. Gracias por haber hecho de mí, la persona que soy ahora. Te quiero y te querré siempre.

A mis padres académicos, mis queridos Antonio y María Jesús, por sembrar en mi tanta confianza y hacerme florecer. El camino ha sido menos duro con vosotros a mi lado, haciéndome sentir una más de vuestras familias y enseñándome tantísimo acerca del valor del calor humano como docente e investigadora.

A ti, Christian, mi amor, por mantener siempre la esperanza y confianza en mí. Por compartir mis nervios como si fueran tuyos y recordarme que "esto es lo mío", no cesando en animarme a lo largo de estos años. Tú y Clay sois un pilar fundamental de mi vida.

A mis abuelos, los más maravillosos que hay, Maricarmen y José, y a mi alma gemela, mi hermana Noelia, por ser esa risa y cervecitas aseguradas a cualquier hora del día. Por ser como sois y quererme por encima de todo, gracias.

A mis amigas, Sonia y Maricarmen, mi *Drama Team*, por vivir esta experiencia como si fuera la vuestra y hacer siempre un huequito a mi tesis en nuestro día a día.

A mi familia, por estos años de escucha y haber inculcado en mí el sentido de la responsabilidad y del trabajo.

A mi segunda familia, Marina, Esther, Antonio, Nieves, Miguel, Reyi y Pepe, por estar siempre para todo sin esperar nada a cambio. Habéis sido fundamentales en este proceso.

A mi departamento, por brindarme la oportunidad de trabajar con cada uno de ellos. José Luis, director del grupo de investigación ICE, gracias por incluirme en el grupo como un miembro igual de valioso que el resto. Juanma, director del departamento de DOE, gracias por contar conmigo para todo y otorgarme tu confianza en estos años. Espero no haberos defraudado. Emilio Crisol, gracias por todo lo que me has enseñado durante esta etapa tan importante para mí y por involucrarte conmigo en lo que he necesitado.

A Davide Capperucci por haberme dejado trabajar con él cada día y haberme hecho disfrutar de Florencia. Me llevo un cachito de ella en mi corazón. Y a David, entonces doctorando y ahora doctor, por esos paseos y charlas interminables y los *spritz* al final del día. Habéis hecho de mi estancia, una experiencia inmejorable.

A todos los profesionales en autismo que han participado de manera desinteresada en este estudio, por su amor y vocación al colectivo de personas con TEA y por aportar vuestro granito de arena hacia una sociedad más inclusiva.

Se cierra una etapa y comienza otra, con el convencimiento de que esta me siga haciendo crecer a nivel personal y profesional y de seguir disfrutándola con la misma aptitud que hasta ahora.

Gracias a todos, porque de una forma u otra, habéis participado en este proceso aportando mucho más de lo que imagináis.

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1 | INTRODUCCIÓN

Las Tecnologías de la Información y la Comunicación (TIC) forman parte del quehacer diario de nuestra sociedad, adquiriendo un papel destacable en el ámbito educativo.

En este marco de proliferación de recursos digitales, las aplicaciones móviles (apps) juegan un papel fundamental como herramienta motivadora de apoyo al aprendizaje. Tanto es así que los estudios sobre el potencial de las TIC y las apps en el ámbito de la educación Formal y No Formal han cobrado valor, ofreciendo variedad de opciones de trabajo para todos los colectivos y edades. Por fortuna, el auge en materia digital alcanza también a las personas con diversidad funcional y, concretamente, a aquellas con trastorno del espectro autista (TEA), a las que se les ofrece diferentes TIC y, concretamente apps, con contenido adaptado a sus necesidades y dificultades. Desde diferentes ámbitos de la ciencia, como el sanitario o el educativo, han sido muchos los investigadores que han guiado su trabajo hacia la reflexión y puesta en práctica de apps en la terapia y educación de personas con autismo, ofreciendo diferentes experiencias alentadoras (Bondioli et al., 2018; Burton et al., 2013; García et al., 2016; Sung, 2018; Vlachou y Drigas, 2017).

El autismo es un trastorno del neurodesarrollo que conlleva dificultades en las áreas de la comunicación, el lenguaje y la interacción social, junto a la existencia de patrones repetitivos y comportamientos e intereses restrictivos (American Psychiatry Association [APA], 2022). En este sentido, tras hacer un barrido por las diferentes áreas en las cuales las personas con autismo presentan más vulnerabilidad –comunicación, lenguaje, ámbito emocional, habilidades instrumentales básicas, funciones ejecutivas o gestión del tiempo– se ha observado que las TIC, en todas sus variantes (móvil, Tablet, tableros de comunicación, ordenadores, etc.), consiguen resultados positivos en su fomento y desarrollo. Diversos estudios (Castro y Mallón, 2019, González et al., 2016; Guzmán et al., 2017; Hernández y Sosa, 2018; Pinel et al., 2018; Silva y Rodríguez, 2018; Terrazas et al., 2016) ponen de manifiesto las bondades que las TIC y las apps ofrecen a este colectivo, existiendo multitud de contenido centrado en su desarrollo integral.

Las investigaciones actuales se han orientado hacia las modalidades y posibilidades inclusivas de escolarización (García, 2021; Rodríguez et al., 2021,) y la preparación de sus profesionales (Sánchez et al., 2021). Se emplaza al lector a su lectura para una visión general de la atención educativa en escuela inclusiva de alumnado con

TEA, e incluso al alumnado con necesidades educativas especiales en general (Gallego y Rodríguez, 2012; 2015; 2016; Rodríguez y Gallego, 2019). Visión que se concreta, de acuerdo al objetivo de esta tesis doctoral, con la implementación de apps en la educación y terapia de personas con autismo, mostrándose como un uso responsable, guiado y programado de las mismas ofrece avances significativos en todas las áreas del desarrollo. Estos estudios son enriquecedores para la investigación actual, pero dan lugar a otras reflexiones igualmente necesarias y no abordadas hasta el momento. ¿Las apps existentes para personas con autismo son de calidad y adecuadas a sus demandas y necesidades?, ¿qué ámbitos del desarrollo abordan?, ¿qué dificultades encuentran en su uso los distintos profesionales que las utilizan?, ¿son usadas con frecuencia? De estos interrogantes parte esta tesis doctoral.

Actualmente, contamos con centenares de apps para personas con autismo y con una gran proliferación de dispositivos digitales en las aulas y en las asociaciones que ofrecen terapia, pero los estudios que abordan los interrogantes anteriores apenas son tratados en la investigación actual. Por ello, los objetivos principales de esta tesis doctoral son evaluar las apps gratuitas para personas con autismo disponibles en Google Play Store y analizar la opinión sobre los beneficios y aplicabilidad de las mismas por parte de los distintos educadores que atienden a personas con autismo. Para el desarrollo de estos objetivos, se optó por el formato de tesis por compendio de artículos.

El primer artículo presentado ofrece el diseño y validación de un sistema de indicadores para la evaluación de apps para personas con TEA. Este instrumento de evaluación fue creado *ad hoc*, dada la inexistencia de instrumentos para la revisión de apps específicas centradas en autismo. El sistema de indicadores estuvo compuesto por un total de 46 subindicadores agrupados según tres dimensiones: diseño/forma, contenido y aspectos pedagógicos.

El segundo presenta una evaluación exhaustiva y profunda de 155 apps específicas para personas con autismo y las agrupa según su puntuación: *No Recomendables*, *Recomendables* y *Altamente Recomendables*. Finalmente, se propone un listado de 14 apps *Altamente Recomendables* a profesionales y familias para su empleo con personas con autismo.

El tercer artículo muestra un análisis de apps según las áreas de trabajo que estas abordan: Teoría de la Mente, habilidades instrumentales básicas, funciones ejecutivas,

gestión del tiempo y, ocio y tiempo libre. Se destaca la poca presencia de apps centradas en el ámbito emocional y en la gestión y planificación temporal.

El cuarto artículo presenta la creación y validación del cuestionario *ad hoc "*Demandas y potencialidades de las TIC y las apps para la atención a personas con autismo (DPTIC-AUT-Q)*"*. Este cuestionario se centra en conocer la opinión de los distintos educadores que trabajan con personas con diversidad funcional y, concretamente autismo, acerca de los beneficios y aplicabilidad de las apps. El cuestionario DPTIC-AUT-Q consta finalmente de 4 subescalas: Subescala 1. Opinión, formación y usos de las TIC por parte del profesional para atender a personas con diversidad funcional; Subescala 2. Formación y usos de las TIC por parte del profesional para atender a las personas con autismo; Subescala 3. Usos y beneficios de las apps en la atención de las personas con autismo; Subescala 4. Usos y posibilidades de las apps específicas para las personas con autismo.

El quinto recoge las percepciones de los diversos profesionales que trabajan con personas con autismo en dos contextos, por un lado, de la ciudad de Granada y por otro de la de Florencia, como producto derivado de las de las dos estancias de investigación realizadas en Italia. Así, se realiza una comparativa entre los beneficios, aplicabilidad y frecuencia de uso por parte de los educadores de Granada y Florencia en el uso de apps con personas con autismo.

Finalmente, se plasman las conclusiones derivadas de los objetivos planteados para la realización de la tesis doctoral.

1 INTRODUCTION

Information and Communication Technology (ICT) forms an integral part of daily life in our society, and takes a significant role in the sphere of education.

In this framework of proliferation of digital resources, apps play a fundamental role as a motivating support tool for learning. This is backed by the fact that studies on the potential of ICT and apps in formal and informal education have grown in importance, offering a variety of work options for all groups and ages. Fortunately, the increase in digital material has also reached people with autism spectrum disorder (ASD), and specifically people with autism, for whom different ICTs and particularly apps are now available with content that has been adapted to their needs and difficulties. Many researchers working in different fields, such as healthcare and education, have theorized and tested apps in therapy and teaching with people with autism, producing different and encouraging experiences (Bondioli et al., 2018; Burton et al., 2013; García et al., 2016; Sung, 2018; Vlachou & Drigas, 2017).

Autism is a neurodevelopment disorder that is characterized by difficulties with social communication and social interaction, and restricted and repetitive patterns in behaviours, interests, and activities (American Psychiatry Association [APA], 2022). In this regard, having reviewed all the different areas in which people with autism are more vulnerable – communication, language, emotions, basic instrumental skills, executive functions, and time management – it has been observed that ICT, in all its variants (smartphone, tablet, communication boards, computers, etc.), achieve positive results in their advancement and development. Various studies (Castro & Mallón, 2019, González et al., 2016; Guzmán et al., 2017; Hernández & Sosa, 2018; Pinel et al., 2018; Silva & Rodríguez, 2018; Terrazas et al., 2016) show the benefits that ICT and apps offer this group, with a wealth of content focused on their integrated development.

Recent studies have looked at the implementation of apps in the education and therapy of people with autism, showing how a responsible, guided and programmed usage of them can produce significant advances in all areas of development. These studies enrich current research, but also give rise to other equally necessary reflections that are yet to be addressed. Are the apps currently available for people with autism of good quality and are they suitable for their requirements and needs? Which developmental areas do they address? What difficulties do different professionals encounter when using them? How often are they used? These questions provide the basis for this doctoral thesis.

There are currently hundreds of apps for people with autism, with a proliferation of digital devices in classrooms and in the associations that offer therapy, but the studies that address the above issues are barely dealt with in current research. For this reason, the main objectives of this doctoral thesis are to evaluate the apps that are freely available for people with autism on the Google Play Store, and to analyse the opinion of their benefits and applicability held by the different educators who attend to people with autism. In order to develop these objectives, I have chosen the format of thesis by compendium of articles.

The first article presented gives the design and validation of a system of indicators for the evaluation of apps for people with ASD. This evaluation instrument was an ad hoc creation, due to the non-existence of instruments for assessing specialized apps for autism. The system of indicators comprised a total of 46 subindicators grouped according to three dimensions: design/form, content, and pedagogical aspects.

The second article details a thorough, in-depth evaluation of 155 specialized apps for people with autism and groups them according to rating: *Not Recommendable*, *Recommendable* and *Highly Recommendable*. Lastly, it provides a list of 14 *Highly Recommendable* apps to professionals and families for their use with people with autism.

The third article provides an analysis of apps according to the areas of attention they address: Theory of Mind, basic instrumental skills, executive functions, time management, and leisure and free time. It highlights the lack of apps focused on the emotions, and on time management and planning.

The fourth article presents the creation and validation of the ad hoc questionnaire, "Demandas y potencialidades de las TIC y las apps para la atención a people with autism (DPTIC-AUT-Q)" ("Demands and Potentials of ICT and Apps for Assisting People with Autism"). The purpose of this questionnaire is to discover the opinion of the different educators who work with people with functional diversity, and specifically autism, about the benefits and applicability of apps. The DPTIC-AUT-Q questionnaire consists of four subscales: Subscale 1: Opinion, training and uses of ICT by professionals for teaching people with functional diversity; Subscale 2: Training and uses of ICT by professionals for teaching people with autism; Subscale 3: Uses and benefits of apps in assisting people with autism; Subscale 4: Uses and possibilities of apps specialized for people with autism.

The fifth article gathers the perceptions of the various professionals who work with people with autism in two different locations: the city of Granada, and the city of Florence, the latter deriving from two research visits carried out in Italy. We are therefore able to conduct a comparison between the benefits, applicability and frequency of use by the educators from Florence and Granada in the use of apps with people with autism.

Finally, I draw conclusions from the work on the objectives set for the doctoral thesis.

2 | MARCO TEÓRICO

2.1 Las Tecnologías de la Información y la Comunicación (TIC) en el ámbito de la Atención a la Diversidad

Vivimos y convivimos en una sociedad en la que las TIC forman parte de nuestro día a día, contribuyendo de manera significativa a la transformación cultural. Según García-Valcárcel (2003) las TIC son "el conjunto de tecnologías (ordenadores, consolas de videojuegos, robótica, tabletas digitales, Smartphone, software educativo y demás), que permiten la adquisición, producción, almacenamiento, tratamiento, comunicación y presentación de información en forma de voz, imágenes, y otros" (p. 42). La sociedad está inmersa en una evolución tecnológica que ha pasado a formar una parte importante de la vida de las personas (Pérez et al., 2018) y de las formas de aprender y enseñar.

El impacto progresivo que han tenido dichas tecnologías en diversos espacios de la sociedad ha supuesto que ámbitos como el educativo se enriquezcan con ellas, ofreciendo un amplio abanico de posibilidades a docentes y discentes. La creación de recursos y materiales tecnológicos para el apoyo del aprendizaje de personas con diversidad funcional ha proliferado en los últimos años, dada la motivación que otorgan y los beneficios derivados de su uso. Las TIC facilitan el acceso al mundo educativo (Fernández-Batanero et al., 2017) y mejoran la atención y calidad de la enseñanza hacia el alumnado diverso, por lo que guiar el ejercicio docente hacia prácticas que incluyan tecnologías será crucial para lograr aprendizajes significativos para la totalidad del alumnado, indistintamente de sus capacidades y/o dificultades (Hernández, 2017). Asimismo, orientar el modelo educativo actual hacia la inclusión de las TIC en el aula supone entender la educación de una forma más amplia y atractiva para el estudiantado (Pérez-Zúñiga et al., 2018).

De esta forma, se exige al sistema educativo la obligación de actualizarse (Luján, 2016), desde las etapas iniciales hasta las superiores (Caurcel et al., 2020; Padilla et al., 2018), no solo en cuanto a la inclusión de TIC en las aulas, sino en relación con la enseñanza de las mismas (Muntaner-Guasp et al., 2021). En este contexto, las tecnologías no deben de verse como un aspecto aislado, sino como un medio para alcanzar fines educativos (García-Peñalvo y Ramírez, 2017).

La repercusión de las TIC para el estudiantado resulta enriquecedora y facilita el aprendizaje (Hernández, 2017), abriendo un mundo de posibilidades a estudiantes con

diversidad funcional (Fernández-Batanero et al., 2017; Istenic y Bagon, 2014; Wallace y Georgina, 2014) y mejorando la calidad de la educación, el desempeño docente (Amador et al., 2015; Fernández-Batanero et al., 2017; Martínez-Abad et al., 2015) y la inclusión educativa (Orozco et al., 2017).

Del mismo modo que las TIC forman parte de la práctica docente en las aulas ordinarias, los estudiantes con diversidad funcional forman parte de ellas y también se benefician del potencial que ofrecen, ya que favorecen la comunicación (Cabero-Almenara et al., 2016; Escobar et al., 2016; Luque y Rodríguez, 2009; Pegalajar y Colmenero, 2014), la participación (Toledo y Llorente, 2016), la integración (Chuang y Kuo, 2016) y la igualdad de oportunidades (Escobar et al., 2016; Fernández-Batanero et al., 2017).

El empleo de TIC en los ámbitos de la educación Formal y No formal se ha ido consolidando poco a poco, contando en la actualidad con multitud de recursos digitales en las distintas instituciones educativas. Cabe resaltar que no debe de hacerse un uso arbitrario de las mismas. Las diferentes TIC pueden emplearse como un método de refuerzo de lo aprendido, para afianzar conceptos, como herramienta motivadora de trabajo o para fomentar el desarrollo de diversas habilidades, pero siempre con un análisis previo de los objetivos que desean conseguirse y con un trabajo responsable entre familia y escuela. De no ser así, la finalidad pedagógica de las TIC podría centrarse solo en el ocio y no en los aspectos formativos de las mismas.

Los estudios actuales sobre la implementación de recursos tecnológicos en las aulas y terapias que reciben las personas con diversidad funcional son numerosos e interdisciplinares y manifiestan el potencial de las TIC y los beneficios derivados de su uso. Ejemplos de ellos son las investigaciones en el ámbito de la discapacidad física (Ilyas et al., 2020; Rabhi et al., 2018; Sinha y Dasgupta, 2021; Zainuddin, et al., 2021), la discapacidad intelectual (Fernández-Batanero et al., 2021; Mitchell et al., 2021), la parálisis cerebral (Bertucco y Sanger, 2018; Curioso, 2021; Karlsson et al., 2018; Petroni et al., 2018), el Síndrome de Down (Chalarca, 2018; Cubukcu et al., 2020; Nacher et al., 2018; Porter, 2018) o los Trastornos del Neurodesarrollo (Mowling et al., 2018; Spitale et al., 2019).

Además de los estudios que muestran la funcionalidad que las TIC ofrecen a las personas con diversidad funcional (Toledo y Llorente, 2016) o a aquellas con Dificultades

Específicas de Aprendizaje (DEA) (Trujillo-Torres et al., 2022a), son numerosos los que se centran en reflexionar sobre la formación digital que tienen los distintos profesionales educativos. Los especialistas del ámbito de la atención a la diversidad tienen que contar con conocimientos suficientes que "ayuden a salvar los problemas con los que los alumnos discapacitados se encuentran a diario, barreras que le impiden el aprendizaje." (Toledo y Llorente, 2016, p. 126). Sin embargo, esta formación en tecnología educativa aplicada a las personas con diversidad funcional aún no está siendo completamente abordada. Castillo y Salazar (2021) indican que en este nuevo escenario de aprendizaje no tiene cabida una educación separada de las tecnologías, ya que en la propia legislación educativa española se menciona la competencia digital del docente (Ley Orgánica 3/2020). Pese a ello, no es una competencia que se esté desarrollando en su plenitud. Desde los propios grados universitarios no se prepara lo suficiente a los futuros educadores para desenvolverse con soltura en entornos virtuales junto a alumnado diverso, ni a incluir de forma activa las TIC en las aulas o terapias (Arancibia, 2020; Fernández-Muñoz et al., 2015; Toledo y Llorente, 2016; Valliant, 2014). Sí es cierto que las instituciones educativas cuentan con numerosos recursos digitales, empero sus profesionales no conocen su funcionamiento y aplicabilidad para la atención de personas con diversidad funcional. Las TIC, más allá de ser un puente en el aprendizaje del alumnado diverso, se erigen como herramientas capaces de salvar las barreras del día a día, por lo que su relevancia no solo abarca el contexto académico, sino su desarrollo integral. En esta aseveración se sustenta el Diseño Universal de Aprendizaje para alumnado con Barreras para el Aprendizaje y la Participación (Rodríguez, 2018). Algunas ventajas reseñables de las TIC se vinculan con el fomento de la comunicación, la autonomía, la adaptación al entorno, las posibilidades laborales, el acceso a la información o el desarrollo cognitivo (Fernández-Batanero y Montenegro, 2019). Diversos estudios han demostrado que la mayoría de docentes en ejercicio y en formación poseen un nivel medio-bajo de conocimientos sobre recursos digitales y una escasa formación en TIC en el ámbito de la atención a la diversidad (Cabero-Almenara y Ruiz-Palermo, 2017; Cabero-Almenara et al., 2016a, 2016b; Fernández-Batanero et al., 2017; Toledo y Llorente, 2016).

La formación inicial y continua son claves para que el profesional sepa abordar desde diferentes perspectivas las dificultades que las personas con diversidad funcional pueden encontrar en su aprendizaje. Dada la potencialidad de las TIC y la motivación que

ofrecen en el ámbito de la atención a la diversidad, resulta esencial que se trabaje en su enseñanza y práctica.

2.2 TIC y Trastorno del Espectro Autista (TEA)

El TEA es un trastorno se caracteriza por presentar "deficiencias persistentes en la comunicación social y en la interacción social en diversos contextos […] presentándose patrones restrictivos de comportamiento, intereses o actividades" (APA, 2014, p. 50). Las alteraciones en el neurodesarrollo afectan a las funcionen cerebrales del individuo, produciendo diferentes niveles de afectación (Mulas et al., 2010) y, consecuentemente, manifestando dificultades en lo que a la interacción social se refiere, como el ámbito emocional, el comunicativo o el del lenguaje.

De esta forma, APA (2022) detalla que el TEA abarca cinco tipologías de trastornos del neurodesarrollo: Autismo, Trastorno de Asperger, Trastorno Desintegrativo Infantil, Síndrome de Rett y Trastorno Generalizado del Desarrollo no Especificado.

La prevalencia de personas con TEA, a nivel nacional e internacional, arroja resultados confusos, ya que no se cuentan con estudios epidemiológicos que reflejen el número exacto de personas diagnosticas dadas las discrepancias en la sintomatología de los que la padecen. Actualmente, podría decirse que existe un incremento de diagnósticos (Alcantud et al., 2017; March et al., 2018) debido a que, entre otros motivos, los procedimientos son más elaborados (Fortea et al., 2013), las investigaciones más numerosas y los especialistas más variados (médicos, psicólogos, pedagogos, logopedas, …). Así, Fortea et al. (2013) en su revisión bibliográfica exponen que entre 60-70 personas de cada 10.000 presentan algún tipo de TEA; APA (2014) y March et al. (2018) detallan que el 1% de la población tendría esta condición. Anzaldo y Cruz (2019) afirman que afectaría a 1 de cada 160 niños en todo el mundo.

2.3 Autismo y TIC: relevancia de las apps para la atención de personas con autismo

El autismo, como se mencionó anteriormente, se encuentra ubicado dentro del TEA. En palabras de Rogel-Ortiz (2005), "el autismo es un trastorno estático del desarrollo neurológico que persiste toda la vida y que incluye un amplio margen de alteraciones conductuales" (p. 1). Wing (1998) habla de la *triada autista* conformada por síntomas vinculados a tres ámbitos: lenguaje y comunicación, ámbito social y, conducta y pensamiento. Este trastorno se manifiesta desde la infancia, iniciándose antes de los tres años (Aguilar-Velázquez et al., 2020; López et al., 2009) y perdurando a lo largo de la vida.

Desde los inicios de Kanner (1943) hasta nuestros días, el principal objetivo de familias, docentes y especialistas ha sido la estimulación temprana en busca del desarrollo integral y, la calidad de vida por y para las personas con autismo. En este sentido, las TIC han adquirido un gran papel en el ámbito educativo (Gómez-García et al., 2020; Trujillo-Torres et al., 2020b), ofreciendo a su vez numerosas y variadas opciones de aprendizaje. Sin ir más lejos, las herramientas y recursos digitales diseñados exclusivamente para personas con autismo han proliferado, ofreciendo gran variedad de oportunidades de desarrollo en diferentes áreas en las que estos presentan mayores dificultades. Por ello, las investigaciones más recientes centradas en el fomento de habilidades diversas apoyadas en Smartphones, Tablets, tableros de comunicación u ordenadores arrojan resultados alentadores y positivos en la terapia de personas con autismo (Castro y Mallón, 2019; Hernández y Sosa, 2018; Ledbetter-Cho et al., 2018; Pinel et al., 2018; Silva y Rodríguez, 2018). Lozano et al. (2013a) definen las TIC para la atención de personas con autismo como herramientas de refuerzo versátiles, flexibles, motivadoras y adaptables al ritmo de aprendizaje personal.

El uso de apps está a la orden del día, por el potencial y facilidades que se derivan de ellas, así como por la comodidad e inmediatez que presentan. Tanto es así, que, en los principales catálogos de aplicaciones, su presencia es inmensa, encontrando apps para multitud de necesidades, situaciones y destinatarios.

Las apps disponibles para Smartphone y Tablet alcanzan a todos los sectores de la sociedad, no ciñéndose simplemente a su uso lúdico, sino que abarcan campos como el médico, el educativo, el social o el financiero.

Esta proliferación de apps alcanza, sin duda, a aquellas personas con necesidades educativas especiales y barreras para el aprendizaje y la participación, como los menores

y adultos con autismo. Se encuentran centenares de apps para el trabajo de las diferentes áreas del desarrollo, así como estudios centrados en su potencial y en los beneficios que les otorgan. Ejemplo de ello son las investigaciones con resultados alentadores derivados del uso de apps con personas con autismo centradas en las funciones ejecutivas (Weng y Bouck, 2014; Li et al., 2018; Yerys et al., 2019; Flynn et al., 2019; Wright et al., 2020; Wagle et al., 2021), en las habilidades instrumentales básicas (Sweidan et al., 2019; Teixeira y Cunha, 2019; Aguilar-Velázquez et al., 2020) o en la Teoría de la Mente (Fage et al., 2018; Flores et al., 2012; Jiménez et al., 2017; Lozano et al., 2013b; Weisblatt et al., 2019).

Sin embargo, su uso no está tan extendido como se desearía. Pese a que las intervenciones apoyadas en TIC y apps otorgan resultados alentadores en las áreas en las que las personas con autismo presentan más dificultades, no es una práctica muy frecuente en las instituciones de enseñanza ni en las terapias psicopedagógicas.

Los estudios sobre el empleo y frecuencia de uso de apps en las instituciones de educación Formal y No Formal con personas con autismo son inexistentes, al igual que lo son los vinculados a otro tipo de recursos tecnológicos (Eye Tracking, Realidad Virtual, Realidad Aumentada (RA), Realidad Mixta, Robótica, Tableros de Comunicación Digitales, etc.). Existen multitud de investigaciones sobre el potencial de las TIC para personas con autismo (Abu-Amara et al., 2021; Giaconi et al., 2021; Lledó et al., 2022; Mosher y Carreon, 2021; Özdemir et al., 2022; Wedyan et al., 2021), pero no son tan numerosas aquellas sobre la motivación para usar dichos recursos, la formación de los educadores en materia digital o las facilidades y dificultades que encuentran los profesionales para su empleo.

Como se ha comentado, la investigación sobre los usos que se hacen de las apps en los centros educativos y en las terapias psicopedagógicas por parte de especialistas para la atención de personas con autismo, así como de los beneficios que se encuentran en su empleo, son escasos. No hay suficiente información con la que contrastar resultados, ni para el uso consciente de educadores y padres.

Lo mismo ocurre con los estudios centrados en la evaluación de apps. Es frecuente encontrar investigaciones que versan sobre los beneficios del empleo de apps específicas para personas con autismo (Sweidan et al., 2019; Smith et al., 2020; Aguilar-Velázquez et al., 2020; Vyshedskiy et al., 2020), pero no sobre si las apps utilizadas son

de una calidad aceptable o si atienden realmente a las necesidades y características del usuario con autismo. Esta nueva línea de investigación centrada en la evaluación de apps es muy reciente y no cuenta con suficiente análisis, profundización y recorrido. En este sentido, algunos autores, como Choez (2018), realizan una revisión y análisis de apps para niños con autismo, destacando que en 2017 había más de 1300 apps, pero no existían investigaciones que evaluaran si eran adecuadas o no. Entre las apps que analiza se destaca la calidad de *José Aprende* o *EmoPLAY*. Díaz (2018) evalúa apps para personas con autismo, resaltando la inexistencia de categorizaciones de acuerdo al tipo de discapacidad o a la calidad de la app, concluyendo que tan solo el 37,68% presentan una calidad aceptable y que estas se centran principalmente en el desarrollo de las competencias sociales. Algunas de las apps que destacan por su calidad son *José Aprende* o *El Viaje de Elisa*. Larco et al. (2018) revisan y evalúan 65 apps para personas con autismo e indican que el 38% presentan una calidad aceptable. Estas se centran mayormente en el desarrollo del entorno social y la autonomía y, en menor medida, en la competencia lingüística y comunicativa. Entre ellas, se encuentran *Pictoagenda* o *Pictotraductor*. Ramón (2019) evalúa apps de realidad aumentada, advirtiendo de la escasez de apps destinadas a este ámbito. Finalmente, ofrece un listado de apps para personas con autismo, entre las que se encuentran *#Soyvisual*, *Proyecto Emociones* o *José Aprende*. Capel (2021) analiza y evalúa 50 apps para el desarrollo de la comunicación para el alumnado con autismo, indicando que 8 presentan una calidad excelente y 17 una puntuación adecuada. Finalmente, entre las apps recomendadas se encuentran *#Soyvisual*, *Symbotalk - AAC Talker*, *MITA*, *Pictoagenda*, *Pictotraductor* y *CommBoards*. Gallardo-Montes et al. (2021a y 2021b) evalúan 155 apps para personas con autismo, de las cuales tan solo 14 alcanzan puntuaciones notablemente superiores al resto. Las apps se centran principalmente en el fomento de funciones ejecutivas, habilidades instrumentales básicas, comunicación y lenguaje, dejando un bajo porcentaje al desarrollo emocional y la gestión del tiempo. Entre ellas, se encuentran *#Soyvisual*, *MITA*, *Symbotalk - AAC Talker*, *CommBoards*, *Smile and Learn*, *LEA* o *Proyecto Emociones*.

Dada la escasez de estudios concretos centrados en la evaluación de apps, indistintamente del sistema operativo en el que se centren, surge esta investigación, con el fin de profundizar en las apps diseñadas de manera concreta para personas con autismo y en la aplicabilidad que los distintos profesionales encuentran para su empleo.

3 | JUSTIFICACIÓN Y OBJETIVOS

Los estudios actuales sobre el potencial de las apps para la atención de personas con autismo están en auge, dada la gran oferta digital existente y los beneficios que ofrecen. En este contexto, nace esta tesis doctoral, con el fin último de indagar de forma exhaustiva las apps diseñadas de manera específica para personas con autismo y su empleo por parte de profesionales pertenecientes a la educación Formal y No Formal.

Si bien es cierto que el uso de dispositivos electrónicos causa reticencias en algunas ocasiones debido a un mal uso (Sevillano, 2020), a la falta de conocimientos sobre sus funcionalidades o a comportamientos adictivos (Ahmed et al., 2021; Effendy et al., 2021; Li et al., 2021; Nasser et al., 2020), los estudios empíricos revisados en los capítulos anteriores manifiestan que, realizando un uso responsable, coordinado y programado, se facilita el desarrollo de multitud de habilidades en déficit y se potencia el aprendizaje en personas con autismo.

Si se realiza una búsqueda en internet acerca del autismo se cuentan por cientos las webs y apps que presentan herramientas de trabajo actualizadas para padres y profesionales, pero… ¿qué se ofrece a las personas con autismo? Al buscar realmente qué se ofrece a este colectivo, aparecen multitud de enlaces relacionados y aplicaciones, sin poder distinguir, a priori, en qué se diferencian o cuáles son mejores. La propuesta de esta tesis doctoral gira en torno a las incógnitas planteadas con anterioridad y cuyas hipótesis de investigación se proponen a continuación.

Las hipótesis de trabajo de las que parte la investigación se han formulado en forma de interrogantes, en función del conocimiento previo sobre cada una de las cuestiones objeto de investigación. Por ello, se pretende dar respuesta a algunas de las siguientes preguntas:

- ¿Hay apps gratuitas y específicas para personas con autismo? ¿Tienen buena calidad?
- ¿En qué áreas del desarrollo se centran las apps que se ofrecen en Google Play Store de manera gratuita para personas con Autismo? ¿Para qué edad están destinadas?
- ¿Los profesionales y especialistas en autismo hacen uso de las apps para atender a personas con este trastorno?
- ¿Con qué finalidad se utilizan las apps? ¿Qué beneficios encuentran en su uso?

Una vez planteado el problema de investigación, cabe destacar por qué se ha centrado esta investigación en el catálogo de aplicaciones Google Play Store para dispositivos Android y no se ha ampliado a otros (iOS). El motivo de ello reside en que, en los centros educativos de Andalucía, la propia Junta de Andalucía ha concedido una Tablet con sistema operativo Android a cada estudiante perteneciente a aulas específicas TEA. Por esta razón, la muestra de apps se ha ceñido a Google Play Store, ya que las apps empleadas por los distintos profesionales en las aulas y/o terapias, principalmente serían descargadas para estos dispositivos.

En base a este problema de investigación, los objetivos principales que se derivan son: evaluar las apps gratuitas para personas con autismo disponibles en Google Play Store y analizar la opinión sobre los beneficios y aplicabilidad de las mismas por parte de los distintos educadores que atienden a personas con autismo. Partiendo de este objetivo general, se plantean los siguientes objetivos específicos:

1. Diseñar y validar un instrumento de evaluación de apps para personas con autismo.

2. Evaluar las apps gratuitas de Google Play Store específicas para personas con autismo.

3. Determinar qué apps son mejores que otras según su calidad y conocer en qué áreas del desarrollo se centran.

5. Diseñar y validar un cuestionario para conocer la funcionalidad y aplicabilidad que encuentran los profesionales en autismo en las apps.

6. Indagar en la frecuencia de uso de las apps por parte de los distintos profesionales y los motivos que los llevan a su empleo.

4 | AGRUPACIÓN DE ARTÍCULOS CIENTÍFICOS

Artículo 1. Diseño de un sistema de indicadores para la evaluación y selección de aplicaciones para personas con Trastorno del Espectro Autista

Revista Electrónica Educare (Educare Electronic Journal) | EISSN: 1409-4258 Vol. 25(3) SETIEMBRE-DICIEMBRE, 2021: 1-24

[Cierre de edición el 01 de Setiembre del 2021]

http://doi.org/10.15359/ree.25-3.18
http://www.una.ac.cr/educare
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Diseño de un sistema de indicadores para la evaluación y selección de aplicaciones para personas con Trastorno del Espectro Autista

Design of an Indicator System for the Evaluation and Selection of Applications for People With Autistic Spectrum Disorder

Projeto de um sistema de indicadores para a avaliação e seleção de aplicações para pessoas com Transtorno do Espectro Autista

Carmen del Pilar Gallardo-Montes
Universidad de Granada
Facultad de Ciencias de la Educación
Departamento Didáctica y Organización Escolar
Granada, España
cgallardo@ugr.es
https://orcid.org/0000-0002-6510-2425

María Jesús Caurcel-Cara
Universidad de Granada
Facultad de Ciencias de la Educación
Departamento Didáctica y Organización Escolar
Granada, España
caurcel@ugr.es
https://orcid.org/0000-0002-2169-9100

Antonio Rodríguez-Fuentes
Universidad de Granada
Facultad de Ciencias de la Educación
Departamento Didáctica y Organización Escolar
Granada, España
arfuente@ugr.es
https://orcid.org/0000-0002-8036-9902

Recibido • Received • Recebido: 18 / 10 / 2019
Corregido • Revised • Revisado: 25 / 06 / 2021
Aceptado • Accepted • Aprovado: 12 / 08 / 2021

Resumen:
Objetivo: Las tecnologías de la información y la comunicación (TIC) aportan a las personas con trastorno del espectro autista (TEA) un abanico de posibilidades de desarrollo. A su vez, son numerosas las aplicaciones (*apps*) destinadas a personas menores con autismo, por lo que esta propuesta pretende ofrecer un listado de indicadores validados que analicen las fortalezas y debilidades de dichas apps. **Metodología**: El análisis exhaustivo de estudios previos ha permitido la creación de este instrumento, en relación con el diseño de la app, su contenido y sus aspectos

Revista Electrónica Educare (Educare Electronic Journal) | EISSN: 1409-4258 Vol. 25(3) SETIEMBRE-DICIEMBRE, 2021: 1-24

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pedagógicos. A través de un estudio instrumental de validez de contenido, se procedió a validar el sistema de indicadores (según su claridad, coherencia, relevancia y objetividad), para lo cual se aplicó el método del juicio experto. **Resultados:** Un total de 12 jueces han puntuado entre buenos y excelentes cada uno de los indicadores y subindicadores diseñados, con unos coeficientes de correlación intraclases excelsos, una concordancia inter-jueces W de Kendall significativa y fuerte, y unos niveles de consistencia interna elevados. Se constató que se trata de un instrumento válido y fiable. **Discusión:** Los resultados positivos derivados de la validación del instrumento han dado lugar a un sistema de indicadores compuesto por criterios deseables para una app destinada a personas con este trastorno. Especialistas en TEA y familiares van a contar con una herramienta intuitiva para la selección de apps adecuada a las necesidades del colectivo, que abarca distintos parámetros.

Palabras claves: Aplicación informática; educación especial; indicadores educativos; instrumento de medida; tecnología educacional; TIC; trastorno del espectro autista.

Abstract

Objective: Information and communication technologies (ICT) provide people with autism spectrum disorder (ASD) with a wide range of possibilities for development. At the same time, there are numerous applications (apps) aimed at children with autism; so, this proposal aims to offer a list of validated indicators that analyze the strengths and weaknesses of these apps. **Methodology:** The exhaustive analysis of previous studies has allowed the creation of this instrument in relation to the design of the app, its content, and its pedagogical aspects. According to its clarity, coherence, relevance, and objectivity, the system of indicators was validated through an instrumental study of content validity, applying the method of expert and judges' judgment. **Results:** A total of 12 judges scored each of the designed indicators and sub-indicators as good to excellent, with excellent Intraclass Correlation coefficients, significant and strong Kendall's W inter-judge agreement, and high levels of internal consistency. It was found to be a valid and reliable instrument. **Discussion:** The positive results derived from the validation of the instrument have resulted in a system of indicators composed of desirable criteria for an app for people with ASD. ASD specialists and family members will have an intuitive tool for the selection of apps adapted to the needs of this group, covering different parameters.

Keywords: Autism spectrum disorder; computer applications; educational indicators; educational technology; ICT; measuring instrument; special education.

Resumo

Objetivo: As Tecnologias de Informação e Comunicação (TIC) proporcionam às pessoas com Desordem do Espectro do Autismo (DEA) uma gama de possibilidades de desenvolvimento. Por sua vez, existem numerosas aplicações (apps) destinadas a crianças com autismo, pelo que esta proposta visa fornecer uma lista de indicadores validados que analisam os pontos fortes e fracos destas aplicações. **Metodologia:** A análise exaustiva de estudos anteriores permitiu a criação deste instrumento, em relação à concepção da aplicação, ao seu conteúdo e aos seus aspectos pedagógicos. Através de um estudo instrumental da validade do conteúdo, procedemos à validação do sistema de indicadores (de acordo com a sua clareza, coerência, relevância e objetividade), aplicando o método de julgamento de peritos e juízes. **Resultados:** Um total de 12 juízes pontuaram entre bom e excelente cada um dos indicadores e subindicadores concebidos, com excelentes coeficientes de correlação intraclasse, uma concordância significativa e forte entre juízes W de Kendall, e altos níveis de consistência interna. Foi considerado como um instrumento válido e fiável. **Discussão:** os resultados positivos derivados da validação do instrumento resultaram num sistema de indicadores composto de critérios desejáveis para uma aplicação a pessoas com esta desordem. Os especialistas em DEA e membros da família terão um instrumento intuitivo para a seleção de aplicações adaptadas às necessidades coletivas, abrangendo diferentes parâmetros.

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Palavras-chave: Aplicação informáticas; educação especial; desordem do espectro autista; indicadores educacionais; instrumento de medição; tecnologia educacional; TIC.

Introducción

Resultan sorprendentes los avances desarrollados en el campo de la educación en consonancia con las tecnologías de información y la comunicación, situándonos en un momento en el que el acceso a diversidad de materiales educativos está a solo un *click*. El ámbito de la educación especial y, en concreto, el del trastorno del espectro autista (TEA), cuenta con profesionales que ofrecen plataformas de consulta y desarrollan materiales *online* para familias, especialistas en TEA y personas con este trastorno.

Las TIC constituyen una herramienta más manipulativa, auditiva y visual (González Cintado et al., 2016; Rodríguez Fuentes, 2017), adaptada a sus necesidades y que ofrece múltiples ventajas a la hora del trabajo con personas con TEA. Parsons et al. (2006) y Terrazas Acedo et al. (2016) coinciden en que ayudan al desarrollo y promoción de habilidades sociales. Pero no solo desarrollan aspectos vinculados al ámbito social y emocional, sino que aumentan la motivación hacia este tipo de tareas (Lozano Martínez et al., 2014). Guzmán et al. (2017) señalan que "el uso de tecnologías para mejorar y estimular, particularmente, la comunicación de los niños con TEA ha aumentado en los últimos tiempos de manera exponencial" (p. 248), y abre un mundo de posibilidades para poder desarrollar otras habilidades en déficits como la atención, anticipación, funciones ejecutivas, memoria de trabajo, secuencias de acciones, organización de eventos, etc.

En relación con el uso de aplicaciones móviles y sus beneficios para personas con TEA, Flores et al. (2012) demuestran que, a través de aplicaciones destinadas al aumento de la comunicación, se potencian los comportamientos vinculados a esta misma, motivando la intención comunicativa. Igualmente, Jiménez Lozano et al. (2017) obtienen resultados positivos empleando aplicaciones cuya finalidad era el uso de sistemas aumentativos de comunicación, fomentando la comunicación y promoviendo el desarrollo de la expresión. A su vez, en este estudio se reflejan experiencias (Bellini y Akullian, 2007; Cafiero, 2005; Mirenda, 2001; Mirenda et al., 2000) que ofrecían resultados beneficiosos, en de la idea de que el formato visual que ofrecen los dispositivos móviles estimula la socialización y comunicación de la niñez con TEA.

Las TIC, hoy, ya no resultan un recurso tan novedoso como años atrás, pero su uso continuado precisa de una revisión constante, para plantear adecuadamente qué es lo que se va a trabajar con ellas y qué se quiere conseguir. Así, como señalan Campos Jiménez et al. (2014), internet es una excelente herramienta a la hora de encontrar material educativo, pero si se realiza una búsqueda acerca del autismo se cuentan por cientos las webs y aplicaciones (apps) que presentan herramientas actualizadas para padres y profesionales. Ahora bien… ¿qué se ofrece a las personas con TEA? Al realizar esa búsqueda aparecen multitud de aplicaciones, muchas más que para otros colectivos como síndrome de Down o parálisis cerebral (Larco et al., 2015), sin poder distinguir, a priori, en qué se diferencian o cuáles son mejores. Las familias al ofrecer a las personas con TEA el dispositivo móvil suelen hacerlo confiando en que determinadas

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aplicaciones, al estar creadas especialmente para este colectivo, van a cumplir con el fin esperado, pero no siempre es así. Haciendo un barrido en Google Play Store, utilizando como palabra clave "autismo", se encuentran alrededor de 230 aplicaciones -búsqueda realizada el 17/07/2018-, pero profundizando un poco más se observa que muchas de estas no tienen relación directa con el autismo. Dado el auge tanto en cantidad como en diversidad, asumida la funcionalidad del medio digital a través de aplicaciones, pero detectada la inespecificidad de gran número de ellas, se pretende establecer unos criterios que determinen por qué una es mejor que otra y cuál de ellas emplear para así facilitar su selección por parte de familiares y profesionales.

Son varios los estudios que han trabajado sobre este tema, con la finalidad de establecer parámetros de evaluación de aplicaciones o plataformas web. Belloch Ortí (2006) plantea una serie de criterios de calidad para evaluar aplicaciones multimedia, entre los que destacan los estéticos, pedagógicos y funcionales; indica, a su vez, aspectos económicos y técnicos. Asimismo, Araujo et al. (2007) proponen "criterios de evaluación … [de] aplicaciones multimedia en entornos de educación y formación a distancia" (p. 3), que plasman la necesidad de evaluarlas partiendo de tres análisis previos: *descriptivo*, atendiendo a aspectos técnicos, diseño, objetivos y contenidos; *pedagógico*, indagando las actividades, materiales o evaluación; y *didáctico*, desarrollando parámetros ligados a operaciones cognitivas, creatividad o motivación. Por su parte, Larco et al. (2015) evalúan aplicaciones educativas para público usuario con discapacidad intelectual, incluyendo algunas para personas con autismo, donde los elementos valorados se relacionan con la funcionalidad, estética, información ofrecida, calidad…

En el trabajo de García-Rodríguez y Gómez-Díaz (2015) se plantean una serie de indicadores con los que evaluar las aplicaciones destinadas a la lectura infantil, ya que como destacan en su trabajo, "la cantidad y variedad de aplicaciones es grande" (p. 2). A su vez, también afirman que, pese a la diversidad de estudios previos sobre aplicaciones, pocos son los que profundizan en evaluarlas. Las autoras ofrecen una plantilla que recoge aspectos fundamentales a evaluar respecto a las dimensiones *forma* y *contenido*.

Con esta investigación se pretende ofrecer un sistema de indicadores de calidad para evaluar aplicaciones para dispositivos móviles destinadas a público usuario con TEA. La idea principal es que familias y profesionales cuenten con una herramienta desarrollada en profundidad con la que determinar qué aplicaciones son las más adecuadas en función del área que quiera trabajarse: comunicación, emociones, gestión del tiempo, habilidades instrumentales básicas –desarrollo del lenguaje, matemáticas, aprendizaje de las letras…–, funciones ejecutivas –organización, memoria, atención…– y ocio.

Metodología para evaluar las aplicaciones para personas con TEA

Los aspectos que se evalúan se encuentran en consonancia con criterios deseables para una aplicación destinada a este colectivo, por lo que los indicadores, y sus consecuentes explicaciones, son rigurosos y analizados desde un punto de vista psicopedagógico. La

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http://doi.org/10.15359/ree.25-3.18
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utilización de un sistema de indicadores es un recurso útil para evaluar de manera tangible productos o servicios ofrecidos. El desarrollo de los indicadores que se presentan ha sido elaborado partiendo de los trabajos previos de Araujo et al. (2007), Belloch Ortí (2006) y García-Rodríguez y Gómez-Díaz (2015).

El sistema de indicadores desarrollado plantea tres dimensiones para valorar: diseño/forma, contenido y pedagogía. Inicialmente se consideró incluir los indicadores "precio de la app" y "sistema operativo", pero ambos fueron excluidos ya que la idea es la de ofrecer esta herramienta como medio útil para analizar aplicaciones y, cabe destacar que, en los centros educativos se conceden *Tablets* con sistema operativo Android con aplicaciones gratuitas, por lo que estos elementos no serían relevantes en este análisis.

A continuación, se presenta cada una de las dimensiones con sus indicadores correspondientes para evaluar aplicaciones en dispositivo móvil o *Tablet*. El valor concedido a cada indicador, en caso de que la aplicación presente dicho criterio, será de 1. También se incluye un apartado de "observaciones", para cuando sea preciso completar cualitativamente una valoración.

A. Dimensión de diseño/forma (D1): cuando se pretende evaluar una aplicación suele atenderse primero a la presentación de sus aspectos formales, a cómo ha sido diseñada y conforme con qué criterios se ha desarrollado. Los indicadores planteados son:

A.1 Disponibilidad: "utilizamos el término disponibilidad para determinar la facilidad de acceso a la propia aplicación" (García-Rodríguez y Gómez-Díaz, 2015, p. 3).

A.1.1 *Idiomas:* se valorará que la aplicación presente varios idiomas. En caso afirmativo, se indicarán cuáles.

A.1.2 *Actualización:* este subindicador se relaciona con lo actualizada que se encuentra la aplicación. Se ha considerado que una aplicación está actualizada cuando la última actualización no supere los tres años.

A.1.3 *Icono identificable:* resulta relevante que una aplicación cuente con un icono que la identifique con el contenido y sea reconocible por el usuario.

A.2 Ergonomía: se refiere a los aspectos vinculados a la visualización de la aplicación, en relación con el color, el tipo y el tamaño de la letra y la claridad del contenido.

A.2.1 *Legibilidad:* se relaciona con la legibilidad de los textos en las diferentes pantallas de la aplicación. Básicamente, si el tipo de letra y el tamaño facilitan la lectura.

A.2.2 *Claridad:* la claridad de la pantalla es esencial para visualizar correctamente el contenido. El fondo y las letras deben contener colores que faciliten la lectura.

A.2.3 *Uso del color:* los colores deben estar en armonía con la plataforma, con tonos uniformes que atraigan la atención del sujeto usuario, pero sin distraerlo de

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http://doi.org/10.15359/ree.25-3.18
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la tarea. La tonalidad adecuada dependerá de la sensibilidad de la persona usuaria, pero, por lo general, especialistas se decantan por colores fuertes.

A.2.4 *Personalización:* las aplicaciones pueden presentar la opción de cambiar su aspecto y adaptarlo a las necesidades del usuario. Se evaluará, si permite modificaciones en los aspectos formales del texto (color, tamaño y tipo de letra) o del audio (eliminación de la música o el idioma del narrador).

A.3 Usabilidad: según la Organización Internacional para la Estandarización (ISO 250000, 2018) la usabilidad se refiere a la capacidad del producto software para ser entendido, aprendido, usado y resultar atractivo para el usuario, cuando se usa en determinadas condiciones (ISO/IEC 25010). La usabilidad depende no solo del producto sino también del sujeto usuario, y según Nielsen (2000) el diseño debe esforzarse por mostrar las actividades de la forma más clara posible y sin actividades que den lugar a confusión.

A.3.1 *Velocidad*: se relaciona con el tiempo que emplea la aplicación en abrirse. Lo ideal es una apertura instantánea, o como máximo de unos 5 segundos.

A.3.2 *Navegación*: la navegación tiene que ser tarea fácil, apreciándose iconos que hagan de la aplicación, un espacio donde se produzca aprendizaje de manera clara, rápida e intuitiva, sin pausas innecesarias ni errores.

A.4 Popularidad: García-Rodríguez y Gómez-Díaz (2015) hacen alusión a la popularidad que otorga a la aplicación el número de descargas que esta tenga. De esta forma consideran:

A.4.1 *Puntuación del público usuario*: hace referencia a las valoraciones que hacen los usuarios en las webs de descarga. Usualmente, se valora con una escala de 1 a 5. Se valorará de manera positiva que la puntuación en Google Play Store sea ≥4.

A.4.2 *Número de descargas*: uno de los mejores indicadores de la popularidad y, por tanto, también de la calidad es el número de descargas. El dato de descargas está presente en Google Play Store según los siguientes criterios: Gris de 1 a 5.000 descargas; Azul de 10.000 a 50.000; Verde de 100.000 a 500.000; y Naranja 1.000.000 o más. Se valorará positivamente que tenga más de 50.000 descargas.

A.4.3 *Premios o reconocimientos recibidos*: se valorará que la aplicación posea algún premio o reconocimiento y se describirá cuál es en el apartado de "observaciones".

A.5 Accesibilidad: según Gil González (2013, p. 9) "una aplicación es accesible cuando cualquier usuario, independientemente de su diversidad funcional, puede utilizarla en su dispositivo móvil satisfactoriamente con su sistema de acceso habitual". Las personas con diversidad funcional presentan un amplio abanico de necesidades, derivadas del nivel de afectación que presenten, así, una aplicación será accesible,

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si cubre "todas las necesidades que un usuario pueda requerir" (Aguado Delgado y Estrada Martínez, 2017, p. 11).

A.5.1 *Acceso a la aplicación por público usuario con TEA*: este subindicador indica si la aplicación atiende a las características del público usuario con TEA y le posibilita su acceso.

A.5.2 *Utilización sin conexión a internet*: uso de la aplicación sin conexión a internet.

B. Dimensión de contenido (D2): se pretenden valorar varios aspectos:

B.1 Calidad del audio: el audio debe ser apropiado para la población destinataria (Araujo et al., 2007); hace referencia a la música, voz y sonidos.

B.1.1 *Sonidos*: se evaluarán positivamente las aplicaciones con sonidos de buena calidad.

B.1.2 *Música:* las aplicaciones que incluyan música serán valoradas positivamente.

B.1.3 *Narración:* la voz que relate cómo proceder en cada actividad debe tener una entonación adecuada durante todo el trascurso del audio.

B.2 Calidad de la narración: la narración debe ser adecuada y entendida sin dificultad.

B.2.1 *Modulación de la voz:* los cambios en el tono, volumen, ritmo, pronunciación y velocidad deben ser acordes a las actividades planteadas.

B.2.2 *Claridad:* la voz debe de ser comprensible y perceptible por el usuario.

B.2.3 Entonación neutral: la voz narradora debe de expresar adecuadamente los tonos exclamativos, interrogativos o enunciativos.

B.3 Contenidos: este indicador se destina a la comprobación de que el contenido se adapte a las necesidades de las personas con TEA.

B.3.1 *Variedad de temas:* la variedad en los temas, tareas, actividades y juegos disponibles supone un aspecto deseable en una aplicación.

B.3.2 *Organización de los contenidos:* la distribución de los contenidos es fundamental para que el usuario pueda acceder de forma adecuada.

B.3.3 *Diferentes niveles*: es deseable que las aplicaciones incluyan distintos niveles de ejecución en función de dificultad o la edad de la persona con TEA.

B.4 Notificaciones: la aplicación puede enviar notificaciones, aunque no se esté utilizando es ese momento, las cuales aparecerán en la barra de notificaciones del dispositivo móvil o por vía *e-mail*. Se valorará positivamente que la aplicación las incluya.

B.5 Ayudas y tutoriales: los apartados de ayuda (como texto escrito o en audio) son útiles para entender las actividades, por lo que es conveniente que la aplicación los incluya.

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B.6 Seguridad: desde el año 2001 existe un código europeo de autorregulación para productos de software interactivo (videojuegos, juegos de ordenador, artículos de educación, …) que tiene como objetivo "informar de forma objetiva y responsable a padres, educadores y al público en general, sobre el contenido … y … la edad para la que se consideran adecuados" (Pérez Alonso-Geta, 2008, p. 37). El sistema PEGI (Pan European Game Information System) "es el mecanismo de autorregulación diseñado por la industria para dotar a sus productos de información orientativa sobre la edad adecuada para su consumo" (Asociación Española de Videojuegos, 2015, párr. 1). De esta manera, se facilita la elección de productos ajustados a la etapa evolutiva del público usuario, restringiendo la interacción de infantes con contenidos inadecuados. Las aplicaciones para personas menores con TEA cuentan con este sistema para clasificar el contenido. Así, en el indicador seguridad se incluye:

B.6.1 *Protección de datos:* todas las aplicaciones, y mucho más las destinadas a personas menores, deben garantizar la protección de "datos de manera que personas o sistemas no autorizados no puedan leerlos o modificarlos" (Costilla Quiroz y de la Cruz Berrospi, 2016, p. 30). Se valorará si la aplicación cuenta con mecanismos que garanticen la confidencialidad y la privacidad.

B.6.2 *Permisos que solicita al instalar la aplicación:* las aplicaciones solicitan "acceso a las funciones de teléfonos inteligentes y tabletas, tales como ubicación y libreta de contactos" (We live security, 2015, párr. 1), aspectos que no deberían ser concedidos y que pueden considerarse innecesarios. Este subindicador vislumbra si la aplicación solicita permisos excesivos en relación con su uso.

B.6.3 *Control parental en la propia aplicación:* es recomendable la existencia de un sistema de control parental en la propia aplicación, se valorará su presencia respecto al acceso a internet o a los ajustes.

B.6.4 *Bloqueo de compras integradas:* existen aplicaciones que incluyen compras para avanzar de nivel o para acceder a material complementario. Se valora positivamente que presente algún tipo de bloqueo de compras en la propia aplicación.

C. Dimensión pedagógica (D3): este apartado se centra en las posibilidades que ofrecen las actividades propuestas en la aplicación para personas usuarias con TEA:

C.1 Interactividad: la interactividad según García-Rodríguez y Gómez-Díaz (2015) "permite al lector actuar y participar como un personaje más de la historia y tomar decisiones en el proceso de lectura. Por ello es conveniente comprobar si la aplicación … incluye animación e interactividad, si está equilibrada, si es excesiva" (p. 11).

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C.1.1 *Permite añadir imágenes o pictogramas personalizados:* se valorará positivamente que la aplicación incluya la opción de añadir pictogramas propios o imágenes que representen rutinas en casa o colegio para favorecer el aprendizaje significativo.

C.2 Adecuación a los ritmos y aprendizajes: Belloch Ortí (2006) plantea la importancia de adaptar las aplicaciones a las características del sujeto usuario, proponiendo ritmos de aprendizaje flexibles, y adaptando la interface al uso de diferentes códigos de comunicación (visual o auditivo). Para poder medir este apartado se valorará:

C.2.1 *Contenido apropiado para los sujetos usuarios:* el contenido tiene que ser apropiado para la edad y relacionado con la finalidad de la aplicación.

C.2.2 *Tiempo de realización suficiente:* es importante que se respeten los tiempos en los que el sujeto usuario está resolviendo un juego de asociación o interpretando una locución o cuento. La aplicación no debería de establecer un tiempo de resolución.

C.2.3 *Diferentes códigos de comunicación:* resulta atractivo para la persona con TEA que las situaciones mostradas propongan diferentes códigos, como el auditivo o el visual, para poder interpretar mejor lo que la aplicación pretende enseñar.

C.3 Seguimiento/evaluación: Belloch Ortí (2006) resalta la utilidad de que la aplicación ofrezca un seguimiento y evaluación de las actividades realizadas. De esta forma:

C.3.1 *Se hace un seguimiento del progreso:* se valorará si posee un sistema de seguimiento que permita una evaluación formativa del aprendizaje realizado.

C.3.2 *Se evalúan las actividades realizadas:* se valorar si posee un sistema de evaluación de las actividades.

Para finalizar, se precisa una interpretación de lo obtenido; en este sentido, hay que establecer qué puntuación será la óptima, de forma que se especifique cuáles serían las aplicaciones adecuadas. El instrumento consta de un total de 14 indicadores, subdivididos en 46 subindicadores, de tal manera que la puntuación de la dimensión diseño/forma oscilará entre 0 y 22 puntos; la de contenido entre 0 y 18 puntos; la pedagógica entre 0 y 6 puntos; y la total entre 0 y 46 puntos. Así, tomando como referencia los tres niveles de aplicaciones establecidos por García-Rodríguez y Gómez-Díaz (2015) y dado que la puntuación total máxima será 46 puntos, la interpretación y valoración de las aplicaciones seguirán los siguientes parámetros:

1. Altamente recomendables: puntuación ≥ 37 (entre 80% y 100% de indicadores).
2. Recomendables: puntuación entre 23 y 36 (entre el 50% y 79% de indicadores).
3. Prescindibles: puntuación ≤ 22 (menos del 49% de los indicadores).

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Una vez concluida la explicación de cada uno de los indicadores desarrollados, es preciso mostrar la hoja de registro que hará operativa la evaluación (Ver Figura 1).

Figura 1: Sistema de indicadores de evaluación de aplicaciones destinadas a personas usuarias con TEA

Nombre:					
Edad a la que se destina:		Fecha de evaluación:			
Ámbito/s que trabaja/desarrolla (comunicación, emociones, gestión del tiempo…):					
Dimensión de diseño/forma					
Indicador	**Subindicador**		**No (0)**	**Sí (1)**	**Observaciones**
Disponibilidad	Idiomas				
	Actualización				
	Icono identificable				
Ergonomía	Legibilidad				
	Claridad				
	Uso del color				
	Personalización	Cambios en el texto			
		Cambios en el audio			
Usabilidad	Velocidad	Apertura rápida			
		Ausencia tiempos muertos			
	Navegación	Sencilla e intuitiva			
		Rápida			
		Funcionamiento correcto			
		Botones identificables			
		Botones de tamaño correcto			
		Botones bien ubicados			
		Acceso al menú desde todas las pantallas			
Popularidad	Puntuación de los sujetos usuarios				
	Número de descargas				
	Premios/Reconocimientos				
Accesibilidad	Acceso a la aplicación por personas usuarias con TEA				
	Utilización sin conexión a internet				

continúa

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Dimensión de contenido					
Calidad del audio	Sonidos				
	Música				
	Narraciones				
Calidad de la narración	Modulación de la voz				
	Claridad				
	Entonación neutral				
Contenidos	Variedad de temas				
	Organización de los contenidos	Distribución			
		Visualización			
	Distintos niveles				
Notificaciones	Envío de notificaciones				
Ayudas y tutoriales	Formato escrito				
	Audio				
Seguridad	Protección de datos				
	Permisos de instalación necesarios				
	Control parental en la propia aplicación	Acceso a internet			
		Ajustes del contenido			
	Bloqueo de compras integradas				
Dimensión pedagógica					
Interactividad	Permite añadir imágenes o pictogramas personalizados				
Adecuación a los ritmos y aprendizajes	Contenido apropiado para las personas usuarias				
	Tiempo de realización suficiente				
	Diferentes códigos de comunicación				
Seguimiento/ Evaluación	Se hace un seguimiento del progreso				
	Se evalúan las actividades realizadas				
PUNTUACIÓN TOTAL:					

Nota: Elaboración propia.

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Aplicación del método del juicio experto para la validación del sistema de indicadores

Se realizó un estudio instrumental de validez de contenido. Esta metodología de investigación consiste en el desarrollo de pruebas y aparatos, incluyendo tanto el diseño o adaptación como el análisis de las propiedades psicométricas de estos mismos (Montero y León, 2007).

Para la validación del sistema de indicadores, se utilizó el método basado en juicio expertos y jueces, ya que como señalan Escobar-Pérez y Cuervo-Martínez (2008) es un método de validación útil para verificar la confiabilidad de un instrumento de evaluación y, como estrategia de evaluación, presenta una serie de ventajas (Cabero Almenara y Llorente Cejudo, 2013) entre las que se encuentra "la posibilidad de obtener información pormenorizada sobre el tema sometido a estudio" (p. 14) y la calidad de las respuestas de los jueces y personas expertas.

Este puede hacerse de manera individual, grupal o a través del método Delphi. El método utilizado fue el *método individual*, en el que la información pertenece a una persona experta en su campo. A cada individuo, se le pide dar una estimación directa de los elementos del instrumento. Esto permite al equipo experto expresar su juicio de manera objetiva, sin intercambiar opiniones y puntos de vista (Cabero Almenara y Llorente Cejudo, 2013), no suponiendo esto una limitación, ya que evita los sesgos ocasionados por conflictos interpersonales o presiones entre las personas expertas (Corral, 2009).

Para la realización del juicio experto se prepararon las instrucciones y módulos; se seleccionaron los sujetos expertos y se les instruyó posibilitando la discusión de los indicadores a través de la explicación detallada del contexto, así como brindándoles toda la información relevante sobre el uso que tendría el sistema de indicadores. Finalmente, el acuerdo entre el grupo se midió calculando la consistencia de sus respuestas (Skjong y Wentworht, 2001 citados en Escobar-Pérez y Cuervo-Martínez, 2008).

Sobre la determinación del número de sujetos expertos necesarios para la validez no hay un acuerdo unánime; Escobar-Pérez y Cuervo-Martínez (2008) afirman que "el número … que se debe emplear en un juicio depende del nivel de experiencia y de la diversidad del conocimiento" (p. 29). Así, se seleccionaron 12 personas expertas mediante un muestreo no probabilístico por conveniencia, según los criterios de selección de Skjong y Wentworht (2001), que son experiencia en la realización de juicios y toma de decisiones basada en evidencia o experticia (grados, investigaciones, publicaciones, posición, experiencia y premios entre otros), reputación en la comunidad, disponibilidad y motivación para participar, imparcialidad y cualidades inherentes como confianza en sí y adaptabilidad.

Del total de las personas expertas, cuatro eran docentes de la Facultad de Ciencias de la Educación de la Universidad de Granada (tres hombres y una mujer). Se les contactó vía correo

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electrónico institucional, donde se les adjuntó una carta formal de invitación para participar en la investigación, que fue descrita perfiladamente. Se les ofreció, junto al plazo de entrega, los datos institucionales de todos los sujetos implicados en la investigación, para entrar en contacto, en caso necesario. El criterio seguido para su inclusión fue su amplia formación académica y científica en las áreas de conocimiento de atención a la diversidad en educación primaria, atención a la diversidad en el aula de infantil, educación inclusiva, didáctica y pedagogía especial, atención psicoeducativa a personas con necesidades educativas especiales y atención educativa a las necesidades especiales. Su edad variaba entre los 36 y los 45 años (M= 39,75 (DT= 3,77), la totalidad con doctorado y con un rango de experiencia profesional entre los 10 y los 19 años (M= 15,2, DT= 4,11).

Dado que el sistema de indicadores quiere facilitar la selección de aplicaciones por parte de docentes y familiares, estos grupos también fueron sometidos a la opinión y juicios de especialistas que trabajaban con personas con TEA. Así, participaron un grupo de cuatro especialistas (un hombre y tres mujeres), con un rango de edad de 39 a 44 años (M= 41,75; DT= 2,50), con una experiencia entre los 4,5 años y los 23 (M= 13,12; DT= 7,85), y cuya formación inicial era diplomado en Maestro Especialidad Educación Especial (75%) y Psicología (25%). Estos sujetos expertos suponían una representación variopinta muy interesante de especialistas que pueden trabajar con las personas con TEA, pues se contó con una especialista que trabajaba con niños y niñas en un aula de autismo en un centro público de educación infantil y primaria, otro que trabajaba en un centro de educación especial, otro que lo hacía en un equipo de orientación educativa (con lo que tiene a su cargo varios centros educativos), y otro que dirigía una unidad de día con taller ocupacional para personas adultas con diversidad funcional.

Y, por último, también se ha contado con cuatro personas expertas (tres hombres y una mujer) en el campo de la informática, las TIC y las aplicaciones. Tenían una media de edad de 34 años (DT= 6,48), con un rango que va desde los 27 a los 42 años, el 75% tenía como formación un ciclo formativo de grado superior relacionado con los sistemas informáticos, el diseño gráfico o la automatización y el 25% cursó ingeniería industrial de electricidad, y contaban con una experiencia profesional media de 12 años (DT= 6,78) con un rango de 5 a 20 años en el sector privado.

Las personas expertas recibieron información previa sobre los objetivos del estudio. Tras la aceptación de la participación en el proceso de validación, se les envió vía email el sistema de indicadores acompañado de una carta de presentación con las instrucciones a seguir. El enfoque seguido en el juicio experto fue cuantitativo y cualitativo para la evaluación del sistema de indicadores. Para la evaluación cuantitativa, debían validar los indicadores y subindicadores en base a los criterios de: *claridad* ("Está formulado con lenguaje apropiado y comprensible. Se comprende fácilmente"), *coherencia* ("Es adecuado para el objetivo del

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estudio. Tiene relación lógica con la dimensión o indicador que está midiendo"), *relevancia* ("Grado de importancia para la dimensión. Es esencial o importante y, por tanto, debe ser incluido") y *objetividad* ("Permite medir hechos observables"), con una escala de 1 a 4, donde: 1=deficiente, 2=aceptable, 3=bueno y 4=excelente. Para la evaluación cualitativa, podían efectuar sugerencias de mejora y comentarios en extenso, así como proponer la eliminación de indicadores o subindicadores.

Para cada uno de los indicadores y subindicadores, se calculó la media y desviación típica como medida central de la tendencia de respuesta del grupo experto. Para la primera dimensión, sobre el diseño y la forma de la aplicación (Tabla 1) se identifican en su totalidad altas puntuaciones. Como puede observarse, la media más alta (M= 4.00) para el criterio de claridad se obtuvo en la propia dimensión y en los subindicadores *Navegación III: Funcionamiento correcto, Navegación VII: Acceso al menú desde todas las pantallas* y *Utilización sin conexión a internet* y la más baja para el subindicador *Icono identificable* (M= 3,58). Estos resultados mostraban que los indicadores y subindicadores de la primera dimensión se comprendían con facilidad y estaban formulados con lenguaje apropiado y comprensible. Respecto a la coherencia, de nuevo la media más alta (M = 4,00) se obtuvo para la propia dimensión y para el subindicador *Navegación III: Funcionamiento correcto*, y la más baja para el subindicador *Personalización I: Cambios en el texto* (M = 3,50). De nuevo, estos valores resultaron satisfactorios pues revelaban que los indicadores y subindicadores diseñados para la primera dimensión eran adecuados para el objeto de estudio y tenían una relación lógica con la dimensión que estaban midiendo. Atendiendo a la relevancia, se encontró que la dimensión en sí era considerada esencial por el equipo experto (M=4,00), así como el indicador de la *accesibilidad* y los subindicadores de los *idiomas*, el *icono identificable* y la *navegación I: sencilla e intuitiva* (M= 4,00). En cambio, el subindicador *número de descargas* (M= 3,22) fue considerado como el menos importante. Estos resultados señalaban que los indicadores y subindicadores seleccionados para esta primera dimensión fueron los adecuados. Y, por último, respecto a la objetividad, encontramos que el grupo de jueces consideró que se trataba de una dimensión objetiva (M= 4,00), y, además, los subindicadores que puntúan más alto a la hora de medir hechos observables fueron el *acceso a la app por usuarios con TEA*, la *utilización sin conexión a internet*, la *navegación I: sencilla e intuitiva* y la *navegación VII: acceso al menú desde todas las pantallas;* siendo el subindicador que puntuó más bajo el *velocidad II: ausencia de tiempos muertos* (M = 4,33). En este sentido, el subindicador *velocidad I: apertura rápida* obtiene una media de 4,41; pues el grupo experto del ámbito informático resaltó que tenía que ver con el terminal utilizado para abrir la aplicación, por lo que recomendaba indicar el tipo de equipo con el que se ha realizado el análisis de la aplicación.

Revista Electrónica Educare (Educare Electronic Journal) | EISSN: 1409-4258 Vol. 25(3) SETIEMBRE-DICIEMBRE, 2021: 1-24

http://doi.org/10.15359/ree.25-3.18
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Tabla 1: Media y desviación típica de las valoraciones dadas por los grupos expertos para la dimensión de diseño y forma de la aplicación

Indicadores	Claridad		Coherencia		Relevancia		Objetividad	
	M	DT	M	DT	M	DT	M	DT
1. Dimensión de diseño y forma	4,00	,00	4,00	,00	4,00	,00	4,00	,00
1.1 Disponibilidad	3,75	,45	3,50	,52	3,58	,51	3,83	,57
1.1.1 Idiomas	3,92	,28	3,67	,49	4,00	,00	3,83	,57
1.1.2 Actualización	3,83	,38	3,83	,38	3,75	,45	3,58	,79
1.1.3 Icono identificable	3,58	,51	3,83	,38	4,00	,00	3,91	,28
1.2 Ergonomía	3,33	,65	3,58	,66	3,58	,51	3,83	,38
1.2.1 Legibilidad	3,83	,57	3,83	,38	3,83	,38	3,83	,57
1.2.2 Claridad	3,83	,57	3,75	,62	3,92	,28	3,83	,57
1.2.3 Uso del color	3,67	,49	3,67	,65	3,67	,65	3,83	,38
1.2.4 Personalización I: Cambios en el texto	3,67	,49	3,50	,67	3,67	,49	3,83	,38
1.2.5 Personalización II: Cambios en el audio	3,75	,45	3,58	,66	3,75	,45	3,83	,38
1.3 Usabilidad	3,92	,28	3,92	,28	3,92	,28	3,91	,28
1.3.1 Velocidad I: Apertura rápida	3,75	,45	3,75	,45	3,42	,90	3,41	,79
1.3.2 Velocidad II: Ausencia de tiempos muertos	3,67	,65	3,83	,38	3,67	,49	3,33	,77
1.3.3 Navegación I: Sencilla e intuitiva	3,92	,28	3,75	,45	4,00	,00	4,00	,00
1.3.4 Navegación II: Rápida	3,83	,38	3,67	,49	3,67	,49	3,83	,38
1.3.5 Navegación III: Funcionamiento correcto	4,00	,00	4,00	,00	3,92	,28	3,91	,28
1.3.6 Navegación IV: Botones identificables	3,75	,45	3,92	,28	3,92	,28	3,91	,28
1.3.7 Navegación V: Botones de tamaño correcto	3,75	,45	3,83	,38	3,75	,62	3,58	,66
1.3.8 Navegación VI: Botones bien ubicados	3,92	,28	3,83	,38	3,67	,49	3,58	,66
1.3.9 Navegación VII: Acceso al menú desde todas las pantallas	4,00	,00	3,75	,45	3,50	,79	4,00	,00
1.4 Popularidad	3,83	,38	3,67	,49	3,67	,49	3,50	,79
1.4.1 Puntuación de los sujetos usuarios	3,92	,28	3,50	,79	3,50	,67	3,41	,90
1.4.2 Número de descargas	3,92	,28	3,75	,45	3,25	,96	3,41	,90
1.4.3 Premios/Reconocimientos	3,75	,45	3,75	,45	3,66	,65	3,83	,38
1.5 Accesibilidad	3,83	,57	3,92	,28	4,00	,00	3,91	,28
1.5.1 Acceso a la aplicación por personas usuarias con TEA	3,75	,86	3,83	,57	3,83	,57	4,00	,00
1.5.2 Utilización sin conexión a internet	4,00	,00	3,92	,28	3,75	,45	4,00	,00

Nota: Elaboración propia.

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http://doi.org/10.15359/ree.25-3.18
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En cuanto a la dimensión de contenido, el grupo experto otorgó altas puntuaciones (entre bueno y excelente) a todos los indicadores y subindicadores seleccionados (Tabla 2). El 52% obtuvo una media de 4, lo que indicaba una claridad excelente; el subindicador *entonación neutral* fue el que puntuó más bajo, con una media de 3,75. El 44% de los indicadores y subindicadores presentó una coherencia excelente, con una media de 4; volviendo a ser de nuevo el subindicador *entonación neutral* el que puntuó más bajo (M = 3,50). El 36% de los indicadores y subindicadores alcanzó los 4 puntos respecto a su relevancia, el 56% entre 3,92 y 3,75 puntos, el subindicador considerado como menos relevante fue la *entonación neutral* (M = 3,67). El 32% de los indicadores y subindicadores presentaban, según jueces, una objetividad excelente, el 52% entre 3,92 y 3,75; donde los subindicadores que puntuaron más bajo fueron la *entonación neutral* y *organización contenidos I: distribución*. De las valoraciones puede desprenderse que el ítem en conjunto peor valorado de la segunda dimensión es la *entonación neutral*, no obstante, sus puntuaciones son elevadas, por lo que no se consideró necesario eliminarlo ni reformularlo.

Tabla 2: Media y desviación típica de las valoraciones dadas por los grupos expertos para la dimensión de contenido de la aplicación

Indicadores	Claridad		Coherencia		Relevancia		Objetividad	
	M	DT	M	DT	M	DT	M	DT
2. Dimensión de contenido	4,00	,00	4,00	,00	4,00	,00	4,00	,00
2.1 Calidad del audio	4,00	,00	4,00	,00	3,92	,28	4,00	,00
2.1.1 Sonidos	3,83	,38	3,83	,38	3,83	,38	3,83	,38
2.1.2 Música	3,83	,38	3,83	,38	3,83	,38	4,00	,00
2.1.3 Narraciones	3,83	,38	3,83	,38	4,00	,00	3,92	,28
2.2 Calidad de la narración	4,00	,00	4,00	,00	4,00	,00	3,92	,28
2.2.1 Modulación de la voz	4,00	,00	4,00	,00	3,83	,38	3,75	,45
2.2.2 Claridad	4,00	,00	4,00	,00	4,00	,00	3,92	,28
2.2.3 Entonación neutral	3,75	,45	3,50	,52	3,67	,49	3,50	,52
2.3 Contenidos	4,00	,00	4,00	,00	4,00	,00	4,00	,00
2.3.1 Variedad de temas	4,00	,00	3,83	,38	3,83	,38	3,75	,62
2.3.2 Organización contenidos I: Distribución	3,83	,38	3,83	,38	3,83	,38	3,50	,67
2.3.3 Organización contenidos II: Visualización	3,83	,38	3,83	,38	3,83	,38	3,75	,45
2.3.4 Distintos niveles	3,83	,38	3,92	,28	3,83	,38	3,92	,28

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http://doi.org/10.15359/ree.25-3.18
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Indicadores	Claridad		Coherencia		Relevancia		Objetividad	
	M	DT	M	DT	M	DT	M	DT
2.4 Notificaciones	3,83	,38	3,67	,49	3,75	,45	3,58	,51
2.4.1 Envío de notificaciones	3,83	,38	3,67	,49	3,75	,45	3,67	,49
2.5 Ayudas y tutoriales	4,00	,00	3,92	,28	4,00	,00	3,92	,28
2.5.1 Formato escrito	3,83	,38	4,00	,00	3,92	,28	3,92	,28
2.5.2 Audio	3,83	,38	4,00	,00	3,83	,38	3,67	,49
2.6 Seguridad	4,00	,00	4,00	,00	3,92	,28	4,00	,00
2.6.1 Protección de datos	4,00	,00	4,00	,00	4,00	,00	3,92	,28
2.6.2 Permisos de instalación necesarios	4,00	,00	4,00	,00	3,92	,28	4,00	,00
2.6.3 Control parental propia aplicación I: Acceso a internet	4,00	,00	3,92	,28	4,00	,00	3,92	,28
2.6.4 Control parental propia aplicación II: Ajustes de contenido	4,00	,00	3,92	,28	4,00	,00	4,00	,00
2.6.5 Bloqueo de compras integradas	3,91	,28	3,83	,38	3,83	,38	4,00	,00

Nota: Elaboración propia.

La dimensión pedagógica también logró buena puntuación, aunque ninguno de sus indicadores y subindicadores alcanzó los 4 puntos de forma unánime (Tabla 3). Así, atendiendo al criterio de claridad, los mejores indicadores fueron los relacionados con el *seguimiento y evaluación* (M = 3,92) y los menos claros el *tiempo de realización suficiente*. El 70% presentó un alto grado de coherencia con una media de 3,92, y el restante 30% puntuó 3,75, por lo que puede afirmarse que todos los indicadores y subindicadores de esta dimensión eran adecuados para el objetivo del estudio. En cuanto a la relevancia, el 50% puntuó 3,92 y el resto entre 3,75-3,83; por lo que eran importantes para el estudio y debían ser incluidos. Y, finalmente, respecto de la objetividad, el 60% obtuvo 3,92 puntos; el indicador *adecuación a los ritmos de aprendizaje* y el subindicador *tiempo de realización suficiente* son los que puntuaron más bajo (M = 3,58).

Tomando en consideración cada dimensión en su conjunto, respecto a los diferentes criterios, cabe inferir lo siguiente (Tabla 4): La primera dimensión de *diseño y forma de la aplicación* obtuvo puntuaciones globales altas, ya que la máxima puntuación que podían otorgarle era de 112 en cada criterio, y es en la *claridad* en la que obtiene la mayor puntuación (M = 106,66), la menor en la *coherencia* (M = 97,91) y una puntuación total de 415,16 puntos sobre 448 posibles. Estos resultados indican que se trata de una dimensión que debe estar presente a la hora de evaluar las aplicaciones para personas con TEA. La segunda dimensión de *contenido* también alcanzó puntuaciones elevadas, pues la máxima puntuación que podía obtener era 100 puntos, obteniendo la puntación más alta en *claridad* (M = 98,00), la más baja en *objetividad* (M = 96,33)

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y una puntuación total de 389,00 de un máximo de 400. De nuevo, puede afirmarse que se trataba de una dimensión necesaria para la evaluación de aplicación. Y la tercera dimensión, la *pedagógica*, fue valorada con una alta puntuación, otorgándole totales muy próximos en los criterios de *coherencia*, *relevancia* y *objetividad*, en torno a 38 puntos de 40 posibles, donde el de *claridad* es el que obtiene una puntuación ligeramente inferior (M = 37,50), y una puntuación total de 152,83 puntos de 160 posibles.

Tabla 3: Media y desviación típica de las valoraciones dadas por los grupos expertos para la dimensión pedagógica de la aplicación

Indicadores	Claridad		Coherencia		Relevancia		Objetividad	
	M	DT	M	DT	M	DT	M	DT
3. Dimensiones pedagógica	3,58	,66	3,92	,28	3,83	,38	3,92	,28
3.1 Interactividad	3,75	,62	3,92	,28	3,92	,28	3,92	,28
3.1.1 Permite añadir imágenes/pictogramas	3,75	,62	3,75	,62	3,92	,28	3,92	,28
3.2 Adecuación a los ritmos de aprendizaje	3,67	,49	3,92	,28	3,92	,28	3,58	,66
3.2.1 Contenido apropiado para el sujeto usuario	3,83	,38	3,92	,28	3,92	,28	3,75	,45
3.2.2 Tiempo de realización suficiente	3,50	,79	3,75	,45	3,75	,45	3,58	,66
3.2.3 Diferentes códigos de comunicación	3,67	,65	3,75	,62	3,83	,38	3,75	,62
3.3 Seguimiento/evaluación	3,92	,28	3,92	,28	3,92	,28	3,92	,28
3.3.1 Se hace un seguimiento del progreso	3,92	,28	3,92	,28	3,75	,45	3,92	,28
3.3.2 Se evalúan las actividades realizadas	3,92	,28	3,92	,28	3,75	,45	3,92	,28

Nota: Elaboración propia.

Tabla 4: Media y desviación típica de las valoraciones dadas por los grupos expertos para la cada dimensión en su conjunto

Dimensión	Claridad		Coherencia		Relevancia		Objetividad		Total	
	M	DT	M	DT	M	DT	M	DT	M	DT
1. Diseño	106,66	4,61	97,91	5,36	104,83	7,34	105,75	5,83	415,16	21,56
2. Contenido	98,00	97,33	97,33	3,98	97,33	4,39	96,33	3,72	389,00	14,70
3. Pedagógica	37,50	4,16	38,66	2,64	38,50	2,71	38,16	3,04	152,83	11,60

Nota: Elaboración propia.

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http://doi.org/10.15359/ree.25-3.18
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Una vez analizadas las valoraciones realizadas, para determinar el grado de acuerdo entre se calcularon los coeficientes de correlación intraclases (ICC) y de concordancia externa W de Kendall. Dichos coeficientes son utilizados para valorar y evaluar la confiabilidad inter-observador (Bao et al., 2009). "Su cálculo se basa en [dividir] en dos partes la variabilidad total de las evaluaciones realizadas; por una parte, la variación debida a la diferencia entre los elementos a evaluar" (Rodríguez Ruiz y Heredia Rico, 2013, p. 48); y por otra, la variabilidad atribuible a la diferencia entre las valoraciones del grupo experto (Shrout y Fleiss, 1979). El ICC está comprendido entre 0 y 1; cuanto mayor valor tenga este coeficiente menor variabilidad es atribuible a la diferencia entre las valoraciones, es decir, mayor acuerdo existe entre las personas expertas. Los resultados obtenidos con respecto al coeficiente de correlación intraclase son: ,955 (D1), ,973 (D2) y ,966 (D3); como estos valores son superiores a ,750 (Shrout y Fleiss, 1979) indicaban que la confiabilidad inter-jueces fue excelente.

El coeficiente de Kendall:

> indica el grado de asociación o nivel de concordancia, como medida de acuerdo entre los rangos de las evaluaciones realizadas por jueces … [a un instrumento determinado], con un rango de 0 a 1, … [donde] el valor 1 representa un nivel de concordancia total, y 0 un desacuerdo total. (Dorantes-Nova et al., 2016, p. 332)

Cuanto mayor es el valor Kendall más intensa es la asociación que otorga validez y confiabilidad al instrumento. Para que el instrumento pueda ser utilizado para los fines para los cuales fue diseñado y si se han obtenido bajos niveles de concordancia, el ítem en cuestión puede modificarse o suprimirse para alcanzar el objetivo de medición pretendido (Escobar-Pérez y Cuervo-Martínez, 2008). Los niveles de acuerdo medidos con W son interpretados de la siguiente forma (Siegel y Castellan, 1988): ,000 < W < ,600 acuerdo pobre; ,600 ≤ W < ,700 acuerdo moderado; ,700 ≤ W < ,800 buen acuerdo y, ,800 ≤ W ≤ 1,00 acuerdo fuerte. Así, para el criterio de *calidad*, el coeficiente de Kendall fue estadísticamente significativo y con un grado de acuerdo fuerte (W= ,980, p= ,000); para el de *coherencia* fue estadísticamente significativo y con un buen grado de acuerdo (W= ,757, p= ,000); para el de *relevancia* fue estadísticamente significativo y el grado de acuerdo resultó fuerte (W= ,861, p= ,000), y para el de *objetividad* fue estadísticamente significativo con un grado de concordancia interjueces total (W= 1,00, p= ,000). Los resultados denotan que con un nivel de significación del 5% existía evidencia de la concordancia entre sujetos expertos en cuanto a la *claridad*, *coherencia*, *relevancia* y *objetividad* de la propuesta; esto es que el sistema de indicadores y el instrumento de evaluación resultaron válidos.

Finalmente, se realizó el análisis de fiabilidad empleando el coeficiente alfa de Cronbach. En todas las dimensiones analizadas los valores del coeficiente α estuvieron por encima de ,900: ,955 (D1), ,973 (D2) y ,966 (D3), y, por lo tanto, fueron excelentes (Hernández Sampieri et al., 2006). Lo que demostró la consistencia interna del sistema de indicadores y el instrumento de evaluación diseñado.

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Conclusiones

El uso de medios tecnológicos como puente para favorecer el aprendizaje en el ámbito educativo ha ido cobrando importancia con el paso de los años. Ello deja ver cómo la tecnología avanza y conecta con todo tipo de colectivos sociales, creando entornos que favorecen el aprendizaje de diferentes estudiantes, incluyendo aquellos grupos con necesidades educativas especiales. De este modo, diseñar entornos de aprendizaje accesible para toda la población es y será el objetivo principal de la sociedad del conocimiento.

Durante el diseño del sistema de indicadores, han ido floreciendo diferentes inquietudes acerca de la diversidad de aplicaciones existentes y los posibles criterios a valorar. Estos criterios han seguido un análisis en profundidad, de forma que se han seleccionado los que posibilitan una evaluación de las aplicaciones lo más enriquecedora posible. Se pretende, ante todo, que este instrumento sea intuitivo y completo, ya que se ha partido de estudios previos con gran rigor científico. Como se ha podido comprobar, es necesario contar con materiales y herramientas que faciliten al usuario la elección de las aplicaciones que mejor se adapten a las necesidades de la persona con TEA. En este sentido, la búsqueda por parte de especialistas y familiares partirá de parámetros previamente establecidos y con criterios adecuados al ámbito que se quiera trabajar con la persona con TEA.

Existe un amplio abanico de aplicaciones destinadas a personas usuarias con TEA, y realizar una exploración acerca de lo que cada una de ellas ofrece no es sencillo. Sin embargo, resulta imprescindible indagar en las funcionalidades que presentan cada una de ellas, ya que, al hablar de una necesidad especial, el proceso de aprendizaje es particular. De esta forma, ser meticuloso en este aspecto y reflexionar sobre los materiales y herramientas ofrecidas a estas personas es relevante para ofrecerles la calidad de vida merecida. Dado que las TIC han avanzado y a día de hoy resultan enriquecedoras para personas con TEA, hacer un uso adecuado de ellas supone un auge en su aprendizaje.

El sistema de indicadores y el instrumento diseñado para la evaluación de aplicaciones para personas con TEA, sometido al juicio experto han resultado válidos y fiables. Las dimensiones, los indicadores y subindicadores recibieron puntuaciones altas (entre buenas y excelentes). El coeficiente de confiabilidad inter-jueces (ICC) fue excelente. Y el coeficiente W de Kendall mostró una concordancia significativa entre jueces en cuanto a la *claridad*, *coherencia*, *relevancia* y *objetividad* de la propuesta y un alto índice de concordancia entre los rangos asignados. Por tanto, el sistema anterior se torna sólido, con indicadores que tienen alto nivel de logro y con unos niveles de consistencia interna excelentes.

En futuros estudios se analizarán las aplicaciones disponibles para Android con el instrumento diseñado, con motivo de su validación experimental. Tras el proceso de validación experimental, y como continuación de ella, se presentará un ranking de las mejores aplicaciones

Revista Electrónica Educare (Educare Electronic Journal) | EISSN: 1409-4258 Vol. 25(3) SETIEMBRE-DICIEMBRE, 2021: 1-24

http://doi.org/10.15359/ree.25-3.18
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por ámbitos de desarrollo para alumnado con TEA, que sea de utilidad para docentes y progenitores. Para cerrar este apartado de prospectiva y proyección del presente trabajo, cabe indicar que convendría adaptar los criterios de valoración de las aplicaciones para otros colectivos que, debido a sus especificidades, requieren características acordes a sus posibilidades, como personas con TDAH o con discapacidades sensoriales, motoras o intelectuales, entre otros.

Declaración de Material complementario

Este artículo tiene disponible, como material complementario:

-La versión preprint del artículo en https://doi.org/10.5281/zenodo.4042051

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Artículo 2. Apps for people with autism: assessment, classification and ranking of the best

https://doi.org/10.1016/j.techsoc.2020.101474

[1]Carmen del Pilar Gallardo-Montes

[1]Faculty of Education, Department of Didactics and School Organization at the Faculty of Education, University of Granada (Spain), Campus "La Cartuja" s/n, 18071, Spain

[1]Antonio Rodríguez Fuentes

[1]Faculty of Education, Department of Didactics and School Organization at the Faculty of Education, University of Granada (Spain), Campus "La Cartuja" s/n, 18071, Spain

[2]María Jesús Caurcel Cara

[2]Faculty of Education, Department of Developmental and Educational Psychology, University of Granada (Spain), Campus "La Cartuja" s/n, 18071, Spain

Abstract

The use of digital resources has become an innovative and proven option in the therapy of people with autism. The utilization of apps in mobile devices – smartphones or tablets – offers autism professionals a complementary medium with which to strengthen deficient skills (communicative and emotional aspects, etc.). Using resources of this kind also serves as a source of motivation for people with this disorder. Through a system of previously validated indicators, we have thoroughly assessed 155 apps for Android that are available for free on the Google Play Store. To select the apps aimed at people with autism, we used the search term "autism" in English and in Spanish. The chosen apps were then assessed and given a score for their design, content and pedagogic dimension. The assessment concluded by establishing a ranking of the apps, differentiating between those that are highly recommendable, recommendable and dispensable. Only 14 apps obtained scores notably higher than the rest. Of these highly recommendable apps, we have included a description, their advantages and disadvantages, and a global assessment. This study aims to offer autism specialists and family members, in a clear and intuitive way, a list of those apps that best fit the needs of people with autism.

Keywords: Educational technology; Special education; Autism; Mobile educational services

1. Introduction

Currently, the development of Information and Communications Technology (ICT) is undergoing changes and improvements, offering multiple forms of learning and interaction to diverse sectors of the population. In the case of people with autism spectrum disorder (ASD), the creation of digital spaces focused on their needs has proliferated in recent years. As Guzmán et al. [1] show, research into their relevance in therapy and clinical medicine is beginning.

The DSM-5 defines ASD as a set of "persistent deficits in social communication and social interaction across multiple contexts [… with] restricted, repetitive patterns of behavior, interests, or activities" [2]. In this regard, the technological options available today for working with people with ASD – principally with children – and for helping to improve their quality of life are wide-ranging [3]. In fact, there are numerous studies

focused on the benefits of ICT for people with ASD. Authors such as Grandin [4] and Jordan and Riding [5] show that, by using the visual in addition to the auditory code, ICT promotes the processing of knowledge and improves perception. This is possible because it tends to be presented with a visual format that attracts people with ASD, given that they process information in a different way [6]. This idea is also highlighted by García et al. [7], who state that ICT stimulates the senses, particularly sight, the development of which is essential for autistic people, since they process most information through this means. Furthermore, Lozano et al. [8] show that ICT favours personalized educational care and makes it possible to repeat tasks. In this way, the person with ASD can find a workspace without restrictions of time or space, offering the opportunity to access knowledge, active and interactive learning, and a world of possibilities for developing deficient skills [1].

With the passing of time, the digital divide between certain groups has been diminishing, offering learning opportunities to all types of people. The use of ICT by students with special needs promotes access to understanding the most complex aspects of everyday life, given that their tools come with a multitude of visual and sound features. Burke and Hughes [9] and Regan et al. [10] reinforce the idea that ICTs offer beneficial resources for people with disabilities. Authors such as González et al. [11], Lozano et al. [8], and Tortosa and de Jorge [12] are alike in stating that ICT for people with autism is a motivating medium. At the same time, ICT offers controllable situations and settings for users [3,13], reducing stress and bringing about anticipation in the face of different stimuli. Moreover, as García et al. [7] state, "ICT and, specifically, mobile apps, are multiplying and, educationally speaking, can be a great resource for children diagnosed with ASD, since they can improve communication, language, the emotions, social intervention and vocabulary".

1.1. Use of apps

Currently, the development of web platforms and apps aimed at families, specialists and people with ASD and, more specifically, those with autism, is growing, as are the studies concerning what is being offered and how people with this disorder can benefit from them. However, despite there being many apps, there are few publications that show the success or influence they have on their users, and there is a scant bibliography on the use of apps.

In other disciplines, there do exist rigorous studies that address the topic of apps and analyse what is currently offered to users, such as the following: Martínez Gómez [14] on educational mathematics apps for children; Galar [15] on the analysis of the quality of educational apps; García Rico [16], concerning the use of the app "PICAA" in students with special educational needs; Mugarza [17], in which the 50 best health apps in Spanish are put forward; Comín [18] on apps designed for child education; Rico [19], focused on the use of apps that address creative processes in artistic education; Roncandio [20], which analyses educational apps in Early Childhood Education; Natarajan et al. [21], related to mobile shopping apps; Rajak and Shaw [22], focused on the evaluation of health apps; Alam et al. [23], in which the factors that influence the behavioural intention of using mHealth apps are explored; and, lastly, Vaclavik et al. [24], on factors influencing confidence in the use of travel apps. There are even specific disciplines on the use of ICT for specific groups, such as for the visually impaired.

Therefore, examining everything that technology offers should be the starting point for seeking the medium through which the person with autism may attain functional communication and, with this, develop language, express emotions, understand the emotions of others and, not least, promote social interaction in accordance with their capacities. For professionals, it is essential to find out what is being offered and what resources are currently available in order to work with people with autism and adapt the materials to their characteristics. Having access to attractive tools that encourage learning will help to improve quality of life insofar as their skills are strengthened. As Guzmán et al. [1] state, "the availability of resources such as the mobile telephone, tactile digital devices, virtual personal and community interfaces, opens up the field of interaction and of problem-solving to a universe almost unlimited in possibilities" (p. 252). Thus, coming to the purpose of this study, to learn what is being offered and how to undertake appropriate usage of ICT is vital for achieving the proposed aims for people with autism, both for professionals and family members.

The app market is varied and offers tools aimed at working on different areas that pose a problem for people with autism, such as communication [25–27], emotions [28–31], time management [32], basic instrumental skills – language, mathematics, etc.– [33], executive functions – organization, memory, attention, etc. – [27,32,34], and leisure/entertainment [35,36]. It must be noted that most of the apps do not specify the

age of the user they are aimed at. Despite this, following a review of the catalogue of existing apps, we can state that they are mostly designed for children.

Having reviewed the literature, we confirm that, up until now, there has been no rigorous analysis of the apps aimed at people with autism, nor has there been a ranking of the best, which would be of use to families and professionals. Therefore, given the purpose of this study, we set forth the following objectives:

1. To analyse the quality of the free apps for people with autism that are available on the Google Play Store.
2. To assess each app according to its design, content and pedagogic aspects.
3. To establish a ranking of the best apps.
4. To determine what areas the apps assessed work with.

2. Method

2.1. Sample

In order to proceed to the analysis of apps aimed at people with autism, we took the Google Play Store search engine, available in mobile devices with the Android operating system, as the starting point. Previous studies [7, 38–42] use app stores because they are the most popular and safest platforms for finding and downloading apps, and the professionals and families of people with autism will rely upon them to search for, download, install and later update these apps. The only filter applied for the search was that the app be free. Chronologically speaking, two searches were made, trying to handle the largest number of apps possible. Using the Spanish keyword “Autismo”, 228 apps were found (January 2019–February 2019), of which 123 were excluded, as per the criteria shown in Table 1, with the final number evaluated being 105. The second search was carried out with the English keyword “Autism”, with 247 apps being found (March 2019–April 2019), of which 192 were excluded according to the exclusion criteria (Table 1) and 50 assessed.

Table 1

App Exclusion Criteria

Exclusion Criteria	Keywords	
	"Autismo"	"Autism"
Unrelated to the topic	52	92
Aimed at professionals/families but not at people with autism	41	0
They would not open or were not compatible with the device utilized	30	82
Repeated	-	18

2.2. Instrument

For the assessment of each app, the "System of Indicators and Instrument for the Assessment and Selection of Apps for People with ASD", designed and validated in Gallardo et al. [37] was used. The use of a system of indicators is a useful resource for assessing the products or services under offer in a tangible way. The aspects that are evaluated are in keeping with the ideal criteria for an app aimed at this community. Hence the indicators, and their consequent explanations, were rigorous and analysed from a psycho-pedagogic point of view. The development of the indicators used was created using previous national and international studies [38–41,43–45]. Three dimensions of each app were evaluated: - Design/form: availability (languages, updating, identifiable icon), ergonomics (legibility, clarity, use of color, personalization), usability (velocity, browsing), popularity (user rating, number of downloads, prizes) and accessibility (access to the app by users with ASD, use without internet connection). - Content: audio and narration quality (sounds, music, narration, voice modulation, clarity, neutral intonation), contents (variety of topics, content organization, levels), notifications, help/tutorials (tutorials in written or audio format) and safety (data protection, installation permissions, parental control, blocking of in-app purchases). - Pedagogic aspects: interactivity (the app allows the uploading of own images or pictograms), appropriateness of pace and learning (content suitable for people with ASD, sufficient time for carrying out activities, different communication codes), monitoring and evaluation of exercises/activities. The instrument consisted of a total of 14 indicators, subdivided into 46 sub-indicators. The presence of each sub-indicator was given a score of 1 point, so that the scoring of the design/form dimension (D1) ranged from 0 to 22 points; that of content (D2) from 0 to 18 points; and the pedagogic (D3) from 0 to 6 points. The total thus ranged between 0 and 46 points. Lastly, to determine whether each of the apps assessed was deemed recommendable or not for users with autism, the following parameters have been used (Table 2).

Table 2

App classification criteria

Group	Score	Percentage of sub-indicators	Classification
1	≥37 points	80-100	Highly recommendable
2	23-36 points	50-79	Recommendable
3	≤23 points	49-0	Dispensable

The instrument was validated by 12 judges, comprising: four teachers from the Faculty of Education Sciences of the University of Granada with extensive academic and scientific training in addressing diversity and the psycho-educational care of people with special educational needs; four professionals with ample experience in working with people with ASD; and four experts in the field of computing, ICT and apps. The experts had to validate the indicators and sub-indicators on the basis of the following criteria: clarity ("It is formulated with appropriate and comprehensible language. It is easily understood"); coherence ("It is suitable for the study objective. It has a logical relation with the dimension or indicator that it is measuring"); relevance ("Degree of importance for the dimension. It is essential or important, and, therefore, it should be included"); and objectivity ("It makes it possible to measure observable facts"). They used a scale of 1–4, namely: 1 = Unsatisfactory, 2 = Satisfactory, 3 = Good, 4 = Excellent. As well as this quantitative assessment, the experts were able to make a qualitative evaluation through comments and suggestions for improvement. Once the judges' ratings had been analysed, the Intraclass Correlation coefficients (ICC) and Kendall's W coefficients were calculated in order to determine the degree of agreement between them. The ICC obtained were excellent (0.955 D1, 0.973 D2 and 0.966 D3). The ICC are measured between 0 and 1 – – the higher the value the coefficient has, the less the variability is attributable to the difference between the expert ratings (in other words, there is better agreement between them). As these values were higher than 0.750 [46], they indicated that the inter-rater reliability was excellent. It also attained a Kendall's W inter-rater concordance that is significant and strong (with values between 0.757 and 1.00, $p < 0.001$), and excellent levels of internal consistency (Cronbach's alpha coefficient above 0.900: 0.955 D1, 0.973 D2 y 0.966 D3), demonstrating that this is a valid and reliable instrument.

2.3. Procedure

Each app was comprehensively assessed following the system of indicators. The apps were installed and assessed during the first quarter of 2019, always using the same device - connected through AC Wi-Fi at a speed of 600 Mb/s - in order to prevent any alteration and to be able to make an assessment under equal conditions. The apps were installed for two weeks on the smartphone, in order to examine the notifications that might be sent to the user, this being one of the sub-indicators under evaluation.

2.4. Design and data analysis

We have carried out a descriptive study, with the aim of learning and evaluating what is being offered to people with autism in terms of mobile apps. We have used a cross-sectional design and a non-experimental quantitative method, since the variables do not undergo any modifications.

In order to undertake the assessment of each app through the system of indicators, the Microsoft Office Excel 2016 program was used. The gathered data were then treated with the SPSS Statistics version 25.0 for Windows pack, with a margin of error of 5% and a reliability level of 95%. Thus, to achieve the proposed objectives, the frequencies and measures of central tendency (mean and standard deviation) have been calculated. And for the comparison between groups, the Kruskal-Wallis non-parametric test for independent samples has been used.

3. Results

After the assessment of the 155 apps, we obtained the following: 9% (n = 14) belonged to Group 1, those that were *highly recommendable*; 85.2% (n = 132) belonged to Group 2, the *recommendable*; and 5.8% (n = 9) to Group 3, the *not recommendable*. Comparing the groups (Table 3), it was observed that the apps in Group 1 attained the highest scores in all dimensions. The apps in Group 3 obtained scores below the mean in all dimensions, while those in Groups 1 and 2 were above. The dimension in which there was the least difference between Groups 1 and 2 was that of design, while the greatest difference was found in that of content. Between Groups 1 and 3, the dimension showing the greatest difference was that of content, and the least, the pedagogic dimension. Lastly, Groups 2 and 3 differed the most in design and the least in pedagogy.

Table 3

Statistically significant differences in the dimensions according to the app groups

Dimension	Groups									Kruskal Wallis		
	3 (*n* = 9)			2 (*n* = 132)			1 (*n* = 14)					
	M	SD	AR	M	SD	AR	M	SD	AR	χ^2	df	p
D1	10.89	3.37	8.33	17.03	1.46	80.01	17.85	0.94	103.82	27.60	2	.000*
D2	6.11	2.84	23.67	10.42	2.66	74.48	15.14	0.86	146.14	46.76	2	.000*
D3	2.33	0.70	32.39	3.38	0.95	75.33	4.85	0.66	132.50	32.86	2	.000*

Note: *D1* = Design/form dimension; *D2* = Content dimension; *D3* = Pedagogic dimension; *Group 3* = dispensable apps; *Group 2* = recommendable apps; *Group 1* = highly recommendable apps; *M* = Mean; *SD* = Standard Deviation; *RP* = Average rank. Statistically significant: *p<.001

Taking the apps belonging to Group 1 as a reference, we present a ranking of the 14 *highly recommendable* apps, with their respective total and individual scores in each of the dimensions assessed (Table 4) – each app was assigned the name with which it appeared in the Google Play Store search engine. None of the apps assessed reached the maximum possible total of 46 points, with 40 being the highest score obtained and only by two of the apps (25%): *"#Soyvisual"* and *"Otsimo"*. Eight (57.14%) of these apps are at the lower limit for forming part of Group 1, with a score of 37 points.

The app *"SymboTalk - AAC Talker"* obtained the best score in Dimension 1, on design, because unlike the others, it stood out for its variety of useable languages, an aspect that few apps had. The lowest-scoring app in this dimension was *"Michelzinho - emoçoes e autismo"*, since it could not be used in different languages and could not be personalized in text or audio.

In Dimension 2, on content, the app "*Otsimo*" attained the highest score, due to the fact that, as well as having indicators common to its rivals, it presented tutorials in audio and in written form, and sent notifications to the smartphone even when the app was not in use, as well as emails to the address of the registered user, informing about changes or new exercises, which made it even more interactive. In contrast, the apps that gained the lowest score were *"SymboTalk - AAC Talker", "CPA"* and *"Emociones, sentimientos y expresiones!"*, because they had no music, no audio tutorials and did not send notifications to the user.

"CPA" and *"Michelzinho - emoçoes e autismo"* were the apps that succeeded in bringing together all of the proposed indicators in the Pedagogic Dimension (D3), as they allowed the user to add their own images or pictographs, offered different codes of communication, sufficient time to carry out the activities, and they monitored and

assessed the proposed activities so that the user could receive feedback on their progress. However, the apps *"Visual schedules and social stories", "Juegos de niños para bebés de 2 a 5 años", "CommBoards - gratis terapia del autismo AAC"* and *"SymboTalk - AAC Talker"* scored the lowest in this dimension, mainly because they lacked any monitoring of the user's progress.

Table 4

Ranking of highly recommendable apps according to scores obtained

Name of the app	Total Score	D1	D2	D3
#Soyvisual	40	19	16	5
Otsimo	40	18	17	5
Autism language and cognitive therapy with MITA	39	18	16	5
Smile and Learn: juegos educativos para niños	39	18	16	5
SymboTalk - AAC talker	38	20	14	4
CPA	38	18	14	6
Visual Schedules and Social Stories	37	18	15	4
Juegos de niños para bebés de 2 a 5 años	37	18	15	4
CommBoards - gratis terapia del autismo AAC	37	18	15	4
Emociones, sentimientos y expresiones!	37	18	14	5
LEA, Lecto Escritura para Autismo	37	17	15	5
Autastico	37	17	15	5
Terapia z tabletem	37	17	15	5
Michelzinho - emoções e autismo	37	16	15	6

Note: D1 = Design/form dimension; D2 = Content dimension; D3 = Pedagogic dimension

It is worth noting that in Group 2 some of the apps attained a similar score to those in Group 1 in certain dimensions. For example, four apps from Group 2 scored 20 points in Dimension 1 (design), the same as those from Group 1 (Table 5).

Table 5

Apps from Group 2 that scored well in Dimension 1

Name of the app from Group 2	Total Score	D1	D2	D3
aBoard CAA	36	20	13	3
ISECUENCIAS LITE	35	20	11	4
Asistente de voz ACC	35	20	12	3
LetME Talk	33	20	9	4

Note: D1 = Design/form dimension; D2 = Content dimension; D3 = Pedagogic dimension

In contrast, with Dimension 2 (content), not one app scored as well as the best app from Group 1. However, there were two apps that obtained 15 points and nine that obtained 14 points (Table 6).

Table 6

Apps from Group 2 that scored highly in Dimension 2

Name of the app from Group 2	Total Score	D1	D2	D3
Speech Blubs: Language Therapy	36	16	15	5
SocialSkills for Autism Kloog2	36	16	15	5
Proyecto Emociones	36	17	14	5
Quien en quien pictogramas	36	17	14	5
Jose aprende	35	18	14	3
Teacch.me	35	16	14	5
ABA DrOmnibus for parents	35	14	14	4
Diegosays autiso habla	34	17	14	3
Horsy	34	17	14	3
Autism help	33	16	14	3
El oledor	32	15	14	3

Note: D1 = Design/form dimension; D2 = Content dimension; D3 = Pedagogic dimension

Regarding Dimension 3 (pedagogic), 74 apps from Group 2 obtained a score that was higher than the mean. To further refine the search, Table 7 shows the seventeen apps that scored 5 in this dimension.

Table 7

Apps from Group 2 that scored highly in Dimension 3

Name of the app from Group 2 (Recommendable)	Total Score	D1	D2	D3
Proyecto Emociones	36	17	14	5
SocialSkills for Autism Kloog2	36	16	15	5
Preescolar juegos en Spanish	36	19	12	5
Quien en quien pictogramas	36	17	14	5
Speech Blubs: Language Therapy	36	16	15	5
Teacch.me	35	16	14	5
Vi.co Hospital Lite	35	17	13	5
Visual reading - educacion especial	35	19	11	5
Proyecto retratos	34	17	12	5
Autimo	34	16	13	5
Emoplay	33	15	13	5
Tarjetas educativas en Spanish	33	16	12	5
Daily tasks	32	17	10	5
AJEDREZ NIÑOS INFANTIL GRATIS	32	17	10	5
Dictapicto	31	18	8	5
ABA Kit	31	15	11	5
El viaje de Elisa	31	18	8	5

Note: D1 = Design/form dimension; D2 = Content dimension; D3 = Pedagogic dimension

Concerning which areas the 155 apps worked with, it was observed that most of the apps addressed several (Table 8). Thus, 95.5% (n = 148) focused on the executive functions, 58.7% (n = 91) worked on language, 50.3% (n = 78) addressed leisure and entertainment, 46.5% (n =72) communication, 40% (n = 62) dealt with the basic

instrumental skills, 14.2% (*n* = 22) focused on the emotions, and, lastly, 11.6% (*n* =18) on time management.

Focusing on the highly recommendable apps, we found that the areas that were most common in each of the apps were the executive functions, communication and language, whereas the emotions and time management were the least addressed.

Table 8

Areas addressed by the highly recommendable apps

App	CO	LA	EM	TM	SK	EX	LE
#SOYVISUAL							
OTSIMO							
Autism Language and Cognitive Therapy with MITA							
Smile and Learn: Juegos educativos para niños							
SymboTalk - AAC Talker							
CPA							
Visual schedules and social stories							
JUEGOS DE NIÑOS PARA BEBES DE 2 A 5 AÑOS							
CommBoards - gratis terapia del autismo AAC							
Emociones, sentimientos y expresiones!							
LEA LECTO ESCRITURA PARA AUTISMO							
AUTASTICO							
TERAPIA Z TABLETEM							
MICHELZINHO - EMOÇOES E AUTISMO							

Note: *CO* = Communication; *LA* = Language; *EM* = Emotions; *GT* = Time management; *SK* = Basic Instrumental Skills; *EX* = Executive Functions; *LE* = leisure/entertainment

On the basis of the results shown above, in Table 9 each of the fourteen highly recommendable apps are presented, according to language, areas dealt with, target user, total score obtained, description, advantages and disadvantages, and global assessment.

Tabla 9

Descripción de las mejores apps

App	Language	Areas	Target Users	Score	Description	Advantages	Disadvantages	Global Assessment
 **#Soyvisual**	Spanish	Development and promotion of language	-	40	It works in a progressive way: oral comprehension, vocabulary, word articulation and sentence construction. It has a space for profile management.	It combines numerous visual aids with their corresponding written expression and audio verbalization. It sends notifications to the user about newly available material.	Only available in Spanish	The design is appropriate and the areas that it works on are set up to stimulate the user through an augmentative system of communication with colours and sounds appropriate to the set of activities.
 **Otsimo**	English and Turkish	Association and recognition of forms, colours and numbers	-	40	Association games with different themes (meals, feelings, numbers…). It includes an area specifically for parents	The activities undertaken are evaluated so that the user can see the progress they have made.	It is not available in other languages and some contents can only be accessed through purchase.	The contents and the catalogue of activities are displayed in a clear way, with all the games accessed in an intuitive way.
 **Autism language and cognitive therapy with Mental Imagery Therapy for Autism (MITA)**	English	Attention, memory, association, language and visual skills	5 years old and under	39	Games are organized into a *tour*. Each activity has to be successfully completed to be able to go on to the next. The exercises increase in difficulty as the user goes on. The activities require attention, and visual and auditory discrimination.	Many areas are worked on to foster different skills in a way that is visual and attractive for the child. If a level is not successfully completed, the child cannot discover the rest, which is motivating and encourages learning.	The section for parents, where the child's progress can be observed, is not free.	This is a good app that promotes learning through play. The scenes are visually appealing. The child is congratulated when they have done an activity well, which also motivates them to continue.

 **Smile and Learn: Juegos educativos para niños**	Spanish, English, French, Portuguese and Italian	Comprehension, attention, creativity and language	6-12 years old	39	The app is navigated via "islands", each of which is dedicated to a subject, such as the sciences, the emotions, the arts, logic, etc. It contains activities such as puzzles or pairing.	Diversity of languages available. The game is very interactive and includes pictographs that facilitate the assimilation of concepts. It includes three levels of difficulty.	There are sections that are not free.	The variety of games and the form in which they are presented to the child make a very motivating medium. The images, stories and sounds are suitable and the format is presented in a clear and intuitive way.
 **CPA**	Spanish	Communication	-	38	It makes it possible to construct sentences that facilitate communication through ARASAAC pictographs (Aragon Centre Augmentative and Alternative Communication Systems).	It contains a series of settings to fit the content to the user. It includes a section with password to access content editing.	Only available in Spanish	The variety of pictographs, along with the combination of the visual and written format, facilitate the user's interaction and communication.
 **SymboTalk - AAC Talker**	49 languages	Augmentative and Alternative Communication (AAC)	-	38	Many panels with ARASAAC pictographs with their corresponding verbalization. A range of sentences can be created relating to the themes offered (fruits, toys, places, etc.).	Creation of personalized panels with images uploaded by the user.	It does not include sounds when clicking on the panels, only narrations.	It enables working on a multitude of areas through the variety of pictographs included. Adding images stimulates the user and promotes meaningful learning.
 **Michelzinho - emoçoes e autismo**	Portuguese	Emotional and social skills	-	38	It asks the user to express an emotion such as joy or surprise and through the camera they can recognise their face.	It offers a way of learning that is more interactive for the child.	It is not available in other languages.	The app stands out for due to its originality. By including music and sounds during facial expression, it holds the attention of the user.

 **Visual schedules and social stories**	English	Communication though stories	6 to 12 years old	37	It tells stories and daily tasks through which the child can come to understand each of the processes and assimilate them.	Colours and themes suitable for children. The content is very visual and appealing.	Only the one language. It only uses written format.	If offers excellent visual aid to encourage communication. It has an area for parents in which own photos and videos can be added so that the interaction with the child can be more rewarding.
 **LEA lecto escritura para autismo**	Spanish	Reading and writing	No age is specified, but the user is required at least to know their letters to be able to interact with the app's exercises.	37	The user can create a profile and access a variety of reading and writing exercises and activities on the emotions, the body, the family and the alphabet.	The stories include audio narration so that the user can read or listen to them.	It does not allow the user to add their own images, and neither does it include other languages.	It is very visual and enables the user to interact through the different spaces designed in an interactive way. The content is clearly organized, as each area is identified by an image and its corresponding written expression.
 **Autastico**	English	Emotions, numbers and shapes	8 years old and under	37	The user can create a personalized character, draw or do puzzles. The activities include music, sounds, assessment of the games undertaken and congratulations after completing the proposed tasks.	Images are combined with sounds, music and narrations	Not available in other languages, and neither does it allow uploading of personalized images.	The colours and way of organizing the content are suitable and adapted to the age and the users.

 **Juegos de niños para bebes de 2 a 5 años**	Spanish	Association, coordination, logical thinking	5 years old and under	37	It has a menu from which the child can choose the game they want to play, such as association games of fruits, vegetables or animals.	It includes an area for parents where they can consult information about the game. It does not include that much dialogue in Spanish, meaning that it could be used by people with other languages.	The section for parents is in English	The app is in general very eye-catching and makes playing the games appealing to the child. The colours and way of organizing the different sections are presented in a clear and intuitive way.
 **TERAPIA Z TABLETEM**	English, Polish and Swedish	Emotions, communication, classification, differentiation, etc.	From 3 years old and up	37	The user can only access the app by registering beforehand with an email. The app contains different games. It includes a section where the child's progress can be consulted.	It works on different areas at a cognitive level and the activities undertaken are assessed.	It has a free trial period, after which the user must pay.	All the content is organized in a very visual way and the drawings and animation are adapted to the users.
 **Emociones, sentimientos y expresiones!**	English, Russian, French, German and Lithuanian	Emotions and feelings	-	37	It has two sections. The first shows images of people or drawings expressing an emotion, and by clicking on them a voice says what the feeling is. The second section shows images of a person and asks the user how they feel, having to indicate it by clicking on the correct drawing.	The images of people express the feelings in a much closer way, apart from including drawings. It assesses whether the user identifies them correctly.	It contains advertising.	The app has different levels, which the user reaches progressively, by understanding every one of the emotions and feelings expressed. The app is very intuitive and it is easy to navigate.

CommBoards - gratis terapia del autismo AAC	Spanish, English, Hebrew, Russian and Chinese	Communication	8 years old and under	37	It enables making panels with pictographs or own images to promote communication and express the needs of the child.	It can be personalized and is interactive, it allows the uploading of own images, voice recording and the editing of the panels to the user's taste.	Different communication codes are not offered, only written format.	It encourages the child's communication since it presents the different pictographs in a very organized way. The audio verbalizations play correctly and enhance understanding of the pictograph.

4. Discussion and conclusions

The app review has made it possible to observe the great variety of existing educational tools for promoting the integral development of people with autism. The catalogue offered by the Google Play Store covers a broad range of essential aspects that make up the psycho-pedagogic intervention in ASD.

It should be noted that this study aimed to show those apps that, due to their design, content and pedagogic dimension, proved to be the most enriching for people with autism. Hence, the didactic application this study focuses on is to provide specialists and family members with those apps that are best adapted for people with autism.

Having reviewed every one of the apps offered for free on Google Play Store, it could be seen how many of them are not aimed at people with autism but solely for families or professionals. Thus, it is essential to be able to select those apps created exclusively for people with ASD, since there are more than 450 apps on offer (using the descriptors “autismo” and “autism”). Likewise, many of the suggested apps do not focus on the needs of people with autism, but appear randomly in the search results, which means that an arbitrary search would result in hundreds of apps, few of which would be those designed exclusively for users with ASD.

Furthermore, most of the apps do not specify the age group they are aimed at. This may either be because the app can be used at any developmental stage, or because this information was overlooked. It is relevant for information of this type to be shown, as it helps in the process of app selection. And given that the age of the target user is not indicated, it would be useful for the app to indicate certain competences that the user should possess in order to use it, since some of them only contain reading and do not include audio narration or sounds that would enable the user to continue using them even if they have not yet attained the skill of reading. Many apps include stories, which means that, if they are not given voice narration by the app itself, their use will be limited even though the content is suitable for people with autism.

It should not be forgotten that the ultimate purpose of the educational apps is to reinforce the daily work carried out by families and professionals in autism. Hence their use should be framed within a specific programme in which the activities complement each other; they should not make an arbitrary use of them.

Currently there are studies focused on the assessment of websites and apps, but not exclusively for the autism community. There are many disciplines that can benefit from these studies, but in the field of autism we have not been able to find studies of this type. Therefore, given that there are no known investigations that evaluate apps specifically for autism in depth, it is difficult to make a comparison of the results. This thus entails a limitation, given that a proper assessment in comparison with other studies cannot be undertaken. However, this is an opportunity for innovation for professionals in the field to make appropriate and responsible use of resources of this type, at the same time offering researchers enriching results of this topical subject area.

It is curious that, after examining the 155 apps, the area of the emotions is that which features the least. ASD presents a symptomatology precisely with deficiencies in social relations, very closely related to the emotions. In fact, despite the fact that this incapacity to recognise the emotional states of other people and to understand their own emotions is the main trait of the disorder, there are few apps that aim to deal with these skills (which, if they are worked on, can be seen to improve). Fortunately, the apps linked to communication and language feature frequently on the Google Play Store catalogue, which is good news as communication (the communicative intention in itself) is the basis upon which developing the other skills can be achieved.

It is noteworthy that, despite there only being 14 apps in the *highly recommendable* group, the large majority of the remaining apps are recommended for therapy with autism, with only 9 in the *not recommendable* group. Thus, even though some apps are less complete than others, the development of apps focused on ASD is obtaining high scores and users can make an optimal use of them.

Regarding the pedagogic dimension, only the apps “CPA” and “Michelzinho - emoçoes e autismo” from those ranked *highly recommendable* attain the maximum score (6 points). In this regard, it is important to work on helping the other apps in the catalogue to achieve essential aspects of this dimension, whereby they can manage to wholly adapt criteria that are key to the development and strengthening of the teaching-learning process. This requires the collaboration of teachers and educators with programming engineers to build accessible pedagogic software.

Aside from this, routines and time management are also areas that need emphasising, because, as is well detailed in APA [2], this disorder presents restrictive

patterns in terms of behavior and activities. The apps that deal with these issues organize the way to set out time to perform routine tasks very well, such as brushing one's teeth or to manage what one is going to do throughout the day. However, these apps are given less space. It is essential that, if ICT and apps are going to be utilizable as resources complementary to education and therapy for people with ASD, they be easy to find by families and specialists, and that they be of good quality.

Regarding future research, it would be worthwhile to enhance the system of indicators by expanding those that refer to the pedagogic dimension, for they only make up 13% of the total score of an app. Additionally, there should be an assessment of the quality with which the apps address the areas where people with ASD present most difficulties. It would also be of value to assess and evaluate the apps that appear when using search terms such as "Pictograms", "Pictographs", "Augmentative and Alternative Communication (ACC)" and "Visual Schedules" in Spanish and in English. This would enable a complete survey of all the material that is offered to people with autism and to distinguish those apps that better adapt to the areas that need to be worked on.

Funding sources This research was supported by the University os Granada and the Spanish Ministry of Education, Innovation and Universities (aid for university teacher training [FPU19/00026]).

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Artículo 3. Technologies in the education of children and teenagers with autism: evaluation and classification of apps by work areas

Education and Information Technologies
https://doi.org/10.1007/s10639-021-10773-z

Technologies in the education of children and teenagers with autism: evaluation and classification of apps by work areas

Carmen del Pilar Gallardo-Montes[1] · María Jesús Caurcel Cara[2] · Antonio Rodríguez Fuentes[1]

Received: 21 July 2021 / Accepted: 1 October 2021

Abstract
Mobile apps represent a resource with great potential for encouraging the development of many skills, given the high number of apps available and the quick access to them. Many professionals and families include these resources in the education and therapy of children with autism. For a group with such particular needs, a review of the apps is great importance, since, due to their characteristics, the apps must provide content, design and pedagogical aspects that fit those needs. Through a previously validated system of indicators, 155 free apps on Google Play were evaluated, using "autism" in English and in Spanish. We determined which work area each app developed, as well as which were the most multifaceted. Having evaluated the recorded data, we calculated frequencies, percentages and reliability, as well as parametric contrast and correlation statistics. We found that the focus of most apps was on executive functions, language and entertainment, with a minority devoted to the emotional sphere or time management. However, 98.06% of the apps worked on several areas, which makes them more functional but with the downside of not being specialized. Most apps were placed in the "recommendable" level but with margin for improvement in increasing their functionality.

Keywords Special education · Autism · Educational technology · Appropriate technology · Assessment · Mobile learning resources

✉ María Jesús Caurcel Cara
caurcel@ugr.es

Carmen del Pilar Gallardo-Montes
cgallardo@ugr.es

Antonio Rodríguez Fuentes
arfuente@ugr.es

[1] Department of Didactics and School Organization at the Faculty of Education, University of Granada (Spain), Campus "La Cartuja" s/n, 18071 Granada, Spain

[2] Department of Developmental and Educational Psychology at the Faculty of Education, University of Granada (Spain), Campus "La Cartuja" s/n, 18071 Granada, Spain

Published online: 16 October 2021

Springer

1 Introduction

Autistic Spectrum Disorder (ASD) is characterized by the presence of impairments and difficulties in areas connected to communication and social interaction, along with restrictive patterns with respect to diversity of behaviours and interests (APA, 2014). Autism is a part of ASD, according to the APA manual. Wing (1998) defines it as a set of symptoms associated with three dimensions (autistic triad): impairments and delay in language and communication, both verbal and non-verbal; impairments in the social sphere, more specifically in interpersonal reciprocity; and impairments in behaviour and thinking.

The global prevalence of people with autism has been measured by various authors and for various contexts, but the figures are not exact. Fortea et al. (2013) show that it could affect 60–70 of every 10.000 people; APA (2014) and March et al. (2018) state that it could comprise 1% of the population; Anzaldo and Cruz Ruiz (2019) assert that it affects one out of every 160 children in the world; and Málaga et al. (2019) show that in countries such as the United States it comprises one of every 59 children, and in Portugal, one of every 806. Even with this lack of agreement, the prevalence is notable. It is therefore important that these children are offered the care and education to enable their comprehensive and autonomous development from an early age. It is vital for professionals and specialists who participate in their education and/or psychopedagogical interventions to have the requisite training and means, including digital techonologies and material specifically designed for this group.

With this in mind, having searched through the different areas in which children and adolescents with this disorder have greater vulnerability – communication, language, emotions, basic instrumental skills, executive functions and time management – we observed that information and communications technology (ICT) in all its varieties (smartphone, tablet, communication boards, computers, etc.) achieves positive results in their enhancement and development. "Pupils with ASD often require the intervention of a wide range of services adapted to their specific needs" (Cappe et al., 2017, p. 498). Various studies (Castro & Mallón, 2019; David et al., 2019; González et al., 2016; Guzmán et al., 2017; Hernández & Sosa, 2018; Lorenzo et al., 2021; Pinel et al., 2018; Silva & de Rodríguez, 2018; Terrazas et al., 2016; Tsikinas & Xinogalos, 2020; Vlachou & Drigas, 2017; Wang & Xing, 2021) show the benefits that ICT offers this community, with a wealth of content focused on the comprehensive and specialized development of people with autism.

1.1 Apps for children with ASD and autism

In particular, apps provide a resource with great potential for working on and encouraging the development of many skills, given the high number of apps available and the quick and simple access to them (Gallardo-Montes et al., 2021a). Similarly, studies focused on children with autism using smartphone and tablet

Table 1 Studies focused on the use of apps with children with Autism Spectrum Disorder

Work	Purpose/Objective	App/Operating System	Results
Jiménez et al. (2017)	To analyse the influence of apps in the development of language and communication in a child with ASD.	*CPA*, *LetMeTalk*, *Niki Talk*, *PictoDroid Lite* … (Android/iOS)	Progress in the prerequisites of language, communicative intent and behaviour.
Fage et al. (2018)	To promote the school inclusion of 30 children with ASD through assistive apps based on cognitive and care rehabilitation.	Package of *School* apps + (iOS)	Improvements in socioadaptive behaviours and social response in the school environment.
Sung (2018)	To examine the effects of the use of apps addressing social skills in 3 children with autism.	*Cuedin-Autism Early Intervention App*, *Autism Help* y *SocialSkills for Autism KLoog2* (Android)	Substantial improvements in social skills.
Bondioli et al. (2018)	To alleviate the sensory tensions that children with autism have when faced with a visit to the dentist and oral care.	*MyDentist* (Android)	Reduction of stress and anxiety in dentist visits.
Teixeira and Cunha (2019)	To teach early mathematical skills to 8 children with autism.	*123 Autism* (Android)	Learning of mathematical skills and increase in attention, concentration, behaviour and motivation.
Sweidan et al. (2019)	Learning of concepts linked to language, mathematics and social skills.	*Autistic Innovative Assistant (AIA)* (Android)	Progress in basic linguistic, mathematical and social concepts.
Lázaro-Cantabrana et al. (2019)	To test the usefulness of a safety app for people with ASD, corroborated with 18 families.	*SOS TEA* (Android)	Improvements in the understanding of information and capacity for expression and communication.
Smith et al. (2020)	Intervention through social stories in digital format with 22 children with autism.	*SOFA* (Android)	Greater comprehension of social stories and decrease in anxiety.
Aguilar-Velázquez et al. (2020)	To work on reading and writing with 10 children with autism.	*LEA: Lecto-Escritura para Autismo* (Android)	Stimulation of learning acquisition of cognitive, perceptual and motor skills, through a controlled, supervised and structured use.
Vyshedskiy et al. (2020)	Language development in 6454 children with ASD.	*Cognitive and Language Therapy with MITA* (Android)	Improvements in perceptive and expressive language.

apps have been increasing, and many authors have described their experience and success in using them (Table 1).

As well as being a good option for entertainment for any section of society, apps have potential beyond mere recreation for children with autism. Their content, and the way it is laid out, is presented in a controlled way, without ups and downs or intimidating situations, which is favourable for children and adolescents with autism (González et al., 2016; Hernández & Sosa, 2018; Terrazas et al., 2016). The digital-format tasks are also attractive to the user (Lozano et al., 2013b; Suárez et al., 2015), offering visual stimuli that are highly appealing to children with autism (García et al., 2016; Hernández & Sosa, 2018; Jiménez et al., 2017). In addition, authors such as García et al. (2016) and Jiménez et al. (2017) uphold the idea that interventions supported by apps facilitate and stimulate language and communication.

1.2 Previous studies on the evaluation of apps

Studies that examine apps for children and adolescents with functional diversity are numerous and varied. Cayton et al. (2015) assessed mathematics apps on the Apple App Store with regard to mathematical content, feedback, user interaction and adaptability. Crescenzi and Grané (2016) carried out a content analysis of 100 apps for children between the ages of six months and eight years old, examining their visual and interactive design, and they concluded that the quality of the aspects they measured was low. Larco et al. (2018) assess the quality of 73 apps on Google Play for people with disabilities, concluding that improvements were needed regarding personalization and interactivity. Kucirkova (2019) studied the design parameters of apps for creating children's stories. Crescenzi et al. (2019), in a systematic review of 200 apps for eight-year-old children, related to the safety and risks involved from an ethical perspective, underline the need to consider several aspects, including: mechanisms for protection; tools to change settings; stereotypes; knowledge held prior to using the app; and the verbal component presented. Leech et al. (2021) study mental health-focused apps for adolescents and young adults and the benefits following their use.

However, there are few studies that focus on the evaluation of apps for people with autism (Table 2). We need to pay attention to the particular areas in which people with this condition have greater difficulty, in order to find those apps that include suitable content based on their needs.

1.3 Spheres or areas in which children and adolescents with autism present greater difficulty

Children with autism exhibit significant impairments in the area of communication, along with many difficulties in language processing (Orellana, 2016; De Castro et al., 2018). As a consequence, there is impaired social interaction. ICT offers resources and tools that promote precisely the communication competence (Peirats et al., 2019). The software that supports language and communication makes it possible to create material that is connected to the communicative process through

Table 2 Studies focused on the evaluation of apps for children with Autism Spectrum Disorder

Work	Purpose/Objective	Conclusions
Sofian et al. (2016)	To identify the existing usability factors that have been used up until now to design the interface of an app for children with autism.	Particular attention is given to efficacy, efficiency, satisfaction, ease of use, appearance and understandable design.
Dattolo and Luccio (2017)	To analyse guidelines for the development of apps accessible to people with ASD.	Not all apps are accessible nor adapted to the characteristics of people with ASD. The language, sounds and narrations could be improved.
Boster and McCarthy (2018)	To investigate the format of apps addressing augmentative and alternative communication.	The importance of a design and format is maintained by speech therapists and families, adapted to the needs of the child with ASD.
Crespo and Martín (2018)	Review of articles focused on iOS and Android apps for children with autism.	The apps focused on behaviour, communication and learning are ideal and numerous for children with autism. However, a greater number of apps for families is needed. Apps for leisure and entertainment for this group are scarce.
Sofian et al. (2018)	Systematic review to study the usability factors used for the design of apps for children with autism.	They find that comprehension and appearance are included as usability factors due to their relation with the characteristics of children with autism.
Adamu et al. (2019)	To study the iOS and Android apps for children with autism developed to provide an environment for learning and communication.	The apps have interfaces adapted to the child's characteristics, which facilitate their concentration in carrying out the tasks given. The apps have improved with the advance of technology, with noticeable improvements in their usefulness.
Xanthopoulou et al. (2019)	To analyse the iOS and Android apps for children with ASD to give an overview of their characteristics and the developmental area they work on.	There is no guidance for the selection and use of the apps, and so families and professionals are advised to supervise the apps before giving them to children.
Sanromà-Giménez et al. (2021)	To design an instrument for the assessment of apps for people with autism.	Instrument focused on discovering the technical and descriptive characteristics of an app for people with autism, as well as their pedagogical aspects, inclusivity and educational accessability.

Table 2 (continued)

Work	Purpose/Objective	Conclusions
Gallardo-Montes et al. (2021b)	Evaluation of 88 apps available on Android focused on basic instrumental skills (oral language, reading, writing and mathematics) for children with autism.	Most of the apps focused on aspects linked to oral language (81.82%) and reading (87.5%), but few were aimed at writing (44.32%) and mathematics (23.86%). For oral language, the sub-area that was least present in the apps was syllables (3.4%); in reading it was reading fluency (5.2%); in writing, teaching spelling (5.13%); and in mathematics, multiplication and division (9.52%).
Gallardo-Montes et al. (2021a)	Assessment of the quality of 155 apps available for Android for people with autism.	The assessment established a ranking of the apps according to the quality of their design, content and pedagogical aspects. Only 14 apps obtain scores notably higher than the rest. These apps best fit the needs of people with autism.
Hanna et al. (2021)	To evaluate apps available on iTunes and Google Play aimed at teaching social skills to people with ASD, giving particular attention to the behaviour change procedures they incorporate.	The quality of the apps and the amount of behaviour change procedures vary between developers. The content that they aim to address should be presented clearly to give good guidance to families and professionals.
Haque et al. (2021)	Assessment of the *mCARE* app available for iOS and Android focused on the remote monitoring of children with ASD.	The Value Sensitive Design (VSD) produces an app that is easier to use in accordance with the socio-economic and cultural values of families.
Hussain et al. (2021)	Systematic review to investigate iOS apps for children with autism and how teachers can use them with these children.	The apps are effective at helping children to acquire linguistic and communicative skills due to their flexibility and portability. A systematic review method is recommended in the use of mobile devices.
Lian and Sunar (2021)	Systematic review to examine mobile augmented reality apps for people with ASD.	The quality of the augmented reality and the design focused on the characteristics of people with ASD need to be improved.

images, personal photographs and pictographs, enabling the user to create personalized schedules and social histories (Hernández & Sosa, 2018). Thus it can be adjusted to the interests of the child, young person or adult with ASD, which is essential for motivating communicative interaction (Baixauli et al., 2017).

Regarding the emotional sphere, children and young people with autism have a diminished capacity for understanding mental representations (Pedreño et al., 2017). An example of this is their difficulty in comprehending emotions, beliefs and intentions (Mazza et al., 2017). Authors such as Lozano and Merino (2015) state that, through a structured and well planned intervention, it is possible to improve the emotional competences. Successful studies and experiences, such as those of Lozano et al. (2013a), González et al. (2016) and Matey (2017), show improvements in understanding emotions with the aid of technological resources and apps in children with autism. Thus, the appropriate and organized use of these types of resources can guide psychopedagogical interventions toward positive results.

Pouw et al. (2013) add that children and adolescents with autism present an impaired capacity to create a Theory of Mind (ToM), which is closely connected with social interaction. This theory addresses the ability of people to attribute mental states to oneself and to others, through which they can understand their own and others' behaviour (Premack & Woodruff, 1978). ToM produces patterns or behaviours that enable a person's communicative and social development with their surrounding environment. Because processes integral to human development operate in ToM, an effort is made to promote them in people with autism from an early age. Some of the areas that converge in ToM are communication, language and the emotional sphere – the areas in which people with autism have most difficulty.

In terms of the basic instrumental skills, Íñiguez (2013) states that "instrumental learning is based on the acquisition of essential instruments and tools that are the basis for accessing the rest of knowledge and attaining an education of quality" (p. 1). People with autism display difficulties in learning these types of competence, such as artihmetic, writing and reading. Detecting these obstacles and treating them are two key aspects in intervening with children with autism.

"Learning to read and write is perhaps the first truly academic action in schools; it marks a before and after in the life of a child. Knowing how to read and write is, nowadays, something we expect of any person" (Autismo Diario, 2017, p. 1). The learning of reading and writing represents a step forward in development, since it gives an improved under-standing of language and its development. Pérez et al. (2012) stress that "teaching to read in autism does not only mean one step further in the natural process of education and culturalization. In autism, reading and writing can provide a way in for intervention on particularly affected aspects" (p. 85). In this regard, apps offer a large range of material to work on these concepts in a playful and active way.

In addition, people with autism exhibit difficulties in tasks connected with executive functions (Peirats et al., 2019). These involve the capacity for holding and managing information (working memory), prepotent response inhibition, flexibility to task change, planning to achieve objectives, and decision-making (Goldstein et al., 2014). "These processes are critical for our daily functioning, as they enable us to carry out independent, intentional and self-directed

behaviour" (Martín et al., 2020, p.8). Authors such as Guzmán et al. (2017) state that digital resources open up a world of possibilities for working on the executive functions. The utilization of apps has therefore emerged as an interesting option, since it combines exercises for memory, organization and attention, along with entertainment and recreational activities.

The enjoyment of free time, in terms of leisure and entertainment, is vital for any person. Hence CeRMi (Spanish Committee of Representatives of Persons with Disabilities) declares that:

> [...] leisure is a fundamental right that enables the personal and social development of people and which nobody should be deprived of because of disability. It is an essential medium for attaining emotional well-being, developing interpersonal relations and promoting the inclusion of people with disabilities. (2018, p.2)

Hence providing digital options to children and adolescents with autism represents an interesting and encouraging step forward for them. Along these lines, Villén (2017) describes the experience undertaken by including the videogame *Minecraft* as "an inclusive leisure alternative for people with ASD" (p. 13).

Therefore, having reviewed the literature, we can see how there is an abundance of studies focused on the benefits of ICT and, more specifically, on the values that apps have in the development of children with autism. Considering that these technological options are presented as groundbreaking and motivating support resources for the teaching-learning process, therapy and skill development, it would be interesting and worthwhile to find out precisely what apps are being offered to this community, what content they work on and their quality. This would help to guide and structure teaching and/or psychopedagogical interventions toward specific goals with certain guarantees for success.

A simple search of the app catalogue produces hundreds of apps for people with autism, but no prior knowledge or clue as to their purpose. According to the review of studies based on apps and autism, there has been no scientific undertaking to evaluate apps specifically for this community, nor has there been an analysis of all the free apps for Android available in the Google Play Store. We therefore intend to discover and recount the number of previous apps and assess their quality and variety. Consequently, this study has the following aims:

1. To discover and calculate the number, variety and quality of apps specifically created for children with autism that exist and are available for Android.
2. To evaluate the different free apps for children with autism available on Google Play Store according to predetermined criteria of quality.
3. To offer a list of apps by area of focus for children and adolescents with autism, in order to recommend their use according to the user's need.
4. To determine which are the most specialized and which the most multifaceted apps for education and intervention with children with autism.

2 Method

2.1 Sample

For the analysis of the apps aimed at children and teenagers with autism, the Google Play Store search engine, available on mobile devices with the Android operating system, was taken as the starting point. The use of app stores for the development of research is a highly utilized resource in the international literature, and is relied upon by a range of researchers. Previous studies (Cayton et al., 2015; Comin, 2015; Crescenzi et al., 2019; Fage et al., 2018; García et al., 2016) have used app stores because they are the most popular and safest platforms for finding and downloading apps. Furthermore, the professionals and families of people with autism rely upon app stores to search for, download, install and later update these apps.

The sample comprised 155 free apps. The search terms "autismo", in Spanish, and "autism", in English, were used, thus covering the greatest number of apps in both languages. In the results section, each app appears with its name in the original language. The search was refined using rigorous pre-established exclusion criteria, which were: apps without any connection to autism; apps aimed at families or autism specialists but not specifically for people with this condition; apps with malfunctions or device incompatibilities; or apps repeated in both searches. Given the high number of apps for children with and without autism, we have only assessed those that include the keyword "autism" in their description.

2.2 Instrument

For the app evaluation, we used a "System of Indicators and Instrument for the Assessment and Selection of Apps for People with ASD", previously designed and validated by Gallardo-Montes et al. (2021c). The use of an indicator system makes it possible to evaluate in a tangible way the services offered by, in this case, the apps available on the Google Play Store. The aspects evaluated were governed by the criteria of what was necessary for an app aimed at children with autism. The proposed indicators were developed and analysed in depth from a psychopedagogical point of view, in accordance with previous studies focused on app evaluation (Araujo et al., 2007; Belloch, 2006; Cayton et al., 2015; Crescenzi & Grané, 2016; Crescenzi et al., 2019; García-Rodríguez & Gómez-Díaz, 2015; Fage et al., 2018; Larco et al., 2018). This instrument evaluated three dimensions of the apps (Table 3):

Table 3 Dimensions evaluated in the apps and indicators assessed

Dimension	Indicators
D1: Design/Form	Availability, Ergonomics, Usability, Popularity, Accessibility.
D2: Content	Audio quality, Narration quality, Content, Notifications, Help/tutorials, Safety.
D3: Pedagogical aspects	Interactivity, Suitability of pace and learning, Feedback/assessment.

The indicator system was made up of 14 items, which were in turn divided into 46 sub-indicators, depending on the dimension. The instruments gave a final score, which allowed us to rank each app as: *highly recommendable/Group 1* (≥37 points); *recommendable/Group 2* (36–23 points); or *not recommendable/Group 3* (≤22 points). The indicator system was positively assessed by a total of twelve judges with extensive experience in the education and technology field. The system obtained excellent Intraclass Correlation coefficients (ICC) (ICC_{D1}=.955, ICC_{D2}=.973 and ICC_{D3}=.966) and significant and strong Kendall's W inter-rater concordance (.757 and 1.00, p<0.001). With a very high Cronbach's alpha coefficient (α_{D1}=.955, de α_{D2}=.973 y α_{D3}=.966), this was a valid and reliable instrument.

2.3 Procedure

In order to proceed to evaluate each app, we used a conventional smartphone connected through AC Wi-Fi at a speed of 600 Mb/s, to prevent any alterations and to be able to make an assessment under equal conditions. Each app was installed on the device for two weeks and assessed progressively and thoroughly according to the indicator system, marking the presence or absence of each indicator and sub-indicator. Likewise, the area that each app worked on was indicated (communication, language, emotions, basic instrumental skills, executive functions and time management). The evaluation took place during the first quarter of 2019.

2.4 Design and data analysis

The study followed a quantitative design, taking the basic, non-experimental, simple descriptive and cross-sectional approach.

The analysis and evaluation of apps were recorded using Microsoft Office Excel 2016, indicating the area or areas they addressed (communication, language, emotions, basic instrumental skills, executive functions and time management) and writing 1 or 0 in each cell depending on the attainment or not, respectively, of the proposed indicator. Then the data were analysed with the SPSS statistical package version 25.0, with a margin of error of 5% and a reliability level of 95%. First, descriptive analysis (mean and standard deviation) was performed, as well as frequencies to find out the distribution by group, according to the quality of the apps evaluated, to determine which area(s) each app addressed, and to establish which area(s) was addressed the most and the least. Second, for the comparison between three groups of apps the univariate ANOVA - given the normality and homoskedasticity of the data - was used with the Bonferroni multiple comparisons test to define the groups in which significant differences were observed and Eta squared for estimations of the effect size. Third, to determine whether the quality of the apps depended on the areas they addressed, the chi-squared non-parametric test was used - given non-normality and homoskedasticity of the data. Finally, Pearson's correlation coefficient was calculated to establish the possible relations between the dimensions analysed, and between the different areas addressed by the apps.

3 Results

The distribution of the apps by groups was as follows: 9.03% ($n=14$) attained the assessment for Group 1 (*highly recommendable*); 85.16% ($n=132$) for Group 2 (*recommendable*); and 5.81% ($n=9$) for Group 3 (*not recommendable*). Each app was examined to find out which area of work it developed.

Of the 155 apps analysed, only 1.94% ($n=3$) focused exclusively on one single area: *"Nursery rhymes songs & kids puzzle games free"*, *"Relax melodies: sueño y yoga"* and *"The sensory processing game-autism & spd free"*, which shows the lack of specialization of the apps as a whole. These three include content linked to leisure and entertainment and belong to Group 2, *Recommendable* apps. In contrast, most apps (98.06%, $n = 152$) work on more than one area simultaneously, although none of the apps dealt with all seven proposed areas simultaneously, suggesting the need for combinations. There were four apps (2.58%) that tackled the highest number (six) of areas simultaneously: *"LEA Lecto escritura para autismo"*, *"Autastico"* (both in Group 1), *"SocialSkills for Autism Kloog 2"* and *"Tealite app"* (both in Group 2). Eleven apps (7.10%) exercised five areas at the same time, including *"Otsimo"*, which obtained the highest overall score, while 20.65% ($n=32$) dealt with four areas at a time, including the high-scoring *"#Soyvisual"*. Finally, 44.52% ($n=69$) handled three areas; and 17.42% ($n=27$) involved two.

The area that was most present in the apps was communication (Table 4), appearing in 72 (46.45%): ten belonging to Group 1 (*Highly Recommendable*), 58 apps to Group 2 (*Recommendable*), and only 4 apps to Group 3 (*Not Recommendable*). In the area of language (Table 4), 91 apps (58.71%), of which 12 belong to Group 1 (*Highly Recommendable*), 75 apps to Group 2 (*Recommendable*), and 4 apps to Group 3 (*Not Recommendable*). Concerning the area of the emotions (Table 4), we found 24 apps (15.48%); only six belonging to Group 1 (*Highly Recommendable*), 18 apps to Group 2 (*Recommendable*), and none to Group 3 (*Not Recommendable*). These three areas present a direct relation with social interaction and, therefore, with ToM, and so we have shown the results jointly (Table 4), given the need to promote these areas simultaneously.

With regard to time management (Table 5), 11.61% ($n=18$) of the apps worked on this area; just one app belonged to Group 1 (*Highly Recommendable*), 15 to Group 2 (*Recommendable*), and two to Group 3 (*Not Recommendable*).

In the area of instrumental skills (Table 6), we found 63 apps (40.65%), of which eight were included in Group 1 (*Highly Recommendable*), 53 in Group 2 (*Recommendable*), and only two in Group 3 (*Not Recommendable*).

In the area of executive functions (Table 7), 148 apps were found (95.48%), of which 14 belonged to Group 1 (*Highly Recommendable*), 128 to Group 2 (*Recommendable*), and six to Group 3 (*Not Recommendable*).

Lastly, in the area of leisure and entertainment (Table 8), 82 apps were found (52.90%), of which eight were in Group 1 (*Highly Recommendable*), 72 in Group 2 (*Recommendable*), and only two in Group 3 (*Not Recommendable*).

We can therefore state that the area of executive functions features most in the apps ($n=148$), followed by the area related to language ($n=91$), then leisure

Table 4 Apps focused on the Theory of Mind (communication, language and emotions)

Name of the app	TS	G	C	L	E	Name of the app	TS	G	C	L	E
1. #Soyvisual	40	1	X	X		**52.** Jade autism	32	2		X	
2. Otsimo	40	1	X	X		**53.** Ajedrez niños inf.	32	2		X	
3. Smile and Learn	39	1		X	X	**54.** Preescolar juegos i.	32	2		X	
4. CPA	38	1	X	X		**55.** El oledor	32	2	X	X	
5. Symbotalk	38	1	X	X		**56.** SocialSkills autism3	32	2	X		X
6. Visual schedules	37	1	X	X		**57.** Aprender español	32	2		X	
7. Michelzhino	37	1	X	X	X	**58.** Picto one	31	2	X	X	
8. LEA	37	1	X	X	X	**59.** Let us talk	31	2	X	X	
9. Autastico	37	1	X	X	X	**60.** Dictapicto	31	2	X	X	
10. Terapia z tabl.	37	1		X	X	**61.** Autism disease	31	2	X		
11. Emociones, se.	37	1	X	X	X	**62.** On tasktimer Aut.	31	2		X	
12. Commboards	37	1	X	X		**63.** Aprender a decir h.	31	2	X	X	
13. Proyecto emoc.	36	2	X		X	**64.** Emotion learning	31	2	X	X	X
14. Aboard CAA	36	2	X	X		**65.** ABA kit	31	2	X	X	X
15. SocialSkills	36	2	X	X	X	**66.** Buddy aprende n.	31	2		X	
16. Preescolar j.	36	2		X		**67.** Pictogramas.es	31	2	X	X	
17. Speech blubs l.	36	2	X	X		**68.** Buddy aprende for.	31	2		X	
18. Socialskills aut	36	2	X	X	X	**69.** Matraquinha	31	2	X	X	X
19. Jose aprende	35	2	X		X	**70.** El viaje de Elisa	31	2		X	X
20. iSecuencias lite	35	2		X		**71.** Autism	30	2	X		
21. Proyecta pecs	35	2	X	X		**72.** Buddy aprende col.	30	2		X	
22. Teacch.me	35	2	X	X		**73.** Action words 3d an.	30	2		X	
23. Comuniquem.	35	2	X	X		**74.** Help talk	30	2	X	X	
24. Vi.co hospital	35	2	X	X		**75.** Mousetrial lite	30	2		X	
25. Lista visual	35	2	X	X		**76.** Conciencia fonológ.	29	2	X	X	
26. Visual reading	35	2	X	X		**77.** Autismo imagen d.	29	2	X	X	

Table 4 (continued)

Name of the app	TS	G	C	L	E	Name of the app	TS	G	C	L	E
27. ABA drOm.	35	2		X	X	**78.** Talking pictures au.	29	2	X	X	
28. Asistente voz	35	2	X	X		**79.** App4autism - timer	29	2	X		
29. Proyecto retr.	34	2		X	X	**80.** Pictodroid lite	29	2	X	X	
30. Pictotea	34	2	X	X		**81.** Niki Talk	28	2	X	X	
31. Autimo	34	2	X		X	**82.** Dialogo AAC lite	28	2	X	X	
32. Diegosays aut.	34	2	X	X		**83.** Aprender cabrito fr.	28	2		X	
33. LEELOO AAC	34	2	X	X		**84.** Pictogramagenda	28	2	X	X	
34. Talk up! Com.	34	2	X	X		**85.** Talking pictures	28	2	X	X	
35. Palabras para	34	2	X	X		**86.** Jabtalk	28	2	X	X	
36. Alfabeto escrit.	34	2		X		**87.** Conversation ther.	28	2	X	X	X
37. Niño alfabeto	34	2		X		**88.** Articulation speech	27	2	X	X	
38. Horsy	34	2		X		**89.** Upcard	27	2	X	X	
39. Abc aut	33	2	X	X		**90.** Diego dice	26	2	X	X	
40. Letmetalk	33	2	X	X		**91.** Special app CAA	26	2		X	
41. Emoplay	33	2	X	X	X	**92.** Petterday agenda p	25	2	X	X	
42. Tealite app	33	2	X	X	X	**93.** Talk to me 100®	25	2	X	X	
43. Cabrito ortogr.	33	2		X		**94.** Autistic bird	24	2	X	X	
44. Preescolar apr.	33	2		X		**95.** Autapp - autismo	24	2		X	X
45. Autism help	33	2	X	X		**96.** говори молча	24	2	X		
46. Letra a letra	33	2		X		**97.** Piktosaac pictogr.	22	3	X	X	
47. Tarjetas educ.	33	2		X		**98.** Autismcpm	19	3	X	X	
48. Pictogramas.es	32	2	X	X		**99.** Speak through pict.	19	3	X	X	
49. Daily tasks	32	2	X			**100.** Autism mindawak.	16	3		X	
50. Autismo help	32	2	X	X		**101.** Autism helper lite	16	3	X		

Table 4 (continued)

Name of the app	TS	G	C	L	E	Name of the app	TS	G	C	L	E
51. Autismo lee	32	2		X							

TS = Total score; G = Group; C = Communication; L = Language; E = Emotions

Table 5 Apps focused on time management

Name of the app	TS	G	Name of the app	TS	G
1. Visual schedules social stor.	37	1	**10.** I'm on it focus timer	29	2
2. Lista visual - visual schedule	35	2	**11.** Pictogramagenda	28	2
3. Tempus	33	2	**12.** Conversation therapy lite	28	2
4. Social skills for autism 3	32	2	**13.** Upcard	27	2
5. Proyect@ habilidades	31	2	**14.** Petterday agenda pictogramas	25	2
6. On tasktimer-utism timer	31	2	**15.** Kids timer	25	2
7. Aprender a decir la hora	31	2	**16.** Temporizador para niños timer	25	2
8. Children countdown timer	29	2	**17.** In2token (Autism Token Boa.)	20	3
9. App4Autism timer, visual	29	2	**18.** Visual time timer	19	3

TS = Total score; G = Group

and entertainment in third ($n=82$), communication in fourth ($n=72$), and basic instrumental skills in fifth ($n=63$). The areas dealt with the least were the emotions ($n=24$) and time management ($n=18$). From these frequencies, illustrated in Fig. 1, we can infer the needs of apps for users with ASD.

Additionally, the average quality of the apps can be affirmed as "*Recommendable*" ($\bar{x}=2.03$, 85.16%) (Fig. 2). They did not attain the utmost quality of "*Highly Recommendable*" (only 9.03%), but neither did they fall into the worst category, with only 5.81% forming the "*Not Recommendable*" group.

Differences were found regarding the above app rating by groups (1, 2 and 3), according to the ANOVA calculation ($F\ (2)=61.20$), which produced significant differences ($p=.000$) with a medium effect size ($\eta^2=.45$). The differences were significant between all the groups, as the Bonferroni post-hoc tests showed ($p=.000$ in all cases), showing heterogeneous subsets. Therefore, not all the apps are valid; users should choose them carefully.

Regarding the evaluation by dimension, only dimensions 2 (on "content") and 3 (on "pedagogical aspects") were matched, with a notable correlation, direct ($r=.57$) and significant ($p=.000$). In contrast, the relation of these dimensions with dimension 1 (on "design and form") was low ($r_{D1\text{-}D2}=.21$, $p=.008$ and $r_{D1\text{-}D3}=.17$, $p=.031$).

The quality of the apps does not depend on the areas they work on, as demonstrated by the Chi-squared test ($\chi^2=5.56$; $p=.011$), thus accepting the null hypothesis of no relationship between evaluations of the apps. In other words, apps of different quality can be found in every area, meaning that they should be evaluated before being employed in any particular area.

Furthermore, the apps analysed are clearly oriented toward certain areas. They are not comprehensive, thus adding to the aforementioned requirement the need for each user to have a clear work objective before arbitrarily using the apps. Indeed, of all the areas observed in the apps, only "communication" and "language" have a direct and significant relationship ($r=.52$, $p=.000$), while "leisure" and "instrumental skills" are indirectly and significantly related ($r=.47$, $p=.000$).

Table 6 Apps focused on basic instrumental skills

Name of the app	TS	G	Name of the app	TS	G
1. #Soyvisual	40	1	**33.** Tarjetas educativas español	33	2
2. Otsimo	40	1	**34.** Autismo lee y escribe gratis	32	2
3. MITA	39	1	**35.** Jade autism	32	2
4. Smile and Learn	39	1	**36.** Niño juego de memoria alim.	32	2
5. LEA Lecto escritura	37	1	**37.** Games for kids sea animals	32	2
6. Autastico	37	1	**38.** Ajedrez niños infantil gratis	32	2
7. Juegos de niños para bebes	37	1	**39.** Rompecabezas de niños din.	32	2
8. Terapia z tabletem	37	1	**40.** Baby piano games & music	32	2
9. SocialSkills Autism Kloog 2	36	2	**41.** Aprender español para niños	32	2
10. Preescolar juegos en españ.	36	2	**42.** Aprender a decir la hora	31	2
11. Isecuencias lite	35	2	**43.** Buddy aprende los numeros	31	2
12. Visual Reading educacion	35	2	**44.** Buddy aprende las formas	31	2
13. Rompecabezas puzzingo	35	2	**45.** Buddy aprende los colores	30	2
14. Niños de dibujo animado	35	2	**46.** Autism speech sequencing	30	2
15. Animals puzzle for kids	35	2	**47.** Kids puzzle car & vechicles	30	2
16. Fotos de animales romp.	35	2	**48.** Vehicles puzzle for kids	30	2
17. Vechicles puzzle for kids p.	35	2	**49.** MouseTrial Lite	30	2
18. ABA DrOmnibus for Par.	35	2	**50.** Conciencia fonologica	29	2
19. Rompecabezas dinosaurios	34	2	**51.** Autismo imagen discusión	29	2
20. Palabras para niños	34	2	**52.** Autsim exit vn	29	2
21. Alfabeto escrito ABC 123	34	2	**53.** Romp. niños-habilidades m.	29	2
22. Animal rompecabezas	34	2	**54.** Aprender cabrito fruta	28	2
23. De suma y resta niños	34	2	**55.** Games for kids wild animals	28	2
24. Niño alfabeto de aprendizaje	34	2	**56.** Puzzles de animales para niños	28	2
25. Gratis niños juego de puzzle	34	2	**57.** Games for kids retro cars	27	2
26. ABC Autismo	33	2	**58.** Special app CAA	26	2
27. Tealite app	33	2	**59.** Puzzles de frutas para niños	25	2
28. Niño conectar los puntos	33	2	**60.** Focus	25	2
29. Cabrito juego de ortografia	33	2	**61.** Games for kids modern cars	23	2
30. Preescolar aprende numeros	33	2	**62.** Autismcpm	19	3
31. Dinosaurios rompecabezas	33	2	**63.** Autism mindawakener	16	3
32. Letra a letra - deletrear	33	2			

TS = Total score; G = Group

4 Discussion and conclusions

Smartphones and tablets are used frequently in the teaching-learning process, in therapy and in the family context of children and adolescents with autism. The use of electronic devices is an encouraging and attractive option for children with autism, due to the auditory and visual format that they often offer. Faced with the imminent technological proliferation of content addressed to minors with this

Table 7 Apps focused on executive functions

Name of the app	TS	G	Name of the app	TS	G
1. #Soyvisual	40	1	**75.** Social skills for autism 3 Kloogs	32	2
2. Otsimo	40	1	**76.** Baby piano games & music	32	2
3. MITA	39	1	**77.** Aprender español para niños	32	2
4. Smile and Learn	39	1	**78.** Picto one	31	2
5. CPA	38	1	**79.** Let us talk	31	2
6. SymbóTalk - AAC Talker	38	1	**80.** Dictapicto	31	2
7. Visual schedules and social	37	1	**81.** Autism disease	31	2
8. Michelzhino- emoçoes	37	1	**82.** Proyect@ habilidades	31	2
9. LEA Lecto escritura	37	1	**83.** On tasktimer-utism timer	31	2
10. Autastico	37	1	**84.** Aprender a decir la hora	31	2
11. Juegos de niños para beb.	37	1	**85.** Emotion learning for autistic	31	2
12. Terapia z tabletem	37	1	**86.** ABA kit	31	2
13. Emociones, sentimientos	37	1	**87.** Buddy aprende los numeros	31	2
14. CommBoards-gratis	37	1	**88.** Pictogramas.es	31	2
15. Proyecto emociones	36	2	**89.** Buddy aprende las formas	31	2
16. Aboard CAA	36	2	**90.** Matraquinha	31	2
17. SocialSkills Autism 2	36	2	**91.** El viaje de Elisa	31	2
18. Preescolar juegos en esp.	36	2	**92.** Autism	30	2
19. Quien es quien	36	2	**93.** Buddy aprende los colores	30	2
20. Speech Blubs: Language	36	2	**94.** Autism speech sequencing zapps	30	2
21. SocialSkills for Autism	36	2	**95.** Kids puzzle car & vechicles	30	2
22. Jose aprende	35	2	**96.** Vehicles puzzle for kids	30	2
23. Isecuencias lite	35	2	**97.** Action Words: 3D Animated	30	2
24. Proyecta PECS	35	2	**98.** Help talk	30	2
25. Teacch.me	35	2	**99.** MouseTrial Lite	30	2
26. Comuniquemonos	35	2	**100.** Conciencia fonologica	29	2
27. Vi.co hospital lite	35	2	**101.** Autismo imagen discusión	29	2
28. Lista visual - visual	35	2	**102.** Autsim exit vn	29	2
29. Visual Reading educacion	35	2	**103.** Talking pictures autism pc	29	2
30. Rompecabezas puzzingo	35	2	**104.** Children countdown timer	29	2
31. Niños de dibujo animado	35	2	**105.** Rompecabezas niños hab.	29	2
32. Animals puzzle for kids	35	2	**106.** App4Autism - timer, visual	29	2
33. Fotos de animales romp.	35	2	**107.** I'm on it: focus timer	29	2
34. Vechicles puzzle for kids	35	2	**108.** Pictodroid lite	29	2
35. ABA DrOmnibus for Par.	35	2	**109.** Preschool bus driver toddler	29	2
36. Asistente de voz AAC	35	2	**110.** Niki Talk	28	2
37. Proyecto Retratos	34	2	**111.** Dialogo AAC Lite Autism	28	2
38. Pictotea	34	2	**112.** Aprendizaje sensorial de niños	28	2
39. Autimo	34	2	**113.** Sonidos animales para niños	28	2
40. Diegosays autismo habla	34	2	**114.** Piano para bebés: juego	28	2
41. Leeloo AAC - Autism	34	2	**115.** Dibujos de arena - sand draw	28	2
42. Talk up! communicator	34	2	**116.** Aprender cabrito fruta	28	2

Table 7 (continued)

Name of the app	TS	G	Name of the app	TS	G
43. Rompecabezas de din.	34	2	**117.** Games for kids wild animals	28	2
44. Palabras para niños	34	2	**118.** Puzzles de animales para niños	28	2
45. Alfabeto escrito ABC 123	34	2	**119.** Sensory baby: games for babies	28	2
46. Animal rompecabezas b.	34	2	**120.** Pictogramagenda	28	2
47. De suma y resta niños	34	2	**121.** Talking pictures: autism, cp	28	2
48. Niño alfabeto	34	2	**122.** Jabtalk	28	2
49. Horsy	34	2	**123.** Conversation therapy lite	28	2
50. Gratis niños juego	34	2	**124.** Kids tap and color (lite)	28	2
51. ABC Autismo	33	2	**125.** Games for kids retro cars	27	2
52. Tempus	33	2	**126.** Articulation speech theraphy	27	2
53. Letmetalk	33	2	**127.** Upcard	27	2
54. Emoplay	33	2	**128.** Special app CAA	26	2
55. Tealite app	33	2	**129.** Petterday agenda pictogramas	25	2
56. Niño conectar los puntos	33	2	**130.** Puzzles de frutas para niños	25	2
57. Cabrito juego de ortogr.	33	2	**131.** Talk to me 100® Lite - Autism	25	2
58. Preescolar aprende num.	33	2	**132.** Kids timer	25	2
59. Dinosaurios rompec.	33	2	**133.** Focus	25	2
60. Autism help	33	2	**134.** Temporizador para niños	25	2
61. Letra a letra - deletrear	33	2	**135.** Comunicatea hus/surestea	24	2
62. Tarjetas educativas	33	2	**136.** AutApp - Autismo	24	2
63. Pictogramas.es	32	2	**137.** Говори молча: аутизм ДЦП	24	2
64. Daily tasks	32	2	**138.** Autistic bird	24	2
65. Autismo help	32	2	**139.** Autism sensory images	24	2
66. Autismo lee y escribe	32	2	**140.** Games for kids modern cars	23	2
67. Jade autism	32	2	**141.** Sensory	23	2
68. Puzzles para niños preesc.	32	2	**142.** Pensar e facer	22	3
69. Niño juego de memoria	32	2	**143.** Piktosaac pictogramas autismo	22	3
70. Games for kids sea	32	2	**144.** In2token (Autism Token B.)	20	3
71. Ajedrez niños infantil	32	2	**145.** Visual time timer	19	3
72. Preescolar juegos infant.	32	2	**146.** Speak through Pictures-Autism	19	3
73. Rompecabezas de niños	32	2	**147.** Autism mindawakener	16	3
74. El Oledor	32	2	**148.** Autism helper lite	16	3

TS = Total Score; G = Group

disorder, it was necessary to analyse what is really being offered to this group, since many professionals and families use devices of this kind on a daily basis and they depend upon the apps to foster the development of deficient skills (communication, emotions, time management, basic instrumental skills, executive functions and leisure/entertainment).

Table 8 Apps focused on leisure and entertainment

Name of the app	TS	G	Name of the app	TS	G
1. Otsimo	40	1	**42.** El Oledor	32	2
2. MITA	39	1	**43.** Social skills for autism 3 Kloogs	32	2
3. Smile and Learn	39	1	**44.** Baby piano games & music	32	2
4. LEA Lecto escritura	37	1	**45.** Aprender español para niños Cog.	32	2
5. Autastico	37	1	**46.** Buddy aprende los numeros	31	2
6. Juegos de niños bebes	37	1	**47.** Buddy aprende las formas	31	2
7. Terapia z tabletem	37	1	**48.** El viaje de Elisa	31	2
8. Emociones, sentimientos	37	1	**49.** Buddy aprende los colores	30	2
9. Proyecto emociones	36	2	**50.** Autism speech sequencing zapps	30	2
10. SocialSkills Autism 2	36	2	**51.** Kids puzzle car & vechicles	30	2
11. Preescolar juegos esp.	36	2	**52.** Vehicles puzzle for kids	30	2
12. Quien es quien	36	2	**53.** Action Words: 3D Animated	30	2
13. Speech Blubs: Lang.	36	2	**54.** MouseTrial Lite	30	2
14. SocialSkills for Autism	36	2	**55.** Conciencia fonologica	29	2
15. Isecuencias lite	35	2	**56.** Autismo imagen discusión	29	2
16. Rompecabezas puzz.	35	2	**57.** Autsim exit vn	29	2
17. Niños de dibujo anim.	35	2	**58.** Rompecabezas niños-habilidades	29	2
18. Animals puzzle	35	2	**59.** Preschool bus driver toddler g.	29	2
19. Fotos de animales	35	2	**60.** Relax melodies: sueño y yoga	29	2
20. Vechicles puzzle	35	2	**61.** Aprendizaje sensorial de niños	28	2
21. ABA DrOmnibus par.	35	2	**62.** Sonidos animales para niños	28	2
22. Rompecabezas de din	34	2	**63.** Piano para bebés: juego	28	2
23. Alfabeto escrito ABC	34	2	**64.** Dibujos de arena - sand draw	28	2
24. Animal rompecabezas	34	2	**65.** Aprender cabrito fruta	28	2
25. Horsy	34	2	**66.** Games for kids wild animals	28	2
26. Gratis niños juego	34	2	**67.** Puzzles de animales para niños	28	2
27. Tealite app	33	2	**68.** Sensory baby: games for babies	28	2
28. Niño conectar los puntos	33	2	**69.** Kids tap and color (lite)	28	2
29. Cabrito juego de ortogr.	33	2	**70.** Games for kids retro cars puzzles	27	2
30. Preescolar aprende num.	33	2	**71.** The sensory processing game	26	2
31. Dinosaurios romp.	33	2	**72.** Puzzles de frutas para niños	25	2
32. Autism help	33	2	**73.** Focus	25	2
33. Tarjetas educativas	33	2	**74.** AutApp - Autismo	24	2
34. Nursery rhymes songs	33	2	**75.** Autistic bird	24	2
35. Pictogramas.es	32	2	**76.** Autism sensory images	24	2
36. Puzzles para niños romp.	32	2	**77.** Games for kids modern cars	23	2
37. Niño juego de memoria	32	2	**78.** Sensory	23	2
38. Games for kids sea	32	2	**79.** Fidget Stress buster	23	2
39. Ajedrez niños infantil	32	2	**80.** Pensar e facer	22	3
40. Preescolar juegos infant.	32	2	**81.** _good_Fidget_Spinner_5891977	21	3
41. Rompecabezas de niñ.	32	2	**82.** Autism mindawakener	16	3

TS= Total Score; G= Group

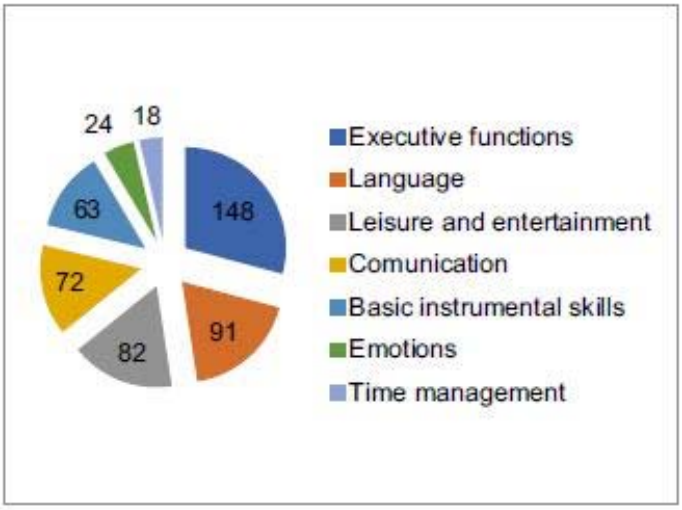

Fig. 1 Frequency of apps that present each of the areas worked on

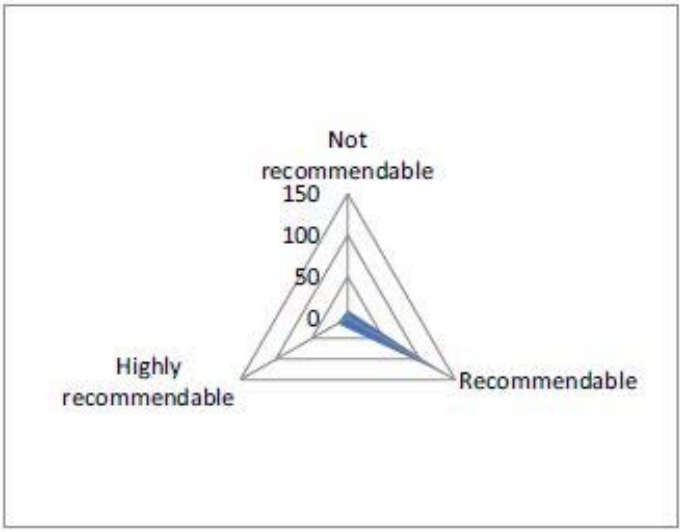

Fig. 2 Rating of the apps overall, assessed for autism

The evaluation of apps for children and adolescents with autism requires in-depth analysis that examines content, design and pedagogical aspects, scrutinizing each app's peculiarities, which should be in keeping with the user's needs.

These days, accessing apps is relatively simple, but selecting which best fit the user's characteristics and needs is not, particularly for families. As Xanthopoulou et al. (2019) and Hanna et al. (2021) point out, no guidance exists for the selection and use of apps. This study will therefore facilitate this selection, since despite specifying a great variety of apps, it clearly shows which areas each one addresses and their overall quality, helping to make searching simpler and more intuitive, and increasing the possibility of finding the required content quickly.

In general terms, the results obtained with this evaluation are encouraging, given the heterogeneity of the apps and the variety of different designs observed. Few apps have obtained an assessment of "*not recommendable*", since most apps were found in the "*recommendable*" group, with an average quality – as Hanna et al. (2021) also found in their study – but with potential for improvement in terms of quality, design, pedagogic aspects and content aimed at children and adolescents with autism. Furthermore, these results are in agreement with the findings of Dattolo and Luccio (2017) and Lian and Sunar (2021), which show that the design and content could be improved, as they were not wholly adapted to the needs and characteristics of people with ASD.

The study revealed the large variety of apps and the enormity of content they offer. Nonetheless, we can highlight several aspects. The apps that based their content on the development of executive functions were the most numerous, being present in 148 apps. This shows current knowledge on the need to promote this area from an early age and throughout the person with autism's development, which authors such as Guzmán et al. (2017) and Peirats et al. (2019) highlight in their studies. Of these 148 apps, only 8 have scientific evidence on the improvements produced in the area of the executive functions in users (Aguilar-Velázquez et al., 2020; Jiménez et al., 2017; Sung, 2018; Vyshedskiy et al., 2020): "*MITA*", "*CPA*" and "*LEA Lecto escritura para autismo*" from the "*highly recommendable*" group, and "*SocialSkills for Autism Kloog 2*", "*LetMeTalk*", "*Autism help*", "*Pictodroid lite*" and "*Niki Talk*" from the "*recommendable*" group. Studies such as that by Teixeira and Cunha (2019) also show progress in the increase in attention and behaviour through the use of the app "*123 Autismo*", which was not included in this study.

The apps linked to ToM were highly represented ($n = 101$), showing an average quality, whereas in the study by Crespo and Martín (2018) they were considered optimal for children with autism. Along the same lines, Adamu et al. (2019) show that the apps addressing communication had interfaces that were tied to the child's characteristics. Previous studies indicate progress in the prerequisites of language, communicative intent and behaviour through the use of the apps "*CPA*" and "*LEA Lecto escritura para autismo*" (both "*highly recommendable*"), and "*LetMeTalk*", "*Autism help*" "*Pictodroid Lite*" and "*Niki Talk*" (from the "*recommendable*" group) (Aguilar-Velázquez et al., 2020; Jiménez et al., 2017; Sung, 2018). Lázaro-Cantabrana et al. (2019) show improvements in the understanding of information, and capacity for expression and communication through the app "*SOS TEA*", which was not analysed in this study. However, the apps that focused on the development of emotions were not predominant in the app catalogue. They mostly fell into the "*recommendable*" group, and none were "*not recommendable*". The imbalance between these apps and the rest was striking. Despite this, the apps available did not obtain bad scores or evaluations. Indeed, authors such as Matey (2017) and González et al. (2016) highlight the encouraging results from the use of mobile apps linked to the emotional sphere.

Likewise, with time management, wherein most of the apps addressing it attained a *recommendable* rating. It seems curious that aspects connected to ToM (Premack & Woodruff, 1978), such as the emotions and time management, routine establishment and task organization, appear so infrequently compared to the rest of the app

catalogue. These areas should be fostered from an early age, given that they are necessary for social interaction itself. Although their number is few, it is encouraging that these apps obtained a good assessment, and can be used effectively and successfully by families, teachers and autism specialists.

The development of basic instrumental skills was included in 63 of the apps assessed, and this was one of the aspects utilized in previous studies, with benefits gained from their use. Examples of these include "*MITA*", rated as "*highly recommendable*" (Vyshedskiy et al. 2020); "*LEA Lecto escritura para autismo*", also "*highly recommendable*" (Aguilar-Velázquez et al., 2020); and "*SocialSkills for Autism Kloog 2*", assessed as "*recommendable*" (Sung, 2018). Other studies, such as those by Teixeira and Cunha (2019) with the app "*123 Autism*", Sweidan et al. (2019) with "*Autistic Innovate Assistant (AIA)*", and Lázaro-Cantabrana et al. (2019) with the app "*SOS TEA*" (not evaluated here), also show successful results in the development of the basic instrumental skills, with progress in mathematical, linguistic and communicative skills.

Regarding the apps for leisure and entertainment, we observe an increase in their presence in the digital app market, in contrast to the study by Crespo and Martín (2018), who report their limited presence and lack of representation, and call for research and development in this area. However, we have not found any scientific evidence on the use of apps for the enjoyment of leisure and free time in children with autism.

Most apps did not focus on one single area, as in the study by Crespo and Martín (2018), making them more functional and multifaceted, but, consequently, not specialized. The two apps with the highest ratings, "*#Soyvisual*" and "*Otsimo*", work, respectively, on four and five areas simultaneously, which means that with a single app different areas are addressed, with content, design and pedagogical approach of quality. Other apps, also high-scoring, included even more areas in their content, such as "*LEA Lecto escritura para autismo*" and "*Autastico*" (both rated as *highly recommendable*), and "*SocialSkills for Autism Kloog 2*" o "*Tealite app*" (both *recommendable*). The quality of the apps did not depend on the areas they worked on, and so we must not assume that all apps are equal; not all apps are valid and they should be chosen with care. The use made of the apps will depend on the aims set by teachers, specialists, and families, as well as on the activity, the content sought and the characteristics of the users.

As was to be expected, the apps that revolve around the area of communication and language revealed a direct relationship. These areas have a strong connection in human interaction, since even though communication encompasses a broad spectrum of expressions (eye contact, gestures, etc.), the presence of a functional language gives it value and meaning. These aspects can be observed in Jiménez et al. (2017): after using mobile devices for this purpose, the communicative processes and language production increased. As has been seen, many apps worked on both topics jointly, and different forms of task and content can be found, depending on the developmental stage of the child or the context in which learning is managed and undertaken.

The purpose of any proper intervention should be aimed at the comprehensive development of the person with autism. Thus, as has been evident throughout the

study, the apps are set up as a constantly changing and updated resource, according to the needs and requirements of the educational system and the practices involved in psychopedagogical intervention. In turn, given the active participation of the family as essential actors in the raising and development of the child with autism, ICT resources such as apps are available to everyone who wishes to make use of them. Times have changed, and with them the way that families help and provide resources to their children. The content of apps not only aims to provide accessibility to people with functional diversity, but also include tutorials and instructions for family members, with intuitive and easy-to-manage designs. However, in the apps specifically for children with autism, these tools were only found in a minority (written tutorials: 24.5%, $n = 38$; audio tutorials: 9.03%, $n = 14$). This lack was also noted by Cayton et al. (2015) and Hanna et al. (2021), the latter stating that contents need to be presented to families in a clear way in order for the orientation and guided use with family members with ASD to be successful.

It was clear, from the analysis undertaken, that when an app is being designed for children with autism, the specialist teams (educators and programmers) need to work together from the beginning of the process to agree on the specific requirements of this group and the options an app can offer, and, when possible, to seek input from the children and teenagers with autism themselves (Fletcher-Watson et al., 2016), or at least with their carers, to ensure that the content is appropriate. As we have seen, there was little relation between the "design/form" dimension and the "content" and "pedagogical aspects" dimensions. This lack of relation could cause dissatisfaction for everyone involved, but particularly among users. In order to overcome difficulties and obstacles, consideration should be given to the Web Content Accessibility Guidelines (WCAG) proposed by the World Wide Web, known as W3C (Lawton, 2005). Close collaboration between teams is also essential to produce better app functionality. Previous studies, such as Sofian et al. (2016, 2018), Sanromà-Giménez et al. (2021) and Gallardo-Montes et al. (2021b), argue precisely for the attention that should be given to the criteria linked to an app's appearance, its usability, accessibility and its pedagogical aspects. The criteria considered in the three dimensions mentioned above could serve not only for their analysis but also as basic guidelines for app creation. Web tools could even be created for prior, online evaluation to see whether an app meets the preestablished dimensions and criteria. This type of tool already exists for other dimensions, such as for assessing website accessibility for people with visual impairment and other specific characteristics, as provided by the Siteimprove Accessibility Checker. Ultimately, the aim is to lessen the barriers to learning and participation faced by some people with functional diversity.

As well as the suitable creation of apps, in terms of their specific use, we recommend that guidance on how to select and use apps be included in both initial and lifelong training in pedagogical-didactic and digital competences, in accordance with criteria such as the above, for teachers, educators and other professionals who work with children with autism. Neither should it be forgotten that close collaboration between schools and families is not only an advantage but a necessity (Xanthopoulou et al., 2019). Establishing user profiles and also profiles for carers or supervisors (teacher, educator, family members, etc.) could foster a more personalized use that is tailored to the needs of the child with autism. We also advise families and

professionals to monitor the apps before offering them to children (Xanthopoulou et al., 2019). And, of course, it is very important that consideration be given when selecting apps for use with children and adolescents with autism to those that are based on scientific principles and/or supported by empirical research (Allen et al., 2016). This is still a hard task, as most apps have not yet been backed by scientific evidence on their validity and efficacy (Crespo & Martín, 2018). It is therefore crucial for there to be collaboration between researchers and teaching and/or multiprofessional teams that use the apps in their work with children with autism. This will facilitate the study and dissemination of their experience and findings, with an emphasis not only on the benefits obtained but also on the difficulties encountered and the potential options to overcome them.

A possible limitation of this study is that there are still few studies on the evaluation of apps for children with autism. Furthermore, in some of the previous studies, they evaluate apps other than those analysed here – the criteria for evaluation are different or the studies are systematic reviews, which makes it difficult to compare results. Yet this also means that this study fills a gap in the research. Another limitation of the study concerns the exclusion of apps developed for other operating systems (iOS, Harmony, etc.), as well as apps that require purchase, since our assessment focuses exclusively on free apps for Android available on the Google Play Store.

In terms of future research, it would be interesting to find out what use both professionals who work with children with ASD and families are actually making of apps. This will make it possible to know whether the best apps are really the most used, if they meet users' needs and the stipulated aims, as well as whether they prove to be intuitive to use (as one would hope), or whether, in contrast, they prove difficult. It would also be worthwhile to assess to what degree an app proves recommendable if it is analysed from the perspective of the quality of the area it addresses.

This study aims to be a novel tool to guide specialists, teachers and families in choosing the best apps for children with autism, according to the content to address and the characteristics of the user. It also sets out to indicate what aspects need improvement in app design, which programmers could bear in mind to enhance accessibility and functionality. Together, this would help apps to become an optimal resource for children with autism.

Availability of data and material There are no data sets or other materials to supply.

Authors' contributions Conceptualization: Carmen del Pilar Gallardo Montes, María Jesús Caurcel Cara, Antonio Rodríguez Fuentes; Data curation: Carmen del Pilar Gallardo Montes, María Jesús Caurcel Cara, Antonio Rodríguez Fuentes; Formal Analysis: Carmen del Pilar Gallardo Montes, María Jesús Caurcel Cara, Antonio Rodríguez Fuentes; Funding acquisition: Carmen del Pilar Gallardo Montes; Investigation: Carmen del Pilar Gallardo Montes, María Jesús Caurcel Cara, Antonio Rodríguez Fuentes; Methodology: Carmen del Pilar Gallardo Montes, María Jesús Caurcel Cara, Antonio Rodríguez Fuentes; Project administration: Carmen del Pilar Gallardo Montes, María Jesús Caurcel Cara, Antonio Rodríguez Fuentes; Resources: Carmen del Pilar Gallardo Montes, María Jesús Caurcel Cara, Antonio Rodríguez Fuentes; Software: Carmen del Pilar Gallardo Montes, María Jesús Caurcel Cara, Antonio Rodríguez Fuentes; Supervision: María Jesús Caurcel Cara, Antonio Rodríguez Fuentes; Validation: Carmen del Pilar Gallardo Montes, María Jesús Caurcel Cara, Antonio Rodríguez Fuentes; Visualization: Carmen del Pilar Gallardo

Montes, María Jesús Caurcel Cara, Antonio Rodríguez Fuentes; Writing – original draft: Carmen del Pilar Gallardo Montes, María Jesús Caurcel Cara, Antonio Rodríguez Fuentes; Writing – review & editing: Carmen del Pilar Gallardo Montes, María Jesús Caurcel Cara, Antonio Rodríguez Fuentes.

Funding This work was supported by the University of Granada and the Spanish Ministry of Education, Innovation and Universities (aid for university teacher training [FPU19/00026]). Funding for open access charge: University of Granada / CBUA.

Code availability Not applicable.

Declarations

Ethics approval Not aplicable.

Consent to participate Not aplicable.

Consent for publication The authors consent to the publication of the results described in the article.

Competing interests The authors have no relevant financial or non-financial interests to disclose.

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Artículo 4. Psychometric properties of the "Demands and potentials of ICT and apps for assisting people with autism" (DPTIC-AUT-Q)

education sciences

MDPI

Article

Psychometric Properties of the Questionnaire "Demands and Potentials of ICT and Apps for Assisting People with Autism" (DPTIC-AUT-Q)

Antonio Rodríguez Fuentes [1], María Jesús Caurcel Cara [2], Carmen del Pilar Gallardo-Montes [1,*] and Emilio Crisol Moya [1]

[1] Department of Didactics and School Organization, University of Granada, 18071 Granada, Spain; arfuente@ugr.es (A.R.F.); ecrisol@ugr.es (E.C.M.)
[2] Department of Developmental and Educational Psychology, Faculty of Education, University of Granada, 18071 Granada, Spain; caurcel@ugr.es
* Correspondence: cgallardo@ugr.es; Tel.: +34-958243741

Abstract: Background: In education, Information and Communication Technology (ICT) has gone from being a convenient option to a permanent necessity. For students and people with functional diversity, it is of seminal importance. It is therefore worth learning how professionals perceive digital tools and apps for people and students with functional diversity and autism: its requirements and potential. As no instrument to measure this exists, we have designed a questionnaire on the requirements and potentials of ICT and apps for assisting people with autism (DP-TIC-AUT). Methods: Our questionnaire has been subjected to content validity using a panel of experts, and construct validity, using Exploratory Factor Analysis and Confirmatory Factor Analysis, and Cronbach's alpha and Composite Reliability. Results: Optimal results were obtained in the above values, thus confirming the validity of DP-TIC-AUT for use in the contexts of its validation. Conclusions: DP-TIC-AUT is a valid instrument. This opens up a range of possibilities for research, firstly descriptive, then of other kinds, and for the adaptation of the instrument to other contexts. This is the first step in improving the creation and use of ICT for people with autism.

Keywords: psychometric properties; validation; functional diversity; autism; ICT; apps

Citation: Rodríguez Fuentes, A.; Caurcel Cara, M.J.; Gallardo-Montes, C.d.P.; Crisol Moya, E. Psychometric Properties of the Questionnaire "Demands and Potentials of ICT and Apps for Assisting People with Autism" (DPTIC-AUT-Q). *Educ. Sci.* **2021**, *11*, 586. https://doi.org/10.3390/educsci11100586

Received: 18 August 2021
Accepted: 20 September 2021
Published: 27 September 2021

1. Introduction

We live and coexist in a society that is based on technology and depends on the benefits it offers. It has been called a knowledge society [1,2] or an information society [3]. It is based on information about and the communication of social, economic and cultural relations [4]. The momentum of information and communication technology (ICT) has brought about changes in the way we organize and manage life in the community and how we deal with tasks of daily living.

The use of technological media as a bridge to enhance learning and integrated development in formal and non-formal education, and in healthcare, has grown in importance over the years. It is evident how technology has progressed and connected with all types of social groups, creating environments that promote the learning and social inclusion of people with special needs. Thus, designing environments of learning and development that are accessible to everyone is and will be the main objective of the knowledge society. In the field of education, it is known as Universal Design for Learning.

One result is the advance in educational technology and teaching methodologies based on digital tools, which have changed teaching–learning processes from more traditional to more innovative approaches.

These new approaches give the student a leading role along with the teacher, requiring the latter to have greater digital knowledge and to know how to adapt their methodology

depending on the new demands of society. Given that the new technologies are everywhere in our environment, teachers and students need to be involved in their responsible and educational use, because they improve the quality of education [5] enabling better learning and greater interaction [6]. This is also a response to the new ideas of neuroeducation derived from neurolearning. In short, this is how the students of today learn; hence, this is how they should be taught.

Conceptual Framework

The training of teachers in technology has been the subject of debate on innumerable occasions and in many contexts, since education-related university degrees have subjects involving ICT. Despite the fact that the law on education in Spain emphasises the need for teachers to be digitally competent [7], the reality is less than satisfactory [8,9], and even less so for students with functional diversity [10]. The near lack of any general ICT subject in teacher training is clearly insufficient for an aspect that has revolutionized teaching and the universal design for learning.

Diversity and Inclusion Technology (DIT) (known as "Tecnologías de Apoyo a la Diversidad" (TAD) in Spanish [11]) has emerged to promote access to information and technology for people with functional diversity, among others. As ICT provides benefits to functionally diverse students, so the coming of DIT gives them even more support, enabling their interaction, social participation [12], inclusion [13], and an independent life [14]. This technology has a design and format adapted to the needs or potential of the user, fomenting the development of cognitive skills, communication and language [14], among other aspects. In other words, it overcomes the Barriers to Learning and Participation (BLP) and comprises a proactive measure for attending to diversity known as the Universal Design for Learning (UDL).

More specifically, for people with autism, this technology can create a bridge to enhance communicative development and interaction with the environment. Wing [15] defines it as a set of symptoms associated with three dimensions (autistic triad): impairments and delay in language and communication, both verbal and non-verbal; impairments in the social sphere, more specifically in interpersonal reciprocity; and impairments in behaviour and thinking. Adding to this, APA [16] includes restrictive patterns regarding the diversity of behaviours, activities and interests.

Similarly, many studies—national and international—have shown scientific evidence on the benefits of ICT and apps in psychopedagogical therapy for people with autism, providing encouraging results following their use. Flores et al. [17] worked on new forms of augmentative and alternative communication with children with ASD, comparing use of the iPad with use of pictograms in physical format. The results show that communicative behaviours increase after use of the iPad. Desai et al. [18] increased the alternative communication skills of a student with autism and another with cerebral palsy through using the iPad. Mercado et al. [19], through the videogame "BCI" that addressed neurofeedback therapies, managed to improve attention, attentional control and sustained attention in children with severe autism. Wedyan et al. [20], following the use of an augmented reality device for children with autism focused on the development of facial expressions, show improvement in social interactions, speech and facial expressions. Jiménez-Lozano et al. [21], using communication apps, discerned improvements in the prerequisites of language, communicative intent and behaviour. Fage et al. [22], through apps based on cognitive and care rehabilitation, show improvements in socio-adaptive behaviours and social response in the school environment. Teixeira and Cunha [23], using mathematics apps, produced positive results in the learning of mathematical skills, increasing attention, concentration, behaviour and motivation. Sweidan et al. [24] state that progress was obtained in basic linguistic, mathematical and social concepts through the use of apps for the learning of concepts of language, mathematics and social skills. Lázaro-Cantabrana et al. [25], meanwhile, confirmed improvements using an app for people with autism in the understanding of information and the capacity of expression and communication.

As well as the support that the different technological options offer for people with autism, they also provide an innovative and encouraging option for them [26–28], given that they are easily manipulated and combine the visual with the auditory format [28,29]. Thus they are adapted to their needs, with many advantages to using them. Parsons et al. [30] and Terrazas et al. [31] agree that they help to develop and promote social skills. Yet, not only do they develop aspects connected to the social and emotional sphere, but they also heighten motivation toward these types of tasks [26]. Guzmán et al. [32] state that "the use of technologies to improve and stimulate the communication of children with ASD, in particular, has exponentially increased in recent times" (p. 248), and it opens up a world of possibilities for developing other impaired skills, such as attention, anticipation, working memory, sequences of actions, organization of events, and so forth.

Recent studies have examined the use of technology in the area of non-formal education [33–36], while in formal education, studies have been carried out in ordinary classrooms [37–39] and in classrooms with students with functional diversity [40–43], revealing its possibilities and functionalities.

Taking the potential of technology in the field of education as a given, having teachers trained in different digital tools and in their use in the classroom with functionally diverse students is essential for the creation of accessible and synchronous environments with up-to-date learning based on ICT. Assessment of the digital training and competence of professionals who teach people with functional diversity has focused on teachers in training and in practice, and in formal education contexts. Various instruments of assessment have been designed and validated for this (Table 1). However, despite the need for there to be professionals with training and experience in ICT for their use with people with functional diversity, the reality is not as encouraging as one would expect. Even though they value ICT positively and see it as a powerful resource in the classroom, teachers do not use these technologies and/or have difficulty using them [44]. Authors such as Cabero-Almenara et al. [45] and Fernández-Batanero et al. [10] have found that there is limited training in technologies applied in the care of diversity for future teachers, and a lack of awareness of their benefits and functionalities. Randazzo and Oteri [46] found positive attitudes toward ICT among university teachers, but they neither use them nor have skill in doing so. This situation could be due to the training they received in higher education, which lacked teaching on how to make good use of virtual environments [12,47,48].

As we can see in Table 1, we have not been able to find studies or tools on assessment for professionals who look after people with functional diversity, and who also work in formal, non-formal and/or public health education contexts. Neither are there assessment instruments on the training in and use of ICT by the various professionals who work with people with autism. Nor, more specifically, are there any studies on the use of apps, despite their huge growth in the education, therapy and psychopedagogic intervention for people with autism [40,49–53]. It was therefore necessary to create an instrument that evaluates the opinion and training received on ICT and apps by the different professionals who work with people with functional diversity, in general, and with people with autism in particular, as well as their requirements and possible uses for better care.

The purpose of this study is the analysis of the psychometric properties of this instrument, the "Demands and Potentials of ICT and apps for attending to people with autism" questionnaire (DPTIC-AUT-Q). The objectives are: (a) to study the content validity through the agreement and consensus of a panel of experts; (b) to assess the stability of the questionnaire by measuring the agreement using the Intraclass Correlation Coefficient and the Kendall coefficient; (c) to corroborate the validity of the comprehension of the instrument through its application to a pilot sample; (d) to determine the multidimensionality of the construct through exploratory factor analysis; (e) to confirm the multidimensionality of the construct through confirmatory factor analysis; and (f) to analyse the reliability of the questionnaire.

Table 1. Previous studies on the use and perceptions of ICT by teachers.

Work	Participants	Evaluation Instrument	Main Objective
Al-Attiyah et al. [54]	Preschool and primary education teachers	Questionnaire regarding the use and opinion of assistive technologies	To research the perceptions on the use of assistive technologies in the teaching of children with special needs in early intervention programmes.
Alshurman et al. [55]	Special education school teachers	Questionnaire focused on communicative, academic, sensory, kinetic, social, self-care, daily life, organization and computer skills	To determine the role of assistive technology in the success of the Individual Education Program for disabled students in Jordan
Arouri et al. [56]	Preschool teachers	Questionnaire for measuring the degree of use of assistive technology, its use in classrooms and their preferences	To discover the opinions on the use of assistive technology for children with functional diversity
Blossom Cygnet et al. [57]	Special education teachers	Questionnaire addressing the knowledge of the skills for handling technological assistance and professional development	To examine the knowledge, skills and professional development for handling assistive technology in the field of special education
Cabero-Almenara et al. [45]	Teacher training students	Questionnaire "Conocimiento tecnológico de los alumnos del grado de Maestro sobre la utilización de las Tecnologías de la Información y Comunicación (TIC) para personas con necesidades educativas especiales (COTETICNE)" ("Technological knowledge of teaching degree students on the use of ICT for people with special educational needs")	To determine the knowledge held on the ICT applied to people with functional diversity
Chukwuemeka & Samaila [58]	Special education school teachers	Questionnaire on the frequency of use of ICT, perceptions about their use and the factors involved	To explore the perception and factors that limit the use of high-tech assistance technology resources in special education schools
Eden et al. [59]	Primary education teachers	Questionnaire linked to the general use of technology and experience, digital competence and attitudes toward iPads	To compare the attitudes, motivation and use of iPads by teachers to help teach children with learning difficulties and children with autism spectrum disorder
Emmers et al. [60]	Special education teachers	Sentiments, Attitudes, Concerns regarding Inclusive Education-Revised (SACIE-R) scales, self-efficacy for Inclusive Practice (TEIP) scale and self-constructed questionnaire	Discover the relationship between attitudes, self-efficacy and behaviour for inclusive education

Table 1. *Cont.*

Work	Participants	Evaluation Instrument	Main Objective
Fernández-Batanero y Bermejo [8]	Teachers	Questionnaire regarding the professional development of teachers and the ease and availability of ICT; discussion group	To discover the attitudes toward ICT and the factors involved in good educational practices with technological support
Fernández-Batanero et al. [10]	Primary education teachers	Questionnaire "Diagnóstico y formación del profesorado para la incorporación de las TIC en alumnado con diversidad funcional—DIFOTICyD" (Diagnosis and training of teachers for the incorporation of ICT for students with functional diversity")	To identify the technological training and knowledge concerning accessibility and ICT applied to people with visual, auditory, cognitive and/or motor impairments
Ortiz-Colón et al. [61]	Teacher training students and teachers	Questionnaire focused on ICT in the organization of educational content, the use of ICT in content design, and teacher training in ICT; interview; discussion group	To analyse the opinions and perceptions about training in ICT and the factors involved in its use
Ortiz-Jiménez et al. [62]	Education professionals	Questionnaire relating to didactic aspects, spaces and resources and teacher training in ICT; discussion group	To discover the perceptions concerning ICT for their use with students with functional diversity
Pegalajar [63]	Future teachers	Questionnaire regarding the didactic implications of ICT for inclusive education, the professional development of teachers in ICT, the attitude of teachers toward inclusion through ICT, and inclusive student practice through ICT	To discover the perceptions concerning ICT for the development of inclusive practices

2. Materials and Methods

2.1. Participants

A total of 328 professionals from areas of formal, non-formal and public health education participated in the pilot study. The criterion for inclusion was to have experience in working with people with functional diversity, in general, and with autism specifically. Consequently, the sample consisted of 122 participants, within the sample size of 100 or more sample units recommended by Hair et al. [64]. The age range was between 20 and 64 years old (M age = 37.88 years, SD = 10.21), of whom 18 were men (14.8%) and 104 were women (85.2%). Table 2 presents the sociodemographic data of the sample. All the participants had access to the internet and ICT at their place of work, mainly the computer (93.4%, n = 114), tablet (69.7%, n = 85) and projector (59.0%, n = 72).

The study used non-probability convenience sampling. To calculate the sample size, we used the formula for unknown populations—as it is difficult to compute the number of professionals that work with people with autism—and a confidence level of 95%, accepting a margin of error of 5.4% (N = 328) for the initial sample and 8.9% for the final sample (n = 122).

Table 2. Sociodemographic data of the 122 participants.

Variables		N (%)
Place of work	State school	78 (63.9)
	Charter school	17 (13.9)
	Association	13 (10.7)
	Special school	11 (9.0)
	Private clinic	9 (7.4)
	Private school	4 (3.3)
Position	Special education teacher	45 (36.9)
	Non-specialist teacher	26 (21.3)
	Speech therapist	14 (11.5)
	Hearing and language teacher	11 (9)
	Specialist teacher	8 (6.6)
	Integration Support Special Needs Teacher	6 (4.9)
	Specialized Special Needs Support Teacher	6 (4.9)
	Special education supervisor	5 (4.1)
	Therapeutic companion	4 (3.3)
	Occupational Therapist	4 (3.3)
	Pedagogue/Educationalist	1 (0.8)
	Psychopedagogue	1 (0.8)
Experience in functional diversity	≤5 years	56 (45.9)
	6–10 years	22 (18.0)
	11–20 years	27 (22.1)
	≥21 years	17 (13.9)
Experience with ASD	≤5 years	83 (68.0)
	6–10 years	21 (17.2)
	11–20 years	12 (9.8)
	≥21 years	6 (4.9)
Ages worked with	0–6 years	72 (59.0)
	7–12 years	100 (82.0)
	13–17 years	33 (27.0)
	18–65 years	10 (8.2)
	≥66 years	4 (3.3)

2.2. Evaluation Instruments

The "Demands and Potentials of ICT and apps for attending to people with autism" questionnaire (DPTIC-AUT-Q) uses a Likert scale, with five response options (1 = Strongly Disagree; 2 = Disagree; 3 = Neither agree nor disagree; 4 = Agree; 5 = Strongly Agree). It

measures the agreement of professionals who work with people with functional diversity in general and with autism in particular on the requirements and possibilities of ICT and apps for improving assistance, and also on their digital training and use. The initial instrument was designed with 125 items organized into four subscales:

1. "Opinion, training and use of ICT by the professional to assist people with functional diversity", based on previous studies by Cabero-Almenara et al. [45], Fernández-Batanero et al. [8], Ortiz-Colón et al. [61] and Pegalajar [63], on attending to diversity and technology in the sphere of formal education. It consists of 26 items in three dimensions:
   a. Dimension I on the opinions of the professional on ICT (items I1 to I12);
   b. Dimension II regarding the professional's ICT training for working with people with functional diversity (items II13 to II20);
   c. Dimension III on the benefits that ICT provides for people with functional diversity (items III21 to III26).
2. "Training in and use of ICT by the professional to assist people with autism", comprising 40 items structured in three dimensions:
   a. Dimension IV regarding the professional's ICT training for working with people with autism (items IV1 to IV9);
   b. Dimension V on the purposes the professional uses ICT for in their work with people with autism (items V10 to V25);
   c. Dimension VI on the benefits provided by ICT for people with autism (items VI26 to VI40).
3. "Uses and benefits of apps in working with people with autism", comprising 24 items and two dimensions:
   a. Dimension VII regarding the purposes the professional uses apps for in assisting people with autism (items VII1 to VII15);
   b. Dimension VIII on the benefits that apps provide for people with autism (items VIII16 to VIII24).
4. "Uses and possibilities of specific apps for people with autism", consisting of 35 items in two dimensions:
   a. Dimension IX on the possibilities offered by specific apps for people with autism (items IX1 to IX21);
   b. Dimension X on the use the professional makes of specific apps for people with autism (items X22 to X35).

2.3. *Procedure*

The study was approved by the Human Research Ethics Committee [2002/CEIH/2021] of the University of Granada (Spain).

We contacted schools and associations that assist people with autism, during the first four months of 2021, asking for their collaboration and describing the aims of the study. The link to the questionnaire, designed using the LimeSurvey platform, was sent by email, along with the prior conditions of its voluntary nature, anonymity, and use. The access link was provided with a single-use numerical password. The information was gathered over a period of one month.

2.4. *Design and Data Analysis*

We conducted a cross-sectional study of instrument content and construct validity. It consisted of developing tests and devices, including both the design or adaptation and the analysis of their psychometric properties [65].

As a method to test the validity of the content, we used a panel of experts. To analyse the metric properties of each item, basic descriptive coefficients (mean, dispersion, kurtosis and skewness) were employed, with SPSS version 26.0. Kolmogorov–Smirnov and

Levene's tests were performed to confirm normality and homoskedasticity of the sample. The validity of the construction was carried out through exploratory factor analysis (EFA) with Factor Analysis version 10.10.01 [66], to determine the goodness of the fit and the validity of the scale [67–70], and confirmatory factor analysis (CFA) with M-PLUS, to establish the validity and reliability of the fit of the model [71,72]. The internal consistency of the instrument was calculated using Cronbach's alpha coefficient with SPSS version 26.0, and the Composite Reliability (CR).

3. Results

3.1. Content Validation

In order to validate the content, expert judgement was used—this being a validation method useful for verifying the reliability of a survey [73].

For the panel of experts, the sample selected followed criteria based on experience, scientific evidence, availability, reputation and motivation [74]. There were eight experts with professional experience and a career in the area of diversity outreach and the inclusion of students with functional diversity. Of these eight experts, four were men and four women, aged between 27 and 64 years old (M = 41.75; SD = 11.78), with a professional experience of between 2 and 42 years (M = 14.13; SD = 13.52), with initial qualification in Pedagogy (n = 4), Psychology (n = 2), Humanities (n = 1) and Psychopedagogy (n = 1). Of all the experts, five were university professors and three guidance counsellors in Educational Guidance Teams.

The approach taken with the panel of experts was mixed. For the quantitative assessment, the experts had to validate the items based on the following criteria: clarity, coherence, relevance and objectivity with the object of study, on a scale of 1 (lowest value) to 4 (highest value). For the qualitative evaluation, the experts used a section for observations where they could make suggestions for improvement and make extensive comments, as well as propose the elimination of items.

The content validity, and the degree of agreement between the experts, was verified through the measurement of the agreement percentage. The Intraclass Correlation Coefficient (ICC) and the Kendall coefficient were tested for each of the subscales described above. The values obtained for the ICC for each subscale were: Subscale 1 = 0.986; Subscale 2 = 0.994; Subscale 3 = 0.994 and Subscale 4 = 0.995, thus determining an excellent inter-rater reliability (>0.750) [75].

With respect to the Kendall coefficient (W), the values were significant, albeit low in all subscales: Subscale 1: 0.153 (clarity); 0.150 (coherence); 0.200 (relevance); 0.211 (objectivity); Subscale 2: 0.125 (clarity); 0.160 (coherence); 0.186 (relevance); 0.132 (objectivity); Subscale 3: 0.138 (clarity); 0.132 (coherence); 0.155 (relevance); 0.123 (objectivity); Subscale 4: 0.127 (clarity); 0.123 (coherence); 0.109 (relevance); 0.160 (objectivity).

After the panel of experts and the statistical results, none of the proposed items was eliminated.

3.2. Construct Validity

Before starting the EFA, the descriptive values of the study were calculated (Tables 3–6), following the steps recommended by experts [76], and values greater than −2.5 and +2.5 [77] in the dispersion tests (skewness and kurtosis) were eliminated. Four items were removed from Subscale 1 (I.4, I.5, III.22 y III.25), and one from Subscale 3 (VIII.22). Following the removal of these five items, the remaining items were renumbered.

Table 3. Description of the items of Subscale 1.

Variables	Mean	Standard Deviation	Variance	Skewness	Kurtosis
I.1	4.37	0.71	0.499	−0.809	−0.025
I.2	3.69	0.97	0.944	−0.492	0.003
I.3	4.18	0.81	0.661	−1.000	1.340
I.4	4.42	0.73	0.526	−1.492	3.566
I.5	4.45	0.76	0.580	−1.542	2.978
I.6	4.18	0.80	0.645	−0.924	1.178
I.7	4.45	0.72	0.514	−1.329	1.763
I.8	4.43	0.73	0.528	−1.120	0.777
I.9	4.43	0.72	0.511	−0.978	0.152
I.10	4.32	0.77	0.599	−0.734	−0.584
I.11	3.85	0.86	0.738	−0.186	−0.782
I.12	4.11	0.86	0.741	−0.604	−0.473
II.13	4.02	0.70	0.487	−0.182	−0.457
II.14	3.90	0.73	0.536	−0.231	−0.231
II.15	3.99	0.71	0.504	−0.270	−0.184
II.16	4.20	0.70	0.490	−0.439	−0.320
II.17	3.30	1.10	1.201	−0.305	−0.383
II.18	3.69	0.83	0.696	−0.488	−0.205
II.19	4.09	0.78	0.612	−0.792	0.630
II.20	4.08	0.80	0.638	−0.743	0.887
III.21	4.16	0.76	0.579	−0.843	1.441
III.22	4.53	0.72	0.515	−2.024	1.649
III.23	4.38	0.76	0.584	−1.440	2.950
III.24	4.48	0.66	0.433	−0.880	−0.323
III.25	4.49	0.72	0.516	−1.737	4.383
III.26	4.28	0.80	0.632	−1.046	1.341

Table 4. Description of the items of Subscale 2.

Variables	Mean	Standard Deviation	Variance	Skewness	Kurtosis
IV.1	3.57	0.99	0.990	−0.284	−0.539
IV.2	3.83	0.96	0.921	−0.788	0.512
IV.3	4	0.80	0.645	−0.292	−0.693
IV.4	3.75	0.71	0.505	−0.150	−0.139
IV.5	3.83	0.78	0.606	−0.436	0.017
IV.6	3.79	0.75	0.566	−0.574	1.003
IV.7	3.98	0.82	0.677	−0.512	−0.206
IV.8	4.07	0.75	0.558	−0.470	−0.049
IV.9	3.87	0.76	0.578	−0.464	0.152
V.10	4.35	0.69	0.478	−0.598	−0.752
V.11	4.43	0.70	0.495	−0.965	0.223
V.12	4.26	0.74	0.542	−0.586	−0.490
V.13	4.28	0.79	0.616	−0.955	0.537
V.14	4.25	0.82	0.670	−1.054	1.233
V.15	4.14	0.87	0.749	−1.053	1.501
V.16	4.22	0.91	0.835	−1.249	1.526
V.17	3.92	0.92	0.853	−0.604	−0.098
V.18	3.89	1	1.005	−0.784	0.248
V.19	3.64	1.12	1.257	−0.570	−0.344
V.20	3.75	1.05	1.096	−0.720	0.182
V.21	3.62	1.13	1.278	−0.643	−0.253
V.22	4.24	0.73	0.530	−0.923	1.910
V.23	3.84	0.99	0.981	−0.701	0.186
V.24	4.07	0.85	0.730	−0.708	0.340
V.25	4.10	0.86	0.734	−0.993	1.471

Table 4. *Cont.*

Variables	Mean	Standard Deviation	Variance	Skewness	Kurtosis
VI.26	3.98	0.90	0.801	−0.584	−0.372
VI.27	3.90	0.93	0.866	−0.614	−0.105
VI.28	3.91	0.96	0.926	−0.723	0.166
VI.29	3.81	1.02	1.030	−0.576	−0.129
VI.30	3.63	1.07	1.144	−0.575	−0.207
VI.31	4.25	0.79	0.617	−1.195	2.181
VI.32	3.91	0.96	0.926	−0.723	0.166
VI.33	4.02	0.87	0.760	−0.869	0.718
VI.34	3.93	0.94	0.888	−0.771	0.106
VI.35	3.80	1.03	1.052	−0.763	0.230
VI.36	4.16	0.80	0.651	−0.981	1.384
VI.37	4.18	0.88	0.777	−1.099	1.068
VI.38	3.80	1.07	1.135	−0.640	−0.313
VI.39	3.84	1.09	1.180	−1.123	0.811
VI.40	4.21	1	0.996	−1.558	2.479

Table 5. Description of the items of Subscale 3.

Variables	Mean	Standard Deviation	Variance	Skewness	Kurtosis
VII.1	4.04	0.79	0.623	−0.487	−0.215
VII.2	3.84	0.89	0.783	−0.345	−0.261
VII.3	3.90	0.90	0.807	−0.644	0.456
VII.4	3.89	0.96	0.913	−0.714	0.450
VII.5	3.73	1.04	1.083	−0.512	−0.345
VII.6	4.28	0.71	0.504	−0.750	0.382
VII.7	3.93	0.94	0.886	−0.886	0.868
VII.8	3.82	0.95	0.900	−0.936	1.053
VII.9	3.79	0.92	0.849	−0.811	0.802
VII.10	3.80	1.01	1.010	−0.842	0.675
VII.11	4.15	0.89	0.794	−0.873	0.376
VII.12	4.06	0.87	0.755	−0.733	0.341
VII.13	3.77	1.09	1.179	−0.677	−0.232
VII.14	3.88	1.03	1.053	−1.081	0.952
VII.15	4.12	1.02	1.043	−1.160	0.852
VIII.16	2.22	1.20	1.441	0.616	−0.687
VIII.17	4.40	0.85	0.725	−1.525	2.214
VIII.18	4.04	0.90	0.813	−0.712	0.105
VIII.19	4.25	0.86	0.738	−1.226	1.521
VIII.20	4.30	0.75	0.561	−0.913	0.578
VIII.21	4.54	0.68	0.467	−1.489	2.075
VIII.22	4.28	0.71	0.504	−1.034	2.505
VIII.23	3.47	1.08	1.168	−0.226	−0.675
VIII.24	4.26	0.78	0.613	−1.247	2.364

Table 6. Description of the items of Subscale 4.

Variables	Mean	Standard Deviation	Variance	Skewness	Kurtosis
IX.1	3.53	0.97	0.946	−0.168	−0.468
IX.2	3.71	0.93	0.870	−0.205	−0.818
IX.3	3.92	0.84	0.698	−0.300	−0.622
IX.4	3.34	0.95	0.903	0.121	−0.649
IX.5	3.58	0.91	0.822	−0.173	−0.405
IX.6	3.66	0.83	0.685	−0.282	−0.379

Table 6. *Cont.*

Variables	Mean	Standard Deviation	Variance	Skewness	Kurtosis
IX.7	3.70	0.75	0.569	−0.157	−0.246
IX.8	3.45	0.83	0.691	−0.121	−0.556
IX.9	3.88	0.79	0.630	−0.509	0.064
IX.10	3.51	0.76	0.574	0.254	−0.325
IX.11	3.70	0.75	0.569	−0.398	0.677
IX.12	3.75	0.74	0.546	−0.200	−0.162
IX.13	3.60	0.84	0.700	−0.268	0.428
IX.14	3.82	0.69	0.469	−0.083	−0.220
IX.15	3.71	0.78	0.613	−0.095	−0.422
IX.16	3.58	0.82	0.669	−0.214	0.061
IX.17	3.61	0.93	0.868	−0.408	0.161
IX.18	3.56	0.97	0.943	−0.661	0.406
IX.19	3.39	0.93	0.868	−0.231	−0.137
IX.20	3.45	0.97	0.945	−0.572	0.116
X.21	3.63	0.83	0.693	−0.110	−0.515
X.22	3.64	0.77	0.589	−0.307	0.455
X.23	3.74	0.71	0.499	−0.167	−0.098
X.24	3.82	0.70	0.491	−0.178	−0.092
X.25	3.87	0.81	0.660	−0.809	1.521
X.26	3.69	0.78	0.606	−0.379	0.484
X.27	3.63	0.81	0.659	−0.480	0.785
X.28	3.96	0.72	0.515	−0.357	0.073
X.29	3.71	0.76	0.582	−0.026	−0.425
X.30	3.70	0.72	0.518	−0.029	−0.287
X.31	3.55	0.86	0.741	−0.348	0.232
X.32	3.87	0.79	0.620	−0.303	−0.305
X.33	3.79	0.79	0.625	−0.548	0.137
X.34	3.58	0.85	0.720	−0.508	0.011
X.35	3.72	0.85	0.728	−0.681	0.768

For the EFA, the procedure for determining the number of dimensions was the method of parallel analysis (PA), to maximize factor simplicity, determining the factors as recommended for PA [78]. The method for factor extraction used was Robust Unweighted Least Squares (RULS), in order to attain better solutions in the ordinal data [79,80] with Promin rotation for Subscales 2, 3 and 4—since the factors were correlated between each other—and varimax for Subscale 1—as not all the factors were correlated or the correlations were very small. The Pearson correlation matrix was used on the basic assumption of normal distribution of the ordinal items. For Subscale 1, Bartlett's statistic (1299.0 (df = 231; p = 0.000010)) and the Kaiser–Meyer–Olkin test (KMO) (0.884, good) were used to check whether the sample came from populations with the same variance and whether it showed an appropriate fit for the sample. A good fit for the data to be subjected to factor analysis was found [81].

As can be seen in the matrix of rotated factors (Table 7), no item was eliminated since they all gave factorial weights with an absolute value higher than 0.30 [81–83]. Thus, after analysing and evaluating the weight of each variable according to the factor, the final version of Subscale 1 was as follows. The three factors obtained explained 60.38% of the total variance. Factor 1, denominated "Opinions", obtained an eigenvalue of 8.08 and explained 36.73% of the common variance. It included eleven items (V1, V4, V7–V11, V19, V20, V21 and V22), and analyses what the professionals think about ICT for working with people with functional diversity. Factor 2, called "Requirements and possibilities", obtained an eigenvalue of 3.08 and explained 14% of the common variance. It comprised four items (V2–V6), examining the demands and possibilities of ICT for its use in assisting people with functional diversity. Factor 3, denominated "ICT Training for Functional Diversity", obtained an eigenvalue of 2.13 and explained 9.65% of the common variance. It

had seven items (V12–V18), which evaluated the professionals' digital training for working with people functional diversity.

Table 7. Matrix of rotated factors Subscale 1.

Variables	Factor 1	Factor 2	Factor 3
V1.	0.510		
V4.	0.579		
V7.	0.830		
V8.	0.909		
V9.	0.915		
V10.	0.634		
V11.	0.737		
V19.	0.718		
V20.	0.783		
V21.	0.581		
V22.	0.812		
V2.		0.574	
V3.		0.698	
V5.		0.564	
V6.		0.416	
V12.			0.717
V13.			0.879
V14.			0.767
V15.			0.725
V16.			0.653
V17.			0.754
V18.			0.566

Regarding the goodness of fit indices of the model, the chi-square was 48.463, which was not significant ($p = 0.999990$), as per Bentler and Bonett [84]. The goodness of fit index (GFI) was 0.987, the adjusted goodness of fit index (AGFI) gave a value of 0.987, and the comparative fit index (CFI) was 0.999. These values are within the intervals recommended by Tanaka and Huba [68]. The root mean square of residuals (RMSR) was 0.001, indicating a good fit [69,85,86]. All these data show an excellent fit for these items and an acceptable model.

Two of the three factors were correlated: Factor 1–2 r = 0.209, $p < 0.05$ (BC Confidence Interval = 0.037–0.388) and Factor 1–3 r = 0.438, $p < 0.05$ (BC Confidence Interval = 0.285–0.628); whereas Factor 2–3 were not correlated, $r = 0.037$, $p > 0.05$ (BC Confidence Interval = −0.140–0.253).

In the case of Subscale 2, the Bartlett statistic (1230.0 ($df = 780$; $p = 0.000010$)) and the Kaiser–Meyer–Olkin (KMO) test (0.901) indicated a very good fit of the data to be submitted to factor analysis [81].

No item was removed since all factorial loads had an absolute value higher than 0.30 [81–83], as can be observed in the matrix of rotated factors (Table 8). The three factors obtained explained 58% of the total variance. Factor 1, called "Training in ICT for autism", obtained an eigenvalue of 17.36 and explained 43.40% of the common variance. It comprised nine items (V1–V10), which evaluated the digital training of the professionals for working with people with autism. Factor 2, denominated "Benefits of ICT for autism", obtained an eigenvalue of 3.82 and explained 9.55% of the common variance. It consisted of 15 items (V10–V16, V19–V24, V40), which examined the benefits of ICT for people with autism. Factor 3, called "Uses of ICT for autism", obtained an eigenvalue of 2.06 and explained 5.15% of the common variance. It comprised 16 items (V17–V18, V26–V39), which analysed the purpose the professionals used ICT for in their work with people with autism.

Table 8. Matrix of rotated factors Subscale 2.

Variables	Factor 1	Factor 2	Factor 3
V1.	0.643		
V2.	0.748		
V3.	0.711		
V4.	0.718		
V5.	0.453		
V6.	0.647		
V7.	0.798		
V8.	0.713		
V9.	0.740		
V10.		0.934	
V11.		0.986	
V12.		1.114	
V13.		0.668	
V14.		0.732	
V15.		0.708	
V16.		0.674	
V19.		0.433	
V20.		0.548	
V21.		0.442	
V22.		0.547	
V23.		0.487	
V24.		0.466	
V25.		0.527	
V40.		0.316	
V17.			0.502
V18.			0.493
V26.			0.602
V27.			0.643
V28.			0.657
V29.			0.602
V30.			0.881
V31.			0.589
V32.			0.719
V33.			0.834
V34.			0.939
V35.			0.760
V36.			0.619
V37.			0.645
V38.			0.746
V39.			0.738

The model demonstrated an excellent fit: the chi-square was 388.065, being non-significant ($p = 0.999990$) [61]; the GFI was 0.981, the AGFI gave a value of 0.977, the CFI was 0.999 and the Non-Normed Fit Index (NNFI) was 1.006. These values are within the intervals recommended by Tanaka and Huba [48]. The RMSR was 0.000, indicating a good fit [69,85,86].

A positive and direct relationship could be observed between all factors of Subscale 2, with significant results at the 0.05 levels. Factors 2–3 showed a good relationship ($r = 0.784$, $p < 0.05$, BC Confidence Interval = 0.781–0.807). Factor 1–2 ($r = 0.417$, $p < 0.05$, BC Confidence Interval = 0.296–0.609) and 1–3 ($r = 0.427$, $p < 0.05$, BC Confidence Interval = 0.253–0.607) presented a moderate positive correlation.

For Subscale 3, the Bartlett statistic (1272.2 ($df = 253$; $p = 0.000010$)) and the Kaiser–Meyer–Olkin (KMO) test (0.876) indicated a good fit of the data to be submitted to factor analysis [81].

One item was eliminated because its factorial load had an absolute value lower than 0.30 [81–83], as can be observed in the matrix of rotated factors (Table 9). The two factors

obtained explained 54.88% of the total variance. Factor 1, "Benefits of Apps for Autism", obtained an eigenvalue of 10.22 and explained 44.43% of the common variance. It consisted of 10 items (V6, V11–V20, V22), which investigated the benefits that apps provide for people with autism. Factor 2 "Uses of Apps in Autism" obtained an eigenvalue of 2.40 and explained 10.45% of the common variance. It comprised 12 items (V1–V5, V7–V10, V13–V14, V21), which analysed the purpose the professionals used apps for in their work with people with autism.

The resulting model was acceptable and presented excellent fit indices: chi-square was 165.268 ($p = 0.986961$) [84], the GFI was 0.977, the AGFI was 0.972, the CFI was 0.996, and the NNFI was 0.995 [68]. The RMSR was 0.031, indicating a good fit [69,85,86].

The two factors of Subscale 3 were positively and directly correlated, showing significance at 0.05 ($r = 0.654$, $p < 0.05$, BC Confidence Interval = 0.608–0.733).

Table 9. Matrix of rotated factors Subscale 3.

Variables	Factor 1	Factor 2
V6.	0.458	
V11.	0.428	
V12.	0.422	
V15.	0.375	
V16.	0.591	
V17.	0.654	
V18.	0.879	
V19.	0.943	
V20.	0.850	
V22.	0.497	
V1.		0.505
V2.		0.632
V3.		0.719
V4.		0.711
V5.		0.913
V7.		0.863
V8.		0.896
V9.		0.903
V10.		0.945
V13.		0.593
V14.		0.590
V21.		0.454

Finally, for Subscale 4, the Bartlett statistic (1214.6 ($df = 595$; $p = 0.000010$)) and the Kaiser–Meyer–Olkin (KMO) test [0.868] indicated a good fit of the data to be submitted to factor analysis [81].

One item was eliminated because its factorial load had an absolute value lower than 0.30 [81–83], as can be observed in the matrix of rotated factors (Table 10). The three factors obtained explained 58.51% of the total variance. Factor 1, "Functionality", obtained an eigenvalue of 14.95 and explained 42.10% of the common variance. It comprised eight items (V8, V10, V15–V20) on the functionality of specific apps for people with autism. Factor 2, "Applicability", obtained an eigenvalue of 3.26 and explained 9.31% of the common variance. It consisted of 12 items (V1–V7, V9, V11–V14) on the applicability of specific apps for people with autism. Factor 3, "Uses of Specific Apps for Autism" obtained an eigenvalue of 2.27 and explained 6.50% of the common variance. It consisted of 15 items (V21–V35), which evaluated what purpose the professionals use specific apps for in their work with people with autism.

Table 10. Matrix of rotated factors Subscale 4.

Variables	Factor 1	Factor 2	Factor 3
V8.	0.445		
V10.	0.433		
V15.	0.412		
V16.	0.501		
V17.	0.498		
V18.	0.714		
V19.	0.702		
V20.	0.674		
V1.		0.858	
V2.		0.898	
V3.		0.768	
V4.		0.693	
V5.		0.805	
V6.		0.603	
V7.		0.503	
V9.		0.561	
V11.		0.481	
V12.		0.556	
V13.		0.571	
V14.		0.479	
V21.			0.523
V22.			0.549
V23.			0.596
V24.			0.658
V25.			0.611
V26.			0.505
V27.			0.737
V28.			0.718
V29.			0.799
V30.			0.778
V31.			0.726
V32.			0.943
V33.			0.863
V34.			0.670
V35.			0.797

The model was adequate and presented some excellent fit indices: the chi-square was 255.361 ($p = 0.999990$) [84], the GFI 0.983, the AGFI 0.979, the CFI 0.999, and the NNFI 1.010 (Tanaka and Huba, 1985). The RMSR was 0.000, indicating a good fit [39,85,86].

The correlational analysis of the final version of Subscale 4 gave significant results at the 0.05 (bilateral) levels. All factors were correlated: Factor 1–2 $r = 0.522$, $p < 0.05$ (BC Confidence Interval = 0.455–0.651), Factor 1–3 $r = 0.596$, $p < 0.05$ (BC Confidence Interval = 0.531–0.685) and Factor 2–3 $r = 0.503$, $p < 0.05$ (BC Confidence Interval = 0.503–0.730).

3.3. Confirmatory Factor Analysis (CFA)

With the objective of contrasting the models built through EFA for each subscale of the questionnaire, we performed a CFA using M-PLUS.

For Subscale 1, the structure that we constructed from the one obtained in EFA can be seen in Figure 1. This shows that the quadratic correlations between the items and their factor are positive. In terms of the absolute fit measures, the chi-square value was statistically significant ($\chi^2 = 1592.286$, $p = 0.0000$), and the value of the Root Mean Square Error of Approximation (RMSEA) was 0.001, indicating an excellent fit [64,87,88]. Regarding the incremental fit indices, the Comparative Fit Index (CFI) was 0.891 and the Tucker–Lewis index (TLI) was 0.878, indicating a reasonable model fit [89]. The Weighted Root Mean Square Residual (WRMR) was 1.039, whereby being close to 1 suggests a good

fit [90]. The results obtained through M-PLUS indicate a good fit of the model for Subscale 1 [64,72].

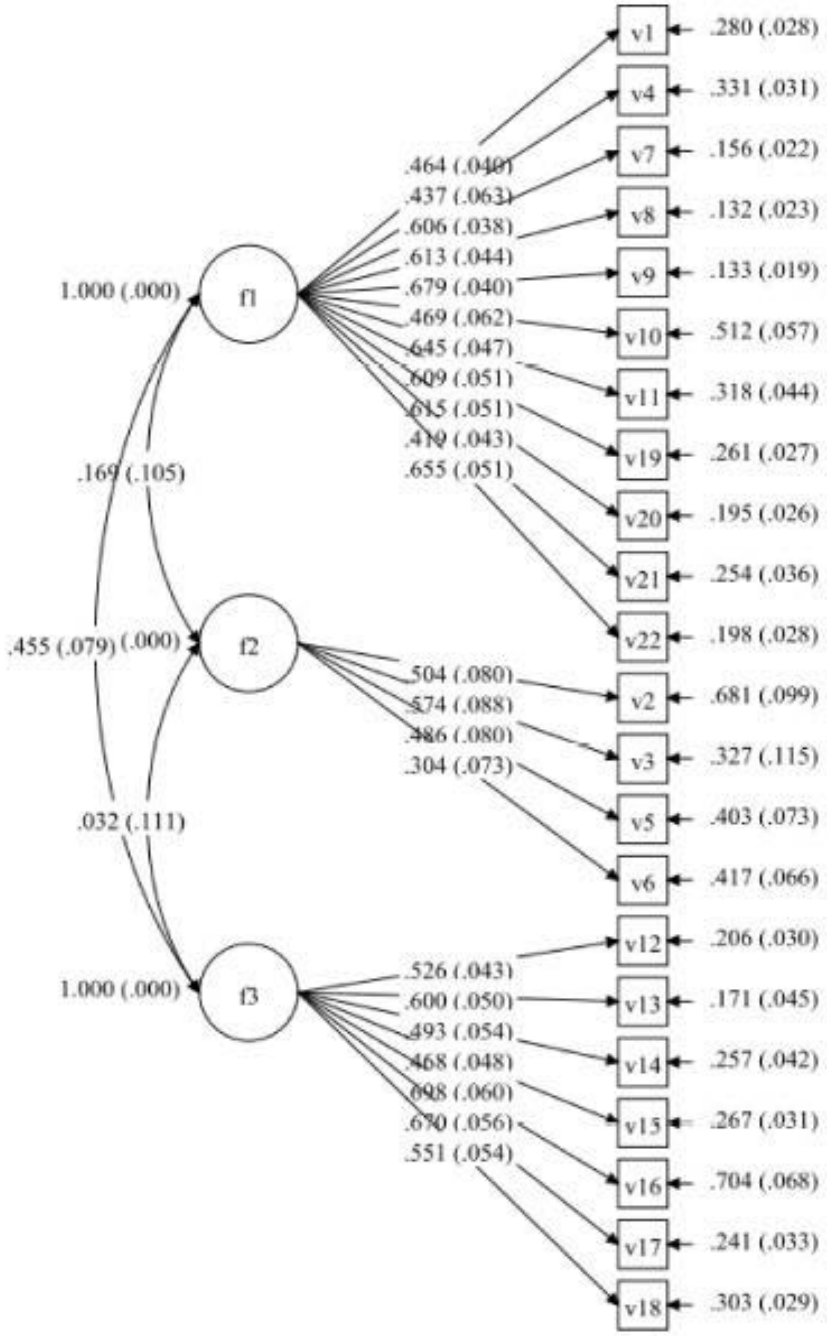

Figure 1. Proposed model. CFA for Subscale 1.

For Subscale 2, the structure that we constructed from that obtained in the EFA was as follows (Figure 2):

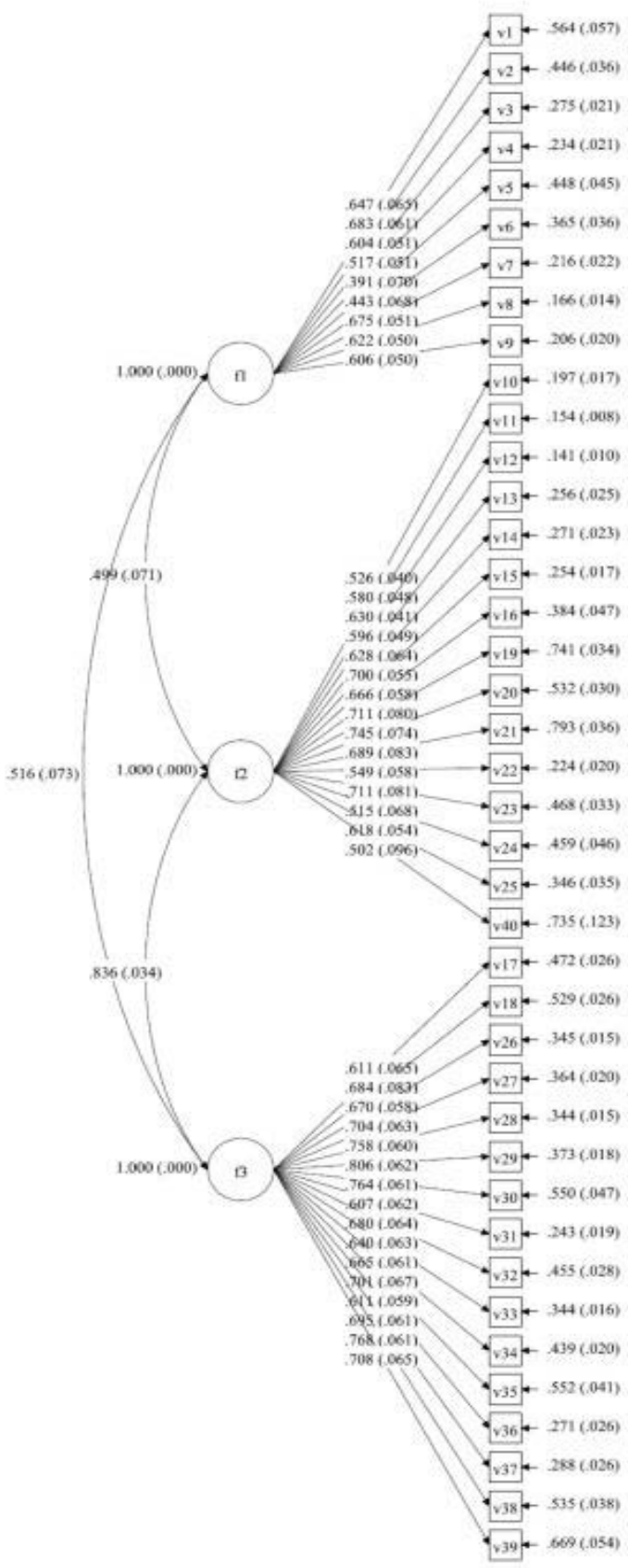

Figure 2. Proposed model. CFA for Subscale 2.

The results of the CFA for Subscale 2 were equally favourable and acceptable [64,72]: the chi-square value was statistically significant (χ^2 = 4158.964, p = 0.0000), while the RMSEA (0.048), SRMR (0.080) and WRMR (1.39) demonstrate the goodness of the model.

For Subscale 3, the structure that we constructed from that obtained in the EFA can be seen in Figure 3. The chi-square value was statistically significant ($p < 0.05$), and RMSEA (0.013), CFI (0.967) and TLI (0.903) indicate a good model fit [64,72].

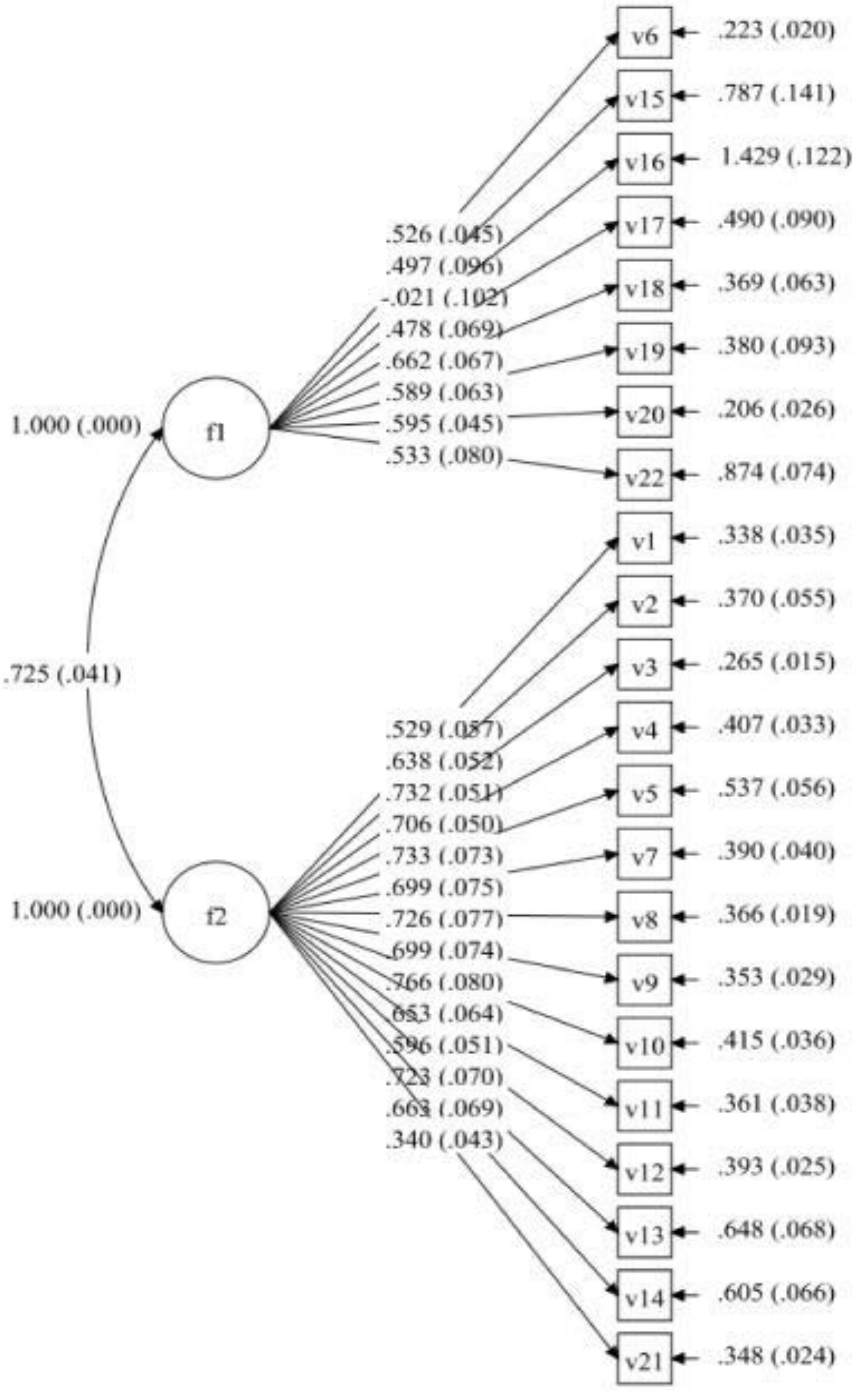

Figure 3. Proposed model. CFA for Subscale 3.

The structure constructed from that obtained in the EFA of Subscale 4 is as follows (Figure 4):

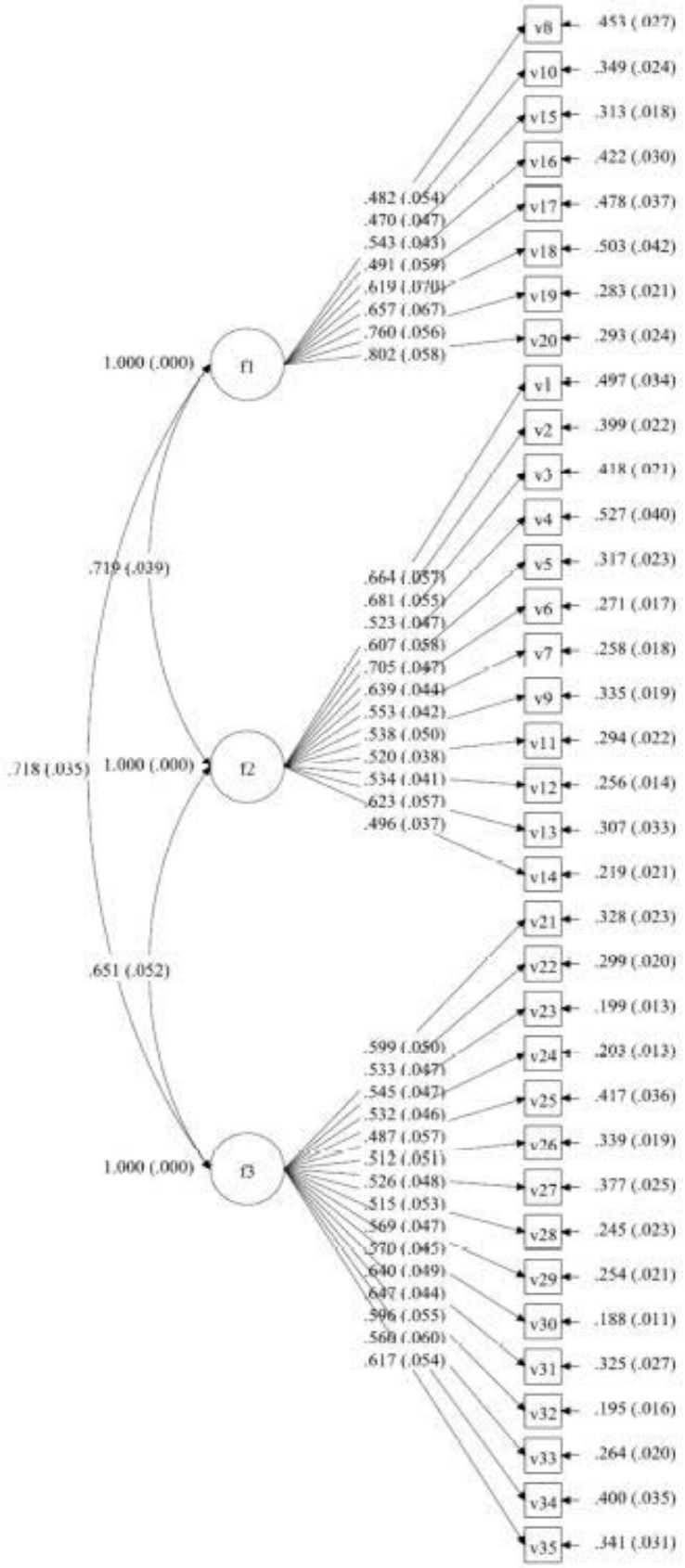

Figure 4. Proposed model. CFA for Subscale 4.

The results of the CFA for the Subscale 4 were favourable and acceptable [64–72]: the chi-square value was statistically significant ($p < 0.05$), RMSEA (0.011), SRMR (0.080), CFI (0.910) and TLI (0.900), demonstrating the goodness of the model.

3.4. *Calculation of Reliability (CR)*

Internal consistency was determined by using Cronbach's Alpha. Although Cronbach's alpha is the test method most commonly used by social researchers [91,92] show that in the CFA it is important to calculate the CR [93] data for each critical factor. In addition, the CR is considered more suitable than Cronbach's alpha because it does not depend on the number of attributes associated with each concept [94]. In general, the CR value is considered adequate when the value of each factor is greater than or equal to 0.70 [64,95,96], but up to 0.60 is acceptable [97,98].

As can be seen in Table 11, a satisfactory Cronbach's alpha—values between 0.75 to 0.96—and CR—values between 0.66 to 0.95—was obtained for each of the factors, indicating a good internal consistency of the questionnaire [67,91,92,95,97,98].

Table 11. Internal Consistency of the Instrument.

		Cronbach's Alpha	Composite Reliability
Subscale 1	Factor 1	0.95	0.93
	Factor 2	0.75	0.66
	Factor 3	0.91	0.88
Subscale 2	Factor 1	0.92	0.90
	Factor 2	0.96	0.94
	Factor 3	0.96	0.95
Subscale 3	Factor 1	0.92	0.76
	Factor 2	0.95	0.94
Subscale 4	Factor 1	0.91	0.88
	Factor 2	0.94	0.92
	Factor 3	0.95	0.94

4. Discussion and Conclusions

The main aim of the study was to test whether the "Demands and Potentials of ICT and apps for attending to people with autism" questionnaire (DPTIC-AUT-Q) was a suitable instrument for measuring different professionals' opinions on the potential and uses of ICT and apps, and their training in them, for working with people with functional diversity, in general, and autism in particular. There are no previous instruments similar to this one, thus no comparison of the psychometric values could be carried out. However, Subscale 1, which is more generic in nature, was constructed from other scales [10,45,61,63]. Below, therefore, we provide a justification for the decisions adopted in its validation. These decisions have been assessed in other studies on instrument validation and have been put forward by experts.

The instrument was subjected to validation by a panel of experts, and using EFA and CFA. Considering that they belong to different professional fields, the views of the expert panel gave greater validity and strength to the process of this study, contributing to the rigour of the questionnaire [73]. Following the analysis of the qualitative evaluations, through the comments and suggestions of the assessing experts for each item and for the questionnaire as a whole, the quantitative results were analysed. These were produced through the analysis of the mean with regard to clarity, coherence, relevance and objectivity of the item interpreted. In terms of modifying the wording or of deleting the proposed item, we took into account whether the item presented a mean that was equal or higher than 1.5 in clarity and/or coherence, and a score higher than 1.5 in standard deviation [99]. None of the 125 items was eliminated. The inter-rater reliability was excellent for ICC values above 0.750 [75] and had a significant Kendall's W. We can therefore conclude that there is

significant agreement between the ranges assigned by the experts for all the questionnaire subscales, and that the instrument has content validity.

Regarding construct validity, before carrying out the EFA, five items were removed due to their indices of skewness and kurtosis higher than −2.5 and 2.5 [77]. Following the EFA, item saturation problems were only observed in Subscale 3—specifically, in Item VII.7, which did not obtain a statistically significant saturation, and it was therefore removed. The definitive version of the questionnaire has 119 items divided into four subscales (see Appendix A: final version).

The factorial structure of Subscale 1 maintained the three original dimensions, extracting three factors, although, as can be seen in Appendix A, some items have better saturation in another dimension: "Opinion", "Requirements and possibilities" and "ICT training for functional diversity". The validity of this structure was subsequently corroborated the CFA, with excellent model goodness-of-fit indices [64,72].

For Subscale 2, the EFA revealed a structure with three latent factors, which corresponded with the three established dimensions: "Training for autism", "Benefits of ICT for autism", and "Uses of ICT for autism". This was corroborated by the CFA, showing adequate model goodness-of-fit values [64,72].

Subscale 3 comprised two factors, coincident with the two dimensions: "Benefits of Apps for Autism" and "Uses of Apps in Autism". Confirmatory procedures demonstrated an adequate fit of the proposed model [64,72].

Lastly, the factorial structure of Subscale 4 comprised three factors, subdividing Dimension IX on the possibilities of specific aims for people with autism into two: "Functionality" and "Applicability". Dimension X, on "Uses of specific apps for autism" (Factor 3) was maintained. This structure was corroborated by the CFA, showing adequate goodness-of-fit values [64,72].

Regarding the internal consistency, the results obtained were satisfactory in terms of Cronbach's alpha coefficients and the CR for all factors, and can be considered highly reliable [64,91,92,95,97,98]. Only Factor 2 of Subscale 1 obtained lower values in both coefficients, albeit within acceptable limits [97,98].

The results demonstrate that the questionnaire—DPTIC-AUT-Q—has satisfactory psychometric quality. We can therefore conclude that, according to the empirical evidence, it can be used with guarantees in similar conditions to those presented here. Having established the instrument's validity, through the empirical evidence corroborated here, its approach and undertaking should be highlighted. It covers all the knowledge expected of a professional from the area of care for diversity and, more specifically, of autism. Throughout the design of the questionnaire, we have looked at those areas in which people with functional diversity and autism have the greatest difficulty and, therefore, greater reinforcement, effort and work, encompassing not only the teacher but specialists from formal, non-formal and healthcare contexts. Most of the national and international instruments we have examined do not specifically analyse the needs and characteristics of people with autism, nor the benefits apps offer them. Therefore, this questionnaire not only considers the requirements and uses derived from using ICT for people with functional diversity, but also examines those with autism and the apps aimed at them, unlike the previous studies we have reviewed.

In terms of limitations, we should point out that the selection of the participants was neither random nor probabilistic, and the final sample size was small, as there were fewer professionals than expected who met the inclusion criteria and worked with people with autism. Another limitation concerns the type of cross-sectional design: carrying out the survey at one single moment in time does not make it possible to verify the questionnaire's test–retest reliability. Another of the limitations is related to the geographical context of the participants, who are all residents of the city of Granada (Spain). In future studies, the application of the questionnaire should be expanded to other Spanish cities to confirm the results obtained here. A further limitation concerns the experts selected, as all of them belonged to the area of higher education and educational guidance teams, while specialists from

non-formal education and healthcare were not considered. The instrument's refinement through the different procedures outlined here make it both possible and recommendable to use it in other studies in order to replicate, validate and generalize its uses in other Spanish-speaking contexts.

Finally, we should mention the practical implications of applying DPTIC-AUT-Q. Its use will help improve the initial and lifelong training of the different professionals who work with people with functional diversity, and particularly with people with autism. It will also guide engineers and programmers to create technological products that are adapted to the needs and possibilities (suitable, functional and accessible) of these collectives.

5. Patents

The questionnaire has been registered in the Territorial Registry of Intellectual Property of Andalusia (Spain) under the title: "Demands and potential of ICTs and apps for the care of people with autism (DPTIC-AUT-Q)". Application Reference: RTA-2276-21. Request identifier: 750120.

Author Contributions: Conceptualization, A.R.F., M.J.C.C., C.d.P.G.-M. and E.C.M.; methodology, A.R.F., M.J.C.C., C.d.P.G.-M. and E.C.M.; formal analysis, M.J.C.C., C.d.P.G.-M. and E.C.M.; investigation, A.R.F., M.J.C.C., C.d.P.G.-M. and E.C.M.; data curation, M.J.C.C., C.d.P.G.-M. and E.C.M.; validation, A.R.F., M.J.C.C., C.d.P.G.-M. and E.C.M.; writing—original draft preparation, A.R.F., M.J.C.C., C.d.P.G.-M. and E.C.M.; writing—review and editing, A.R.F., M.J.C.C., C.d.P.G.-M. and E.C.M.; visualization, M.J.C.C. and E.C.M.; supervision, A.R.F., M.J.C.C. and E.C.M.; project administration, A.R.F.; funding acquisition, A.R.F. and C.d.P.G.-M. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Vice-Rector's Office for Equality, Inclusion and Sustainability of University of Granada (aid for the Support and Promotion of Research on Inclusion 2020 [INV-INC108-2020]) and Spanish Ministry of Education, Innovation and Universities (aid for university teacher training [FPU19/00026]).

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Human Research Ethics Committee of the University of Granada (Spain) [2002/CEIH/2021 approved in February 2021].

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Final version of the questionnaire, "Demands and potentials of ICT and apps for assisting people with autism" (DPTIC-AUT-Q) ["Demandas y potencialidades de las TIC y las apps para la atención a personas con autism" (DPTIC-AUT-Q)].

For each statement, mark the box corresponding to your degree of agreement, according to your personal and/or professional criteria, based on the following scale [Marque para cada afirmación la casilla correspondiente a su grado de acuerdo, según su criterio personal y/o profesional, en base a la siguiente escala]:
1. Strongly disagree [Completamente en desacuerdo]
2. Disagree [En desacuerdo]
3. Neither agree nor disagree [Ni de acuerdo ni en desacuerdo]
4. Agree [De acuerdo]
5. Strongly agree [Completamente de acuerdo]

SUBSCALE 1. Opinion, Training and Uses of ICT by Professionals for Assisting People with Functional Diversity [SUBESCALA 1. Opinión, Formación y Usos de las TIC Por Parte del Profesional Para Atender a Personas con Diversidad Funcional]									
Dimension 1: Opinion [Dimensión 1: Opinión]									
N° Initial Item [N° Ítem inicial]	**N° EFA Item [N° Ítem AFE]**	**N° Final Item [N° Ítem Final]**	*ICT for People with Functional Diversity … [Las TIC Para Personas con Diversidad Funcional …]*	**Scale [Escala]**					
				1	*2*	*3*	*4*	*5*	
I.1.	V1.	1.	Improve the competences of the teacher [Mejoran las competencias del docente]						
I.6.	V4.	2.	Require advice on the search for, selection and evaluation of ICT resources for the teaching-learning process [Requieren asesoramiento sobre la búsqueda, selección y evaluación de recursos TIC para el proceso de enseñanza-aprendizaje]						
I.9	V7.	3.	Provide greater flexibility in the teaching-learning process [Aportan mayor flexibilidad en el proceso de enseñanza-aprendizaje]						
I.10.	V8.	4.	Make it possible to meet educational needs [Permiten responder a las necesidades educativas]						
I.11.	V9.	5.	Are easy to use in attending to diversity [Son fáciles de utilizar en el ámbito de la atención a la diversidad]						
I.12	V10.	6.	Enable inclusion [Favorecen la inclusión]						
II.13	V11.	7.	Offer multiple opportunities in attending to diversity [Ofrecen múltiples oportunidades en el ámbito de la atención a la diversidad]						
III.21	V19.	8.	Improve performance and efficacy [Mejoran el rendimiento y la eficacia]						
III.22	V20.	9.	Increase motivation in learning [Aumentan la motivación hacia el aprendizaje]						
III.25	V21.	10.	Make access to information possible [Posibilitan el acceso a la información]						
III.26	V22.	11.	Make it possible to achieve aims in a more flexible way [Permiten alcanzar los objetivos de forma más flexible]						
Dimension 2: Requirements and Possibilities [Dimensión 2: Requerimientos y Posiblidades]									
N° Initial Item [N° Ítem Inicial]	**N° EFA Item [N° Ítem AFE]**	**N° Final Item [N° Ítem Final]**	*Demands and Necessities of ICT for Assisting People with Functional Diversity … [Demandas y Necesidades de las TIC Para Atender a Personas con Diversidad Funcional …]*	**Scale [Escala]**					
				1	*2*	*3*	*4*	*5*	
I.2.	V2.	12.	They require greater commitment and effort in my work [Exigen mayor dedicación y esfuerzo en mi labor]						
I.3.	V3.	13.	They require specific training [Requieren formación especifica]						
I.7.	V5.	14.	They need more material means and investment by management [Precisan mayores medios materiales e inversión por parte de la Administración]						
I.8.	V6.	15.	They help give more attention to diversity [Ayudan a prestar una mejor atención a la diversidad]						
II.14.	V12.	16.	I would know how to choose specific ICT according to their needs [Sabría seleccionar TIC especificas en función de sus necesidades]						
Dimension 3: Training in ICT for Functional Diversity [Dimensión 3: Formación TIC para Diversidad Funcional]									
N° Initial Item [N° Ítem Inicial]	**N° EFA Item [N° Ítem AFE]**	**N° Final Item [N° Ítem Final]**	*ICT Training of Professionals for Assisting People with Functional Diversity … [Formación TIC del Profesional Para Atender a Personas con Diversidad Funcional …]*	**Scale [Escala]**					
				1	*2*	*3*	*4*	*5*	
II.15.	V13.	17.	I know the main limitations that can condition its use [Conozco las principales limitaciones que pueden condicionar su uso]						
II.16.	V14.	18.	I know different internet sites where I can find specific resources [Conozco diferentes lugares de Internet donde poder localizar recursos especificos]						
II.17.	V15.	19.	I know how to design activities with non-specialist educational software [Sé diseñar actividades con software educativo generalizado]						
II.18.	V16.	20.	I feel prepared to help them in the use of technical aids and use of ICT [Me siento preparado para ayudarles en el uso de los apoyos técnicos y utilización de las TIC]						
II.19.	V17.	21.	It makes it easier for me to design and adapt activities [Me facilita el diseño y adaptación de las actividades]						
II.20.	V18.	22.	It helps me to carry out assessment [Me ayudan a realizar la evaluación]						

SUBSCALE 2: Training in and Uses of ICT by Professionals to Assist People with Autism [SUBESCALA 2. Formación y Usos de las TIC Por Parte del Profesional Para Atender a Las Personas con Autismo]									
Dimension 1: Training in ICT for Autism [Dimensión 1: Formación en TIC Para Autismo]									
N° Initial Item [N° Ítem Inicial]	**N° EFA Item [N° Ítem AFE]**	**N° Final Item [N° Ítem Final]**	***ICT Training of Professionals for Assisting People with Autism … [Formación TIC del Profesional Para Atender a Personas con Autismo …]***	**Scale [Escala]**					
				1	*2*	*3*	*4*	*5*	
IV.1.	V1.	23.	I know how to use specific software to create materials [Sé utilizar software específico para realizar materiales]						
IV.2.	V2.	24.	I am capable of making curricular adaptations using ICT [Soy capaz de realizar adaptaciones curriculares usando TIC]						
IV.3.	V3.	25.	They enable me to apply teaching strategies to facilitate their inclusion [Me permiten aplicar estrategias didácticas para facilitar su inclusión]						
IV.4.	V4.	26.	I can describe the main limitations that multimedia materials may contain [Puedo describir las principales limitaciones que pueden contener los materiales multimedia]						
IV.5.	V5.	27.	I know the possibilities of operative systems and browsers for modifying accessibility, speed, font size … [Conozco las posibilidades de los sistemas operativos y los navegadores para modificar la accesibilidad, la velocidad, el tamaño de la letra …]						
IV.6	V6.	28.	I know what difficulties that may arise for them in its use [Conozco las dificultades que les pueden surgir en su uso]						
IV.7	V7.	29.	I consider myself competent at locating specific materials on the web [Me considero competente para localizar en la red materiales específicos]						
IV.8	V8.	30.	I know what possibilities ICT offer them [Conozco las posibilidades que las TIC le ofrecen]						
IV.9	V9.	31.	I feel prepared to help them with the use of technological aids and their use [Me siento preparado para ayudarles con el uso de los apoyos tecnológicos y su utilización]						
Dimension 2: Benefits of ICT for Autism [Dimensión 2: Beneficios de las TIC Para Autismo]									
N° Initial Item [N° Ítem Inicial]	**N° EFA Item [N° Ítem AFE]**	**N° Final Item [N° Ítem Final]**	***ICT for People with Autism … [Las TIC Para Personas con Autismo …]***	**Scale [Escala]**					
				1	*2*	*3*	*4*	*5*	
V.10.	V10.	32.	It increases motivation [Incrementan la motivación]						
V.11.	V11.	33.	It supports learning [Apoyan el aprendizaje]						
V.12.	V12.	34.	It improves learning [Mejoran el aprendizaje]						
V.13.	V13.	35.	It facilitates independent learning [Facilitan el aprendizaje autónomo]						
V.14.	V14.	36.	It increases active participation [Aumentan la participación activa]						
V.15.	V15.	37.	It strengthens memory [Refuerzan la memoria]						
V.16.	V16.	38.	It improves attention [Mejoran la atención]						
V.19.	V19.	39.	It provides capabilities for relating with others [Aportan capacidades para relacionarse con los demás]						
V.20.	V20.	40.	It helps recognize emotions in others [Ayudan al reconocimiento de emociones en los demás]						
V.21.	V21.	41.	It helps to understand symbolic play [Ayudan a entender el juego simbólico]						
V.22.	V22.	42.	It increases skills linked to vocabulary acquisition [Incrementan habilidades vinculadas a la adquisición de vocabulario]						
V.23.	V23.	43.	It develops oral language in people with autism [Desarrollan el lenguaje oral en personas con autismo]						
V.24.	V24.	44.	It helps to ask for something in an instrumental way [Ayudan a pedir algo de modo instrumental]						
V.25.	V25.	45.	It enhances skills linked to reading and writing [Incrementan habilidades vinculadas a la lectura y escritura]						
V140.	V40.	46.	It promotes leisure and entertainment [Fomentan el ocio y entretenimiento]						
Dimension 3: Uses of ICT for Autism [Dimensión 3: Usos de las TIC en Autismo]									
N° Initial Item [N° Ítem Inicial]	**N° EFA Item [N° Ítem AFE]**	**N° Final Item [N° Ítem Final]**	***Uses of ICT for People with Autism … [Usos de las TIC Para Personas con Autismo …]***	**Scale [Escala]**					
				1	*2*	*3*	*4*	*5*	
V.17.	V17.	47.	To facilitate the perception of time [Facilitar la percepción del tiempo]						
V.18.	V18.	48.	To enhance communicative and social skills [Favorecer las destrezas comunicativas y sociales]						
V126.	V26.	49.	To develop communication [Desarrollar la comunicación]						
V127.	V27.	50.	To develop oral language [Desarrollar del lenguaje oral]						
V128.	V28.	51.	To develop understanding of emotions [Desarrollar la compresión de emociones]						
V129.	V29.	52.	To develop the expression of emotions [Desarrollar la expresión de emociones]						
V130.	V30.	53.	To manage time [Gestionar el tiempo]						

V1.31. V1.32.	V31. V32.	54. 55.	To stimulate cognitive development [Estimular el desarrollo cognitivo] To develop autonomy [Desarrollar la autonomía]					
V1.33.	V33.	56.	To carry out tasks related to planning [Realizar tareas relacionadas con la planificación]					
V1.34.	V34.	57.	To carry out tasks related to organization [Realizar tareas relacionadas con la organización]					
V1.35.	V35.	58.	To carry out tasks related to self-regulation [Realizar tareas relacionadas con la autorregulación]					
V1.36.	V36.	59.	To carry out tasks related to memory [Realizar tareas relacionadas con la memoria]					
V1.37.	V37.	60.	To facilitate learning how to read [Facilitar el aprendizaje de la lectura]					
V1.38.	V38.	61.	To facilitate learning how to write [Facilitar el aprendizaje de la escritura]					
V1.39.	V39.	62.	To facilitate learning arithmetic [Facilitar el aprendizaje del cálculo]					

SUBSCALE 3: Uses and Benefits of Apps in Assisting People with Autism [SUBESCALA 3. Usos y Beneficios de las Apps en la Atención de las Personas con Autismo]									
Dimension 1: Benefits of Apps for Autism [Dimensión 1: Beneficios de las Apps Para Autismo]									
N° Initial Item [N° Ítem Inicial]	**N° EFA Item [N° Ítem AFE]**	**N° final Item [N° Ítem Final]**	***Apps for People with AUTISM … [Las Apps Para Personas con Autismo …]***	**Scale [Escala]**					
				1	*2*	*3*	*4*	*5*	
VII.6.	V6.	63.	Stimulate cogitive development [Estimula el desarrollo cognitivo]						
VII.11.	V11.	64.	Make it easier to carry out memory-related tasks [Facilita realizar tareas relacionadas con la memoria]						
VII.12.	V12.	65.	Facilitate learning how to read [Facilita el aprendizaje de la lectura]						
VII.15.	V15.	66.	Promote leisure and entertainment [Fomenta el ocio y entretenimiento]						
VIII.16.	V16.	67.	Complement the use of other, traditional means of working (book, blackboard, etc.) [Complementa el uso de otros medios de trabajo tradicionales (libro, pizarra …)]						
VIII.18	V17.	68.	Make psychopedagogic intervention more effective [Hace que la intervención psicopedagógica sea más efectiva]						
VIII.19.	V18.	69.	Are a complement for reinforcing what has previously been worked on [Es un complemento para reforzar lo trabajado con anterioridad]						
VIII.20.	V19.	70.	Are a way to consolidate concepts [Es una forma de afianzar conceptos]						
VIII.21.	V20.	71.	Are a motivating tool [Resulta una herramienta motivadora]						
VIII.23.	V22.	72.	Facilitate socialization [Facilita la socialización]						
Dimension 2: Uses of Apps for Autism [Dimensión 2. Usos de las Apps en Autismo]									
N° Initial Item [N° Ítem Inicial]	**N° EFA Item [N° Ítem AFE]**	**N° Final Item [N° Ítem Final]**	***Uses of Apps for People with Autism … [Usos de las Apps Para Personas con Autismo …]***	**Scale [Escala]**					
				1	*2*	*3*	*4*	*5*	
VII.1.	V1.	73.	To develop communication [Desarrollar la comunicación]						
VII.2.	V2.	74.	To develop oral language [Desarrollar del lenguaje oral]						
VII.3.	V3.	75.	To develop understanding of emotions [Desarrollar la compresión de emociones]						
VII.4.	V4.	76.	To develop expression of emotions [Desarrollar la expresión de emociones]						
VII.5.	V5.	77.	To manage time [Gestionar el tiempo]						
VII.7.	V7.	78.	To develop autonomy [Desarrollar la autonomía]						
VII.8.	V8.	79.	To carry out tasks related to planning [Realizar tareas relacionadas con la planificación]						
VII.9.	V9.	80.	To carry out tasks related to organization [Realizar tareas relacionadas con la organización]						
VII.10.	V10.	81.	To carry out tasks related to self-regulation [Realizar tareas relacionadas con la autorregulación]						
VII.13.	V13.	82.	To facilitate learning how to write [Facilitar el aprendizaje de la escritura]						
VII.14.	V14.	83.	To facilitate learning arithmetic [Facilitar el aprendizaje del cálculo]						
VIII.22.	V21.	84.	To hold attention for longer time [Mantener la atención durante más tiempo]						

SUBSCALE 4: Uses and Possibilities of Specific Apps for People with Autism [SUBESCALA 4. Usos y Posibilidades de las Apps Especificas Para las Personas con Autismo]									
Dimension 1: Functionality [Dimensión 1: Funcionalidad]									
N° Initial Item [Nº Ítem Inicial]	**N° EFA Item [Nº Ítem AFE]**	**N° Final Item [Nº Ítem Final]**	*Functionality of Specific Apps for People with Autism . . . [Funcionalidad de las Apps Especificas Para Personas con Autismo . . .]*	**Scale [Escala]**					
				1	*2*	*3*	*4*	*5*	
IX.8.	V8.	85.	They enable universal accessibility (changes in font size, colour, graphic elements, etc.) [Permiten una accesibilidad universal (cambios del tamaño de letra, en el color, en los elementos gráficos, . . .)]						
IX.10.	V10.	86.	They function correctly [Funcionan correctamente]						
IX.15.	V15.	87.	They respect the pace of learning [Respetan el ritmo de aprendizaje]						
IX.16.	V16.	88.	They enable the user to add personalized images or pictograms [Permiten al usuario añadir imágenes o pictogramas personalizados]						
IX.17.	V17.	89.	They specify the age they are designed for [Especifican la edad a la que van destinadas]						
IX.18.	V18.	90.	They are available in several languages [Están disponibles en varios idiomas]						
IX.19.	V19.	91.	They track the user's progress [Realizan un seguimiento del trabajo]						
IX.20.	V20.	92.	They facilitate assessment and user progress tracking [Facilitan la evaluación y seguimiento del usuario]						
Dimension 2: Applicability [Dimensión 2: Aplicabilidad]									
N° Initial Item [Nº Ítem Inicial]	**N° EFA Item [Nº Ítem AFE]**	**N° Final Item [Nº Ítem Final]**	*Applicability of Specific Apps for People with Autism . . . [Aplicabilidad de las Apps Especificas Para Personas con Autismo . . .]*	**Scale [Escala]**					
				1	*2*	*3*	*4*	*5*	
IX.1.	V1.	93.	They can be found easily on Google Play or the App Store [Se encuentran con facilidad en Google Play Store o en App Store]						
IX.2.	V2.	94.	They are available on smartphones [Están disponibles para móvil]						
IX.3.	V3.	95.	They are available on tablets [Están disponibles para Tablet]						
IX.4.	V4.	96.	There are many of them [Son numerosas]						
IX.5.	V5.	97.	They are varied in terms of subject area (emotions, communication, time management, etc.) [Son variadas en cuanto a temática (emociones, comunicación, gestión del tiempo . . .)]						
IX.6.	V6.	98.	They include tasks that respond to their needs [Contienen tareas que responden a sus necesidades]						
IX.7.	V7.	99.	Their design is adapted to their characteristics [Tienen un diseño que se adapta a sus caracteristicas]						
IX.9.	V9.	100.	They offer different codes of communication (visual, auditory) [Presentan diferentes códigos de comunicación (visual/auditivo)]						
IX.11.	V11.	101.	They are intuitive and easy to use [Son intuitivas y fáciles manejar]						
IX.12.	V12.	102.	They present their content in a clear and intuitive way [Presentan los contenidos de forma clara e intuitiva]						
IX.13.	V13.	103.	They specify what content they include [Especifican qué contenidos incluyen]						
IX.14.	V14.	104.	They include suitable content [Incluyen contenidos adecuados]						
IX.21.	V21.	105.	They offer a controllable environment and situation [Ofrecen un entorno y situación controlable]						
Dimension 3: Uses of Specific Apps for Autism [Dimensión 3: Usos de las Aplicaciones Especificas Para Autismo]									
N° Initial Item [Nº Ítem Inicial]	**N° EFA Item [Nº Ítem AFE]**	**N° Final Item [Nº Ítem Final]**	*Uses of Specific Apps for People with Autism . . . [Usos de las Apps Especificas Para Personas con Autismo . . .]*	**Scale [Escala]**					
				1	*2*	*3*	*4*	*5*	
X.22.	V22.	106.	Work on the area of emotions in a suitable way [Trabajar el ámbito de las emociones de forma adecuada]						
X.23.	V23.	107.	Work on the area of oral language in a suitable way [Trabajar el ámbito del lenguaje oral de forma adecuada]						
X.24.	V24.	108.	Work on the area of communication in a suitable way [Trabajar el ámbito comunicativo de forma adecuada]						
X.25.	V25.	109.	Work on the area of leisure and entertainment in a suitable way [Trabajar el ámbito del ocio y entretenimiento de forma adecuada]						
X.26.	V26.	110.	Work on autonomy in a suitable way [Trabajar la autonomía de forma adecuada]						
X.27.	V27.	111.	Work on time management in a suitable way [Trabajar la gestión del tiempo de forma adecuada]						
X.28.	V28.	112.	Work on cognitive stimulation in a suitable way [Trabajar la estimulación cognitiva de forma adecuada]						
X.29.	V29.	113.	Work on planning in a suitable way [Trabajar la planificación de forma adecuada]						
X.30.	V30.	114.	Work on organization in a suitable way [Trabajar la organización de forma adecuada]						
X.31.	V31.	115.	Work on self-regulation in a suitable way [Trabajar la autorregulación de forma adecuada]						

X.32.	V32.	116.	Work on memory development in a suitable way [Trabajar el desarrollo de la memoria de forma adecuada]					
X.33.	V33.	117.	Work on learning how to read in a suitable way [Trabajar el aprendizaje de la lectura de forma adecuada]					
X.34.	V34.	118.	Work on learning how to write in a suitable way [Trabajar el aprendizaje de la escritura de forma adecuada]					
X.35.	V35.	119.	Work on learning arithmetic in a suitable way [Trabajar el aprendizaje del cálculo de forma adecuada]					

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Artículo 5. Functionality of apps for people with autism: Comparison between educators from Florence and Granada

1. Introduction

The use of mobile apps is the order of the day, due to the potential and ease of use they offer, and the convenience and immediacy that they give. So much so, that in the main app catalogues, their presence is immense, with apps for a multitude of needs, situations and target users.

The apps available for smartphones and tablets extend to all sectors of society, and are not confined merely to ludic use but address fields such as medicine, education, and social or financial areas.

This proliferation of apps has undoubtedly reached those people with more specific needs and difficulties, such as children and adults with autism. There are hundreds of apps for working on different areas of development, while there are many studies focused on their potential and on the benefits that they provide. One example of this is the research – with encouraging results – on the use of apps focusing on the executive functions for people with autism (Weng & Bouck, 2014; Li et al., 2018; Yerys et al., 2019; Flynn et al., 2019; Wright et al., 2020; Wagle et al., 2021), on the basic instrumental skills (Sweidan et al., 2019; Teixeira & Cunha, 2019; Aguilar-Velázquez et al., 2020), or on the Theory of Mind (Fage et al., 2018; Flores et al., 2012; Jiménez et al., 2017; Lozano et al., 2013; Weisblatt et al., 2019).

However, their use is not quite as widespred as might be wished. People with autism have difficulties in aspects linked to communication, language and social interaction (APA, 2014), and, despite the fact that interventions using information and communication technology (ICT) and apps have produced encouraging results in these areas, it is not particularly common practice in teaching institutions or in psychopedagogic therapies.

Studies on the usage and frequency of use of apps in formal and informal education with people with autism are non-existent, as is the case with studies on other types of technological resources (Eye Tracking, Virtual Reality, Augmented Reality (AR), Mixed Reality, Robotics, Digital Communication Boards, etc.). There are many

studies on the potential of ICT for people with functional diversity and, more specifically, autism (Abu-Amara et al., 2021; Giaconi et al., 2021; Lledó et al., 2022; Mosher & Carreon, 2021; Özdemir et al., 2022; Wedyan et al., 2021), but not so many that look at the motivation for using such resources, the digital training of educators, or the difficulties and simplicities that professionals find in their use. Table 1 shows previous studies from different countries on the perceptions of educators regarding the application of various technologies in the classroom with students with ASD or, specifically, autism.

Table 1

Previous studies on the perception of teachers regarding the application of technologies in the classroom with people with autism

Study	**Sample**	**Objectives**	**Conclusions**
Escobedo & Tentori (2014)	7 teachers (Mexico)	To analyse the impact of implementing MOBIS (Augmented Reality - AR) with teachers of students with autism	- AR is a real support aid during cognitive therapy - It improves teaching performance - It reduces teachers' workload
Lledó et al. (2020)	20 schools (Spain)	Identify and assess the application of inclusive response measures in classrooms specifically for students with ASD	- Apps show potential for working with students with ASD - Lack of teacher training in technologies - Lack of knowledge about apps for students with ASD
Martínez (2020)	20 teachers (Spain)	Analyse teacher training with regard to ICT and AR in specialized classrooms	- ICT and AR are a motivating element for teaching - ICT and AR promote active participation - Lack of teacher training on digital technology
Sabayleh & Alramamneh (2020)	70 teachers (Jordan)	Identify the obstacles teachers find when implementing technologies in classrooms with students with autism	- Lack of equipment, digital resources and coordination between teachers - Lack of training for designing digital educational programs - Difficulty of students in using different technologies - Software barely adapted to the needs of students with autism
Omar et al. (2020)	8 teachers (Malaysia)	Perception of teachers on using the app *Autism Aid* in classrooms with students with autism	- The most experienced teachers support the use of tablets with apps more than those with less experience - Most teachers recognize the potential of tablets - Tablets can disrupt the pace of the class and the rest of students - Apps facilitate access to the school curriculum
Saladino et al. (2020)	142 teachers (Italy)	Discover teachers' perception about the use of technologies	- Technologies significantly assist in the development of key competences - They encourage the participation and inclusion of students with ASD - Apps enhance the communication and interaction of children with ASD - Teachers with more experience do not use ICT - Teachers need to know which digital resources are suitable for each student

As stated, research on the motivation for using apps, frequency of use and the difficulties found by professionals who work with people with autism in order to use them are almost non-existent. This is also the case for studies focused on app evaluation. There are several studies on the benefits of using apps designed specifically for people with autism (Sweidan et al., 2019; Smith et al., 2020; Aguilar-Velázquez et al., 2020; Vyshedskiy et al., 2020), but not on whether the apps used are of an acceptable quality or if they really attend to the needs and characteristics of the user with autism. In this regard, Choez (2018) carried out a review and analysis of apps for children with autism, highlighting that in 2017 there were more than 1300 apps, but that there were no studies that assessed whether they were suitable or not. Among the apps analysed in this study, *José Aprende* and *EmoPLAY* stood out for their quality. Díaz (2018) evaluated apps for people with autism, noting the lack of categorizations according to type of disability or the quality of the app, concluding that only 37.68% were of acceptable quality, and that these focused mainly on the development of social competences. Some of the apps that stood out for their quality were *José Aprende* and *El Viaje de Elisa*. Larco et al. (2018) reviewed and assessed 65 apps for people with autism, concluding that 38% were of acceptable quality. These apps (among which we find *Pictoagenda* and *Pictotraductor*) were mainly focused on the development of the social environment, autonomy and, to a lesser degree, linguistic and communicative skills. Ramón (2019) evaluated augmented reality apps, asserting that there was a scarcity of apps designed for this purpose, and offered a list of apps for people with autism, including *#Soyvisual*, *Proyecto Emociones* and *José Aprende*. Capel (2021) analysed and assessed 50 apps for developing communication for students with autism, indicating that 8 were of excellent and 17 of adequate quality. Among the recommended apps were: *#Soyvisual*, *Symbotalk - AAC Talker*, *MITA*, *Pictoagenda*, *Pictotraductor* and *CommBoards*. Gallardo-Montes et al. (2021a y 2021b) evaluated 155 apps for people with autism, of which only 14 attained scores that were notably higher than the rest. The apps mainly focused on advancing executive functions, basic instrumental skills, communication and language, with less space dedicated to emotional development and time management. Noteworthy apps were: *#Soyvisual*, *MITA*, *Symbotalk - AAC Talker*, *CommBoards*, *Smile and Learn*, *LEA* and *Proyecto Emociones.*

Yet, as already mentioned, there is a scarcity of research both on the uses made of apps in schools and in psychopedagogic therapies by specialists for attending to people with autism, and on the benefits found in their use. There is not enough information that

would make it possible to compare results, or for educators and parents to be able to make a conscious choice over their use. This study, therefore, has the following aims:

1. Investigate the frequency of use of apps by educators in Florence and Granada.
2. Determine the benefits that educators in Florence and Granada find when using apps for attending to people with autism.
3. Discover what uses educators in Florence and Granada make of apps for attending to people with autism.
4. Determine the benefits and uses of apps according to sex, age, years of experience, city of origin, place of work, and type of teacher.
5. Find out which apps specifically for people with autism are used by educators in Florence and Granada.

2. Method

This is a quantitative study with a non-experimental, comparative and cross-sectional descriptive design.

2.1 Participants

The initial sample comprised 1261 professionals from working in education in the cities of Granada (G), Spain (n = 443) and Florence (F), Italy (n = 818). After the first analysis, based on the inclusion criterion of "experience with the use of apps for people with autism", the final sample sample ended up with 286 participants, 159 from Granada and 127 from Florence. For the participant selection, non-probability convenience sampling was undertaken.

The participants from Granada consisted of 159 women (84.3%) and 25 men (15.7%), with ages between 20 and 64 years old (M = 37.67; SD = 10.50), and with experience working with children with autism below the age of 10 years old (84.9%). The majority were Therapeutic Pedagogy teachers (34.6%) and general teachers (20.1%) who work in the stages of primary education (80.5%) and preschool (57.2%), in schools with internet access (98.7%) and available computers (93.7%), tablets (73.6%) and projectors (62.3%).

The participants from Florence were made up of 127 women (89.9%) and 13 men (10.2%), aged between 25 and 58 years old (M = 37.98; SD = 8.14), and with experience with people with autism younger than 10 years old (95.3%). They were mostly support teachers (74.0%) and general teachers (42.5%) who worked in the stages of primary

education (55.9%) and preschool (37.8%), in schools with internet access (95.3%), and with computers (89.8%), projectors (56.7%) and tablets (55.9%).

Bearing in mind the significant number of female participants, the sex and/or gender did not result in bias in this investigation, as studies in Social Science and Legal Science have a predominance of women (Gialamas et al., 2013; Marín-Díaz, 2018).

2.2 Instrument

In order to discover the use and frequency that the educators make of apps, along with the benefits that they find in them for working with people with autism, we administered the Italian version of the questionnaire – "Questionario sulla formazione e sulle competenze legate all'use delle ICT degli insegnati che operano con alunni disabili" ["Questionnaire on training and competences related to the use of ICT for teachers who work with disabled pupils"] (Gallardo-Montes et al., 2020), and the Spanish version, "Demandas y potencialidades de las ICT y las apps para la atención a people with autism (DPTIC-AUT-Q)" ["Demands and Potentials of ICT and Apps for Assisting People with Autism"] (Rodríguez et al., 2021). It had a section on sociodemographic data and four subscales connected to ICT: Subscale 1: Opinion, training and uses of ICT by professionals for teaching people with functional diversity; Subscale 2: Training and uses of ICT by professionals for teaching people with autism; Subscale 3: Uses and benefits of apps in assisting people with autism; Subscale 4: Uses and possibilities of specialized apps for people with autism. In order to meet the aims of this study, we have only used the third subscale, "Uses and benefits of apps in assisting people with autism", which comprised questions with Likert-scale responses (1 = Completely disagree; 5 = Completely agree). It had two dimensions: Dimension 1 (D1): Benefits of apps for autism (items 63-72); Dimension 2 (D2): Uses of apps for autism (items 73-84), and a question on the frequency of use of apps (1 = Little, 4 = A lot).

The questionnaire has adequate psychometric properties. It obtained excellent Intraclass Correlation coefficients in Subscale 3 (Italian version = .955; Spanish version = .994); significant Kendall's W inter-rater concordance, $p < 0.001$ (Italian version = .192 clarity; .197 coherence; .202 relevance; and .218 objectivity; Spanish version = .138 clarity; .132 coherence; .155 relevance; and .123 objectivity); and an exceptional internal consistency: $\alpha_{\text{Italy\_Subscale\_3}} = .998$; $\alpha_{\text{Spain\_Subscale\_3}} = .951$.

2.3 Procedure

First, the approval of the University of Granada Ethics Committee on Human Research (Spain) was obtained for the questionnaire, receiving a favourable report [2002/CEIH/2021]. The questionnaire was then administered during the period between 2020 and 2021. In the case of Italy, the questionnaire was administered to teachers who were undergoing sessions of continuing education for teachers on attending to diversity, at the Università degli Studi di Firenze (University of Florence). In Spain, it was administered to teachers and educators of schools and associations in the city of Granada. The link to access the questionnaire, designed on the *LimeSurvey* platform, was provided in face-to-face sessions and via email. At all times, participants were informed of the voluntary nature of the questionnaire, its anonymity and data exclusivity, as well as the aims of the study.

2.4 Data Analysis

The data were analysed with the SPSS v.26.0 statistics packet. The descriptive statistics (mean, mode and standard deviation), frequencies, parametric inferential and intrafactorial correlation analyses were calculated. For the dichotomous variables "city", "sex" and "type of teacher in Granada", Student's *t* test was used and the effect size calculated (Cohen's *d*). For the variables "years of experience with autism", "age", "educational stage", "place of work", and "type of teacher in Florence", the ANOVA *F*-test was used, followed by Tukey's HSD and Bonferroni tests, along with the homogeneous subsets test, calculating the effect size using eta squared (η^2). Estimations of the effect size were also performed by calculating Cohen's d and Eta squared (small: $0.20 < d < 0.30$; medium: $0.30 < d < 0.80$; and large: $d > 0.80$).

For the data analysis relative to the variable "age", four groups were established according to the minimum and maximum age of the participants: Group 1: 20 to 30 years old; Group 2: 31 to 40 years old; Group 3: 41 to 50 years old; and Group 4: 51 to 64 years old. Regarding the variable "years of experience", the groups established were: Group 1: ≤5 years; Group 2: 6-10 years; Group 3: 11-20 years; and Group 4: 21-30 years. The option >30 years of experience con people with autism was covered in the questionnaire, but no participant had such professional experience, and so this group is not included in the analyses.

3. Results

The frequency of use of apps (Table 2) showed that the teachers in Granada used them to a greater extent than their Florentine counterparts. In Granada, the option "quite a lot" was chosen by 80% of the participants, compared to 57% in Florence.

Table 2

Frequency of use of apps in Granada and Florence (N = 286)

Frequency of use	Granada *N* (%)	Florence *N* (%)
Little	5 (3.1)	7 (5.5)
Sometimes	64 (40.3)	51 (40.2)
Quite a lot	80 (50.3)	57 (44.9)
A lot	10 (6.3)	12 (9.4)

In Table 3, according to the values of the mean and the mode, we can see that the opinion of the participants on the benefits and uses of the apps for people with autism was situated between Options 4 "Agree" and 5 "Fully agree". Only Item 72 "Enhances socialization", was positioned at Option 3, "Neither agree nor disagree".

In Dimension 1, regarding the benefits that apps can provide people with autism, the educators showed that they proved to be a motivating option for working with them, since they complemented the use of other, more traditional media (books, blackboard, etc.), and helped to reinforce and consolidate the concepts previously studied. However, they were less in agreement that apps enhanced socialization, learning to read, and the encouragement of leisure and entertainment.

Regarding Dimension 2, concerning the uses the educators made of the apps with people with autism, the most notable feature was that they helped to hold attention for longer, and they facilitated communication, development of autonomy and learning calculus. However, their use was not aimed at the development, understanding and expression of emotions, or at tasks related to time management or self-regulation.

Table 3

Opinion of teachers from Granada and Florence about the benefits and uses of apps for attending to people with autism (N = 286)

	ITEM	*M*	*SD*	M_o	%				
					1	2	3	4	5
D1. Benefits of apps	63. Stimulate cognitive development	4.15	0.83	4	1.4	2.4	11.9	48.6	35.7
	64. Facilitate performing tasks related to memory	4.07	0.88	4	1.0	4.2	16.4	43.4	35.0
	65. Enable learning how to read	3.96	0.96	4	2.8	3.8	19.9	41.6	31.8
	66. Promote leisure and entertainment	3.85	1.08	4	3.8	8.4	17.8	38.5	31.5
	67. Complement the use of other work media...	4.30	0.91	5	2.1	3.5	7.7	35.7	51.0
	68. Make the psychopedagogic intervention...	4.05	0.90	4	1.4	4.2	16.8	43.4	34.3

	69. It is a good complement to reinforce what has been worked on…	4.21	0.86	5	1.4	2.8	11.9	41.6	42.3
	70. It is a way to consolidate concepts	4.22	0.76	4	0.3	1.7	12.6	46.5	38.8
	71. It is a motivating tool	4.40	0.78	5	0.3	2.4	9.1	32.9	55.2
	72. It facilitates socialization	3.46	1.02	3	2.8	13.6	36.0	29.7	17.8
D2. Uses of apps	73. Develop communication	3.92	0.90	4	2.1	4.2	19.6	47.9	26.2
	74. Develop oral language	3.74	0.99	4	3.1	7.0	25.5	41.3	23.1
	75. Develop understanding of emotions	3.71	1.01	4	4.5	4.9	26.9	42.0	21.7
	76. Develop the expression of emotions	3.67	1.02	4	3.8	7.7	27.3	39.5	21.7
	77. Manage time	3.63	1.06	4	3.8	10.1	27.6	36.4	22.0
	78. Develop autonomy	3.91	0.94	4	2.4	4.5	21.0	43.7	28.3
	79. Carry out tasks related to planning	3.77	1.00	4	3.8	5.6	24.5	42.0	24.1
	80. Carry out tasks related to organization	3.78	0.99	4	3.1	6.6	24.1	41.6	24.5
	81. Carry out tasks related to self-regulation	3.71	1.00	4	4.2	4.9	29.4	39.2	22.4
	82. Facilitate learning how to write	3.76	1.07	4	3.8	9.4	20.6	38.8	27.3
	83. Enable learning calculus	3.81	1.04	4	4.9	6.3	17.1	46.2	25.5
	84. Hold attention for longer	4.20	0.82	4	0.7	2.8	13.3	42.3	40.9

Note. *M* = Mean; *SD* = Standard deviation; M_o = Mode

In Table 4 we can see how the participants from Granada produced a higher mean than those from Florence with regard to the benefits that they considered the apps had for people with autism (Dimension 1), and the uses they made of them (Dimension 2).

Table 4

Mean and standard deviation of the benefits and uses of apps according to each city

City	**Benefits apps**		**Uses apps**	
	M	***SD***	***M***	***SD***
Granada (*n* = 159)	4.14	0.65	4.65	0.86
Florence (*n* = 127)	3.97	0.67	4.45	0.91
Total (*n* = 286)	4.07	0.66	4.56	0.89

Note. *M* = Mean; *SD* = Standard deviation

The analysis of correlations (Table 5) showed that there was a strong ($r = .795$) and significant ($p < 0.01$) positive relation between the benefits that the educators found in apps and the use and utility they gave them. Significant ($p < 0.01$) but weak (from .297 to .311) positive correlations can likewise be seen in the frequency of use of apps with the benefits ($r = .297$) and with the usefulness ($r = .311$) they gave them.

Weak (from -.080 to -.126) negative correlations can be seen in the age of the participants with the benefits ($r = -.126$) and uses of the apps ($r = -.080$).

Table 5

Pearson's correlation coefficient between the benefits of the apps, the uses and applications, the age of the educator and the frequency of use

	Benefits	Uses	Age	Frequency
1. Benefits of the apps	1			
2. Uses and applications of apps	.795**	1		
3. Age of the educator	-.126*	-.080	1	
4. Frequency of use of apps	.297**	.311**	.002	1

Note: ** The correlation is significant at level 0.01 (two-tailed); * The correlation is significant at level 0.05 (two-tailed).

According to the city of origin (Table 6), significant differences are observed in 36.36% of the items ($p < .05$). In Dimension 1 (D1), regarding the benefits of the apps, the participants from Granada obtained higher means than the teachers from Florence with an effect size between small ($d > 0.20$) and medium ($d > 0.50$). These items indicated that the apps for people with autism stimulated cognitive development ($t(284) = -2.57$, $p = .011$), enabled learning how to read ($t(284) = -2.33$, $p = .021$), promoted leisure and entertainment ($t(284) = 5.37$, $p = .000$), and, moreover, were a motivating tool for working with them ($t(284) = 2.94$, $p = .004$).

In Dimension 2 (D2), regarding the uses that the educators made of apps, the participants from Granada similarly obtained higher means than those from Florence, with an effect size between small ($d > 0.20$) and medium ($d > 0.50$). The differences showed that the teachers from Granada used apps more with the purpose of developing communication ($t(284) = -2.37$, $p = .018$), oral language ($t(284) = -2.19$, $p = .029$), and the comprehension ($t(284) = -3.19$, $p = .002$) and expression of emotions ($t(284) = -3.41$, $p = .001$), than the teachers from Florence.

Table 6

Significant differences in the benefits and uses of apps as a function of city

	Dependent Variables	Florence		Granada		*t*	*d*
		M	*SD*	*M*	*SD*		
D1	63. Stimulate cognitive development	4.01	0.87	4.26	0.77	-2.57*	0.30
	65. Enhance learning how to read	3.81	1.03	4.08	0.89	-2.33*	0.28
	66. Encourage leisure and entertainment	3.49	1.05	4.14	1.01	-5.37***	0.63
	71. They are a motivating tool	4.25	0.84	4.52	0.72	-2.94**	0.35
D2	73. Develop communication	3.78	0.97	4.03	0.83	-2.37*	0.28
	74. Develop oral language	3.60	1.06	3.86	0.92	-2.19*	0.26
	75. Develop the understanding of emotions	3.50	1.06	3.88	0.93	-3.19**	0.38
	76. Develop the expression of emotions	3.45	1.04	3.86	0.97	-3.41**	0.41

Note. *M* = Mean; *SD* = Standard Deviation; *t* = Student's *t*, *d* = Cohen's *d*, *$p < .05$, **$p < .01$, ***$p < .001$

The variable "sex" produced significant differences (Table 7) in two items of Dimension 2, with a medium effect size ($d > 0.50$). The women from Florence used apps more than the men for the purpose of holding the attention of people with autism for longer ($t(125) = -2.25$, $p = .037$). The women from Granada, for their part, used apps for developing the understanding of emotions more than men ($t(157) = -2.13$, $p = .034$).

Table 7

Significant differences in the benefits and uses of apps as a function of sex

City	Dependent Variables	Men		Women		*t*	*d*
		M	***SD***	***M***	***SD***		
Florence	84. Hold attention for longer	3.62	0.96	4.15	0.85	-2.25*	0.58
Granada	75. Develop the understanding of emotions	3.52	0.82	3.95	0.94	-2.13*	0.49

Note. *M* = Mean; *SD* = Standard deviation; *t* = Student's *t*, *d* = Cohen's *d*, *$p < .05$.

The variable regarding the age of the participants revealed differences in the teachers from the two countries (Table 8), with more differences arising among those from Granada.

In Florence, the oldest participants (51 and 64 years old) were those who used apps the least for developing autonomy ($F(3) = 2.84$, $p < .041$, $\eta^2 = .058$) (item 78 - D2) compared to their younger colleagues.

In Granada, the youngest teachers (20-30 years old) held the view – to a greater degree than the rest – that the benefits found in apps were that they made psychopedagogic intervention more effective ($F(3) = 2.84$, $p < .38$, $\eta^2 = .019$) and that they consolidated concepts ($F(3) = 2.90$, $p < .037$, $\eta^2 = .046$) (items 68 and 70 - D1). In terms of using apps for developing communication ($F(3) = 3.37$, $p < .013$, $\eta^2 = .007$) (item 73 - D2), those aged between 41 and 50 years old stated that they used them more, compared to those aged between 31 and 40 years old. With regard to using apps to carry out tasks of planning ($F(3) = 2.98$, $p < .033$, $\eta^2 = .035$) and organization ($F(3) = 2.88$, $p < .038$, $\eta^2 = .045$) (items 79 and 80 - D2), the teachers aged between 41 and 50 years old reported using them more than the other participants. Lastly, as regards using apps for carrying out tasks related to self-regulation ($F(3) = 3.60$, $p < .015$, $\eta^2 = .049$) (item 81 - D2), the youngest age group (20-30 years old) presented a greater use than the teachers from Granada aged between 31 and 40 years old.

Table 8

Significant differences in the benefits and uses of apps as a function of age

City	Dependent Variables	Age Groups (years old)								*F*	η^2
		20-30		31-40		41-50		51-64			
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*		
Florence	78. Autonomy	3.90	0.76	3.94	0.98	3.90	1.03	2.86	0.69	2.84*	.058
Granada	68. Effective intervention	4.24	0.82	3.77	1.03	4.12	0.87	3.76	0.94	2.89*	.019
	70. Consolidate concepts	4.52	0.61	4.15	0.83	4.22	0.82	4.05	0.74	2.90*	.046
	73. Communication	4.16	0.79	3.74	0.90	4.27	0.74	3.90	0.77	3.37*	.007
	79. Planning	3.96	0.86	3.62	1.05	4.00	0.81	3.43	0.87	2.98*	.035
	80. Organization	3.96	0.97	3.66	0.98	3.98	0.72	3.38	0.92	2.88*	.045
	81. Self-regulation	4.02	1.02	3.47	1.04	3.93	0.85	3.48	0.93	3.60*	.049

Note. *M* = Mean; *SD* = Standard deviation; *F* = ANOVA, η^2 = eta squared, *$p < .05$

As a function of years of experience, we can only see significant differences for the participants from Florence (Table 9): $F(3) = 3.83$, $p = .012$, $\eta^2 = .019$. The Bonferroni and Tukey post hoc comparisons and the homogeneous subset tests revealed that the educators with 11 to 20 years' experience made more use of apps for the development of communication for people with autism ($M = 5.00$, $SD = 0.00$), as opposed to those with 6 to 10 years' experience ($M = 3.39$, $SD = 0.96$) (item 73 - D2).

Table 9

Significant differences in the benefits and uses of apps as a function of years of experience

Dependent Variables	Years of experience (Florence)								*F*	η^2
	≤ 5 years		6-10 years		11-20 years		21-30 years			
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*		
73. Develop communication	3.87	0.94	3.39	0.96	5.00	0.00	4.00	1.00	3.83*	.019

Note. *M* = Mean; *SD* = Standard deviation; *F* = ANOVA, η^2 = eta squared, *$p < .05$

The educational stage taught by the teachers also proved to be a determining factor (Table 10). In Florence, those working in primary education considered that it was more beneficial to work with apps to enable people with autism to learn how to read than those teachers who from preschool education ($F(3) = 2.76$, $p < .045$, $\eta^2 = .100$) (item 65 - D1). Those in secondary education found more benefits than the teachers who simultaneously worked in both preschool and primary education in the use of apps to consolidate concepts ($F(3) = 3.11$, $p < .029$, $\eta^2 = .026$) (item 70 - D1), to promote socialization ($F(3) = 2.94$, $p < .036$, $\eta^2 = .012$) (item 72 - D1), and to hold attention for longer ($F(3) = 6.22$, $p < .001$, $\eta^2 = .069$) (item 84 - D2). The teachers in both preschool and primary education simultaneously revealed that they most agreed with using apps to carry out tasks related

to self-regulation ($F(3)$ = 3.03, $p < .032$, $\eta^2 = .066$) (item 82 - D2) and learning calculus ($F(3)$ = 4.30, $p < .006$, $\eta^2 = .067$) (item 83 - D2) than those who only worked in primary education. Similarly, the participants from secondary education agreed most with the use of apps to learn calculus compared to the preschool teachers.

Table 10

Significant differences in the benefits and uses of apps as a function of the educational stage taught by the teachers from Florence

		Educational stages worked in									
	Dependent Variables	**Preschool (*n* = 14)**		**Primary (*n* = 32)**		**Preschool & Primary (*n* = 36)**		**Secondary (*n* = 45)**		***F***	***η²***
		M	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***		
D1	65. Reading	3.14	1.51	3.81	0.90	4.06	0.96	3.82	0.94	2.757*	.100
	70. Consolidate	4.07	0.92	4.19	0.74	4.42	0.65	3.93	0.69	3.109*	.026
	72. Socialize	3.64	1.08	3.38	0.833	3.86	0.93	3.29	0.92	2.937*	.012
D2	82. Self-regulation	3.00	1.36	3.69	0.93	3.94	1.07	3.82	0.94	3.029*	.066
	83. Calculus	3.00	1.36	3.72	0.85	4.06	0.92	3.87	0.89	4.301**	.067
	84. Attention	4.21	1.05	4.13	0.85	4.50	0.66	3.71	0.92	6.223**	.069

Note. M = Mean; SD = Standard deviation; F = ANOVA, η^2 = eta squared, *$p < .05$, **$p < 0.01$.

In Granada (Table 11), the main differences can be observed in the teachers of primary education over those from secondary education in revealing a greater degree of agreement on the benefits of apps for encouraging leisure and entertainment ($F(4)$ = 3.33, $p < .012$, $\eta^2 = .022$) (item 66 - D1), for the motivation these tools give ($F(4)$ = 3.21, $p < .014$, $\eta^2 = .008$) (item 71 - D1), and the good use they can be put to in order to hold student attention for longer ($F(4)$ = 2.98, $p < .021$, $\eta^2 = .027$) (item 84 - D2). The educators who worked with adults also showed a higher degree of agreement than those from secondary education regarding the benefits of apps for carrying out memory-based tasks ($F(4)$ = 2.76, $p < .032$, $\eta^2 = .006$) (item 64 - D1), the motivation they give the student ($F(4)$ = 3.21, $p < .014$, $\eta^2 = .008$) (item 71 - D1), and their use for learning calculus ($F(4)$ = 2.84, $p < .021$, $\eta^2 = .027$) (item 84 - D2).

Table 11

Significant differences in the benefits and uses of apps as a function of the educational stage taught by teachers from Granada

		Educational Stages Taught											
	Dependent Variables	Preschool (*n* = 18)		Primary (*n* = 56)		Preschool & Primary (*n* = 71)		Secondary (*n* = 9)		Adults (*n* = 5)		*F*	η^2
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*		
D1	64. Memory	4.28	0.83	4.18	0.86	4.15	0.92	3.33	1.00	4.80	0.45	2.715*	.006
	66. Leisure	4.06	0.94	4.45	0.66	4.01	1.17	3.33	1.19	4.40	0.89	3.328*	.022
	71. Motivat.	4.56	0.62	4.57	0.66	4.54	0.74	3.78	0.97	5.00	0.00	3.216*	.008
D2	83. Calculus	3.78	1.01	3.78	0.88	4.00	0.96	2.89	1.36	4.60	0.55	2.843*	.027
	84. Attention	4.28	0.85	4.45	0.63	4.20	0.80	3.67	1.12	4.80	0.45	2.981*	.027

Note. *M* = Mean; *SD* = Standard deviation; *F* = ANOVA, η^2 = eta squared, **p* < .05

The teachers' work location (urban/rural/both) produced statistically significant differences in both countries. We can see that the Florentine teachers (Table 12) from urban areas revealed more benefits in using apps to enhance socialization than the teachers from rural areas or with jobs in both places ($F(2) = 3.31$, $p < .040$, $\eta^2 = .007$) (item 72 - D1). The same occurred with the use of apps for developing communication ($F(2) = 3.45$, $p < .035$, $\eta^2 = .025$) (item 73 - D2) and expressing emotions ($F(2) = 3.73$, $p < .027$, $\eta^2 = .020$) (item 76 - D2).

The participants from Granada (Table 12) who worked in both locations (rural and urban) found more benefits than those who were only in either rural or urban areas in using apps as a complement to reinforce what had previously been worked on ($F(2) = 4.40$, $p < .014$, $\eta^2 = .040$) (item 69 - D1).

Table 12

Significant differences in the benefits and uses of apps as a function of the work location of teachers from Florence and Granada

		Work Location, Florence							
	Dependent Variables	Urban (*n* = 19)		Rural (*n* = 95)		Both (*n* = 13)		*F*	η^2
		M	*SD*	*M*	*SD*	*M*	*SD*		
D1	72. Enhance socialization	3.89	0.88	3.39	0.95	3.85	0.80	3.309*	.007
D2	73. Develop communication	4.21	0.71	3.65	1.03	4.08	0.49	3.449*	.025
	76. Develop the expression of emotions	3.89	0.81	3.31	1.09	3.85	0.69	3.725*	.020
		Work Location, Granada							
	Dependent Variables	**Urban (*n* = 110)**		**Rural (*n* = 44)**		**Both (*n* = 5)**		***F***	$\boldsymbol{\eta^2}$
		M	***SD***	***M***	***SD***	***M***	***SD***		
D1	69. A complement for reinforcing…	4.29	0.78	3.95	1.10	5.00	0.00	4.404*	.040

Note. *M* = Mean; *SD* = Standard deviation; *F* = ANOVA, η^2 = eta squared, **p* < .05

The work location revealed differences in the participants from the two cities. The general teachers from Florence (Table 13) showed more agreement over the use of apps for developing oral language, compared to those who worked as both general and support teachers ($F(2) = 4.47$, $p < .013$, $\eta^2 = .07$) (item 74 - D1).

Table 13

Significant differences in the benefits and uses of apps as a function of the teaching position of the educators from Florence

	Type of Teacher, Florence							
Dependent Variables	**General (*n* = 33)**		**Support (*n* = 71)**		**Both (*n* = 22)**		***F***	***η²***
	M	***SD***	***M***	***SD***	***M***	***SD***		
D2 74. Develop oral language	3.97	0.85	3.61	1.01	3.14	1.25	4.470*	0.71

Note. *M* = Mean; *SD* = Standard deviation; *F* = ANOVA, η^2 = eta squared, *$p < .05$

The general teachers from Granada (Table 14) were more in agreement, with a medium effect size ($d \geq 0.50$), on the use of apps as a way to enhance learning how to write, compared with the support teachers (Therapeutic Pedagogy) ($t(85) = 2.13$, $p = .037$) (item 82 - D2).

Table 14

Significant differences in the benefits and uses of apps as a function of the teaching position of the educators from Granada

	Type of Teacher, Granada						
Dependent Variables		**General (*n* = 30)**		**Support (Therapeutic pedagogy) (*n* = 55)**		***t***	***d***
		M	***SD***	***M***	***SD***		
D2	82. Enhance learning how to read	4.20	0.81	3.73	1.06	2.13*	0.50

Note. *M* = Mean; *SD* = Standard deviation; *t* = Student's *t*, *d* = Cohen's *d*, *$p < .05$.

The apps specifically for people with autism shown in Table 15 have been ordered according to the ranking of the best apps established by Gallardo-Montes et al. (2021). In this ranking, the highest-rated and highest quality apps on a national and international level were positioned in descending order.

The teachers from Florence (N = 127) did not reveal a significant use of apps specifically for people with autism; only three of them were highly used out of the 23 that were presented: *MITA: Language and Cognitive Therapy* (n = 27) (focused on working

with the basic instrumental skills, executive functions, and leisure and entertainment) (languages: Italian, English and Spanish), *Aboard CAA (ACC)* (*n* = 26) (languages: English), and *Symbotalk - AAC Talker* (*n* = 18) (both focused on developing communication, language and the executive functions) (languages: Italian, English and Spanish).

The educators from Granada (*N* = 159) did reveal a greater use of specialized apps. Of the 23 apps set out, 12 were used the most: *#Soyvisual* (*n* = 80) (language: Spanish); *Smile and Learn: Juegos educativos para niños* (*n* = 73) (languages: Italian, English and Spanish); *LEA: lecto escritura para autismo* (*n* = 69) (language: Spanish); *José Aprende* (*n* = 69) (language: Spanish); *¡Emociones, sentimientos y expresiones!* (*n* = 57) (language: English); *Proyecto emociones* (*n* = 44) (language: Spanish); *Proyect@ PECS* (*n* = 40) (language: English); *MITA: Language and Cognitive Therapy* (*n* = 32) (languages: Italian, English and Spanish); *Symbotalk - AAC Talker* (*n* = 45) (languages: Italian, English and Spanish); *Juego de niños para bebés de 2 a 5 años* (*n* = 38) (language: English); *Aboard CAA (ACC)* (*n* = 23) (language: English); and *Lista visual -Visual Schedule* (*n* = 21) (languages: Italian, English and Spanish). These apps were designed for developing communication, language and the emotions (Theory of Mind), enhancing the basic instrumental skills, the executive functions, time management, and leisure and entertainment.

Table 15

Quality, specialized apps for people with autism used by the teachers from Florence and Granada

App	Languages of the app				Florence	Granada
	Spanish	Italian	English	Other	*N* (%)	*N* (%)
1. #Soyvisual	X				1(0.8)	80(50.3)
2. Otsimo Juegos de educación especial para niños	X		X		3(2.4)	11(6.9)
3. MITA: Language and Cognitive Therapy	X	X	X		27(21.3)	32(20.1)
4. Smile and Learn: Juegos educativos para niños	X	X	X		5(3.9)	73(45.9)
5. CPA: Comunicador personal adaptable	X				2(1.6)	6(3.8)
6. Symbotalk - AAC Talker	X	X	X		18(14.2)	45(28.3)
7. Michelzhino - emoçoes e autismo				X	1(0.8)	4(2.5)
8. Visual schedules and Social stories			X		4(3.1)	10(6.3)
9. LEA: lecto escritura para autismo	X				2(1.6)	69(43.4)
10. Autastico			X		2(1.6)	10(6.3)
11. Juego de niños para bebés de 2 a 5 años			X		4(3.1)	38(23.9)
12. Terapia Z Tabletem			X		1(0.8)	6(3.8)
13. ¡Emociones, sentimientos y expresiones!			X		4(3.1)	57(35.8)
14. Commboards: gratis terapia del autismo AAC	X		X		4(3.1)	9(5.7)
15. Proyecto emociones	X				3(2.4)	44(27.7)
16. Aboard CAA (ACC)				X	26(20.5)	23(14.5)
17. Social skills for autism Kloog2			X		2(1.6)	6(3.8)

18. José Aprende	X			0(0.0)	69(43.4)
19. Proyect@ PECS			X	8(6.3)	40(25.2)
20. Vi.co hospital Lite	X	X	X	13(10.2)	4(2.5)
21. Lista visual -Visual Schedule	X	X	X	0(0.0)	21(13.2)
22. ABA DrOmnibus for Parents			X	10(7.9)	10(6.3)
23. Speech Blubs: Language Therapy			X	13(10.2)	18(11.3)

Statistically significant differences were revealed in the use of specialized apps for people with autism according to the city of origin (Table 16).

The educators from Florence were different in the use of 2 specialized apps compared to those from Granada: *Juego de niños para bebés de 2 a 5 años* (language: English) ($t(284) = -5.13$, $p = .000$) and *Vi.co hospital Lite* (languages: Italian, English and Spanish) ($t(284) = 2.77$, $p = .006$) with a small ($d \geq 20$) and medium ($d \geq 0.50$) effect size, respectively.

The participants from Granada revealed that they made greater use of 10 specialized apps compared to those from Florence. Those with a large effect size ($d \geq 0.80$) between them are: *#Soyvisual* (language: Spanish) ($t(284) = -10.99$, $p = .000$), *LEA: lecto escritura para autismo* (language: Spanish) ($t(284) = -9.25$, $p = .000$) and *José Aprende* (language: Spanish) ($t(284) = -9.83$, $p = .000$). The apps with a medium effect size ($d \geq 0.50$) are: *¡Emociones, sentimientos y expresiones!* (language: English) ($t(284) = -7.28$, $p = .000$), *Proyecto emociones* (language: Spanish) ($t(284) = -6.08$, $p = .000$), *Proyect@ PECS* (language: English) ($t(284) = -4.37$, $p = .000$) and *Lista visual -Visual Schedule* (languages: Italian, English and Spanish) ($t(284) = -4.38$, $p = .000$). While the following apps show a small effect size: *Smile and Learn: Juegos educativos para niños* (languages: Italian, English and Spanish) ($t(284) = -8.93$, $p = .000$), *Symbotalk - AAC Talker* (languages: Italian, English and Spanish) ($t(284) = -2.90$, $p = .000$) and *Autastico* (language: English) ($t(284) = -1.98$, $p = .000$).

Table 16

Statistically significant differences in the use of specialized apps according to the city of origin

Name of the app	**Florence**		**Granada**		***t***	***d***
	M	***SD***	***M***	***SD***		
1. #Soyvisual	0.01	0.09	0.50	0.50	-10.99***	1.36
4. Smile and Learn: Juegos educativos para niños	0.40	0.20	0.46	0.50	-8.93***	0.16
6. Symbotalk - AAC Talker	0.14	0.35	0.28	0.45	-2.90**	0.35
9. LEA: lecto escritura para autismo	0.02	0.13	0.43	0.50	-9.25***	1.12
10. Autastico	0.02	0.13	0.06	0.24	-1.98*	0.21
11. Juego de niños para bebés de 2 a 5 años	0.03	0.18	0.24	0.43	-5.13***	0.64
13. ¡Emociones, sentimientos y expresiones!	0.03	0.18	0.36	0.48	-7.28***	0.91

15. Proyecto emociones	0.02	0.15	0.28	0.45	-6.08***	0.78
18. José Aprende	0.00	0.00	0.43	0.50	-9.83***	1.22
19. Proyect@ PECS	0.06	0.24	0.25	0.44	-4.37***	0.54
20. Vi.co hospital Lite	0.10	0.30	0.03	0.16	2.77**	0.29
21. Lista visual -Visual Schedule	0.00	0.00	0.13	0.34	-4.38***	0.54

Note. *M* = Mean; *SD* = Standard deviation; *t* = Student's *t*, *d* = Cohen's *d*, **p* < .05, ***p* < .01, ****p* < .001.

4. Discussion and conclusions

ICT offers a world of possibilities that, combined with responsible usage, can encourage and enhance cognitive processes and the development of different capabilities in people with functional diversity. More specifically, it has been shown that apps are a motivating tool (Martínez, 2020) and a good teaching option for working with people with autism (Lledó et al., 2020), but their use is not as widespread as it should be.

The frequency with which the participants used the apps lies between the options "sometimes" and "quite a lot", with a slightly higher frequency observable for the teachers from Granada. In fact, the Spanish participants found more benefits and greater applicability in apps for attending to people with autism than their Florentine counterparts.

Generally speaking, the participants from both countries found that the apps were beneficial because they could be used as a complement to traditional media and methods, in order to consolidate and reinforce concepts previously worked on and, furthermore, as a motivating resource, a finding that is in line with Martínez (2020). Fewer benefits were found in the use of apps for the learning of reading and for promoting socialization and leisure. Regarding the uses that the teachers made of the apps, these were mostly as a means to hold attention for longer, to enhance communication, to develop autonomy and encourage the learning of calculus. A lesser use of apps was connected to the development and expression of emotions, and to carrying out tasks connected to time management, organization, planning and self-regulation.

Strong correlations, therefore, were found between the benefits and the use of apps. As more benefits were found after using the apps, the educators discovered greater applicability in them for work and attending to people with autism. We also observed that the higher the frequency of app use, the more benefits and applicability the participants from both countries found in them. This suggests that, beforehand, the potential of the apps may not be perceptible, and the apps designed specifically for working with people with autism may not be known (Lledó et al, 2020), or there is a lack of training for their

use (Lledó et al, 2020; Martínez, 2020; Sabayleh & Alramamneh, 2020), but as they are used, the return and practice increase. Teachers need to know what digital resources are suitable for each student (Saladino et al., 2020), in order to be able to use them and give meaning to the educational practice.

As a function of the city of origin, the participants from Granada found more benefits than those from Florence in the apps as a motivating tool for cognitive development, learning how to read, and the promotion of leisure and entertainment. Equally, the Granada teachers revealed a greater use of apps for developing communication (Saladino et al., 2020), oral language and the understanding and expression of emotions.

In terms of sex, the Florentine women used apps more than the men for the purpose of holding attention for longer when attending to people with autism. However, in Granada, the female participants used them more to develop understanding of emotions. There are no previous studies regarding this variable, nor on the use of apps, therefore no comparisons can be made.

The variable of age also produced differences according to country. In Florence, the oldest participants used apps less for developing autonomy in people with autism than their younger colleagues. In Granada, the youngest teachers found more benefits in the use of apps to consolidate concepts and to make psychopedagogic interventions more effective. The participants aged between 41 and 50 years old revealed a greater use of apps for developing communication and to carry out tasks linked to planning and organization when compared to those aged between 31 and 40 years old. These data cannot be compared to previous studies: as stated before, there are no studies that examine these aspects.

According to the variable of the teachers' years of experience with people with autism, while in Granada there were no apparent differences, this was not the case in Florence. The participants with less experience indicated that they used apps for developing communication less than those with more experience. In the study by Saladino et al. (2020) in Italy, it was found that educators who had more professional experience with people with ASD used ICT less frequently. Nevertheless, a priori, these results could be compared due to the similarity of the variable "experience" and "city of origin", as the

data are very generic and do not go into detail about the use of apps or the purpose of using ICT.

Statistically significant differences were also found according to the education stage. In Florence, the teachers of primary education were more aligned with those from preschool education regarding the benefits of apps to facilitate learning how to read. The participants who taught secondary school found more benefits and greater applicability in apps as a socializing tool, for consolidating concepts, for learning calculus, and for holding attention for longer when teaching people with autism, compared to the earlier educational stages. Those participants who worked in both preschool and primary education were more in agreement over the use of apps for developing writing than those who only taught the preschool stage. In contrast to Florence, in Granada the educators who worked with adults and in primary education stated that apps were a motivating tool and that they helped to hold students' attention for longer, in comparison with the participants who worked in secondary education. The main difference occurred in Item 84, regarding the use of apps to hold the attention of people with autism for longer. Whereas in Florence the secondary school teachers were more in agreement over this item than those from preschool and primary education, in Granada it was those from primary education who stood out over those from secondary education.

The location of the teachers' employment also had an influence. In Florence, the participants from urban areas were more in agreement than those from rural areas over the use of apps to enhance socialization, develop communication and expression of emotions. However, the teachers from Granada who worked in both rural and urban areas indicated that they were more aligned over the benefits of apps as a complement to reinforce what had been worked on previously.

Regarding the job description, in Florence those who worked as general teachers showed greater agreement on the use of apps for developing oral language. This was also the case in Granada but in regard to the use of apps for learning how to write.

The use of specialized apps revealed higher use by the teachers from Granada compared to their Florentine counterparts. They were presented with a list of 23 specialized apps that stood out for their quality in catering for people with autism. Only three of these apps had a high usage by the participants from Florence, which were the same apps mentioned in previous studies on the benefits apps provide this group (*MITA:*

Language and Cognitive Therapy, *Aboard CAA (ACC)*, and *Symbotalk - AAC Talker*) (Capel, 2021; Gallardo-Montes et al., 2021a and 2021b). In Granada, there was a more positive tendency. The percentage of apps used was higher, as were the participants who used them. 12 apps were used the most: *#Soyvisual*, *Smile and Learn: Juegos educativos para niños*, *LEA: lecto escritura para autismo*, *José Aprende*, *¡Emociones, sentimientos y expresiones!*, *Proyecto emociones*, *Proyect@ PECS*, *MITA: Language and Cognitive Therapy*, *Symbotalk - AAC Talker*, *Juego de niños para bebés de 2 a 5 años*, *Aboard CAA (ACC)*, and *Lista visual -Visual Schedule*. These results are encouraging, since they mean that the different specialists in autism in the province of Granada support teaching and psychopedagogic therapy with validated digital tools that had the quality required for the needs of people with this disorder. These apps can also be found in previous studies, such as Choez (2018), Díaz (2018), Ramón (2019), Aguilar-Velázquez et al. (2020), Vyshedskiy et al. (2020), Capel (2021), and Gallardo-Montes et al. (2021a y 2021b).

The language of the apps was not a deciding factor for their use. Most of them were in English, yet despite this they were used more by participants from Granada than from Florence. There were statistically significant differences in the use of some apps that were only in Spanish and not in Italian, making the reason for the differences in favour of the teachers from Granada understandable. This only occurred with four apps of the ten that revealed differences, since the rest were in Italian, English and Spanish. For this reason, it should be repeated that language was not a determining factor.

The teachers from both cities highlighted the benefits of apps for cognitive stimulation and their preferred use for developing communication and oral language. These aspects are priorities in the progress of people with autism, as a fundamental part of their comprehensive development. These results fit perfectly with the aforementioned apps, since they were mainly focused on communicative-linguistic development and the executive functions. It was also evident that the apps were used very little for the understanding and expression of emotions, time management, planning and organization, which could be connected to the scarcity of apps aimed at developing the Theory of Mind and time management for people with autism (Gallardo-Montes et al., 2021b). These results could also be due to the teachers' lack of digital training (Lledó et al., 2020; Martínez, 2020; Sabayleh & Alramamneh, 2020) or the insufficient funding and resources available in formal and informal education (Sabayleh & Alramamneh, 2020).

Among the benefits indicated by the teachers, it was highlighted that apps complement the use of other work media such as textbooks or the blackboard, that they are motivating tools for people with autism, and that they were an aid to reinforcing and consolidating concepts. In short, we can say that apps significantly support the development of key competences (Saladino et al., 2020), enable access to the school curriculum (Omar et al., 2020), and provide assistance during cognitive therapies (Escobedo & Tentori, 2014).

For future research, it would be important to address the subject of teachers' digital training regarding the existing resources for working with people with autism (Apps, Eye Tracking, Augmented Reality (AR), Digital Communication Boards, etc.), thus examining further whether different professionals have sufficient training in ICT or if their schools' funding is sufficient for using technologies in classrooms or therapy.

Among the limitations of this study is the difficulty of accessing a larger sample, because the use of apps is not very widespread in the education sphere and in attending to people with autism. Another limitation is tied to the lack of previous studies with which to compare our results in terms of age, sex and professional experience with people with autism.

The practical implications derived from this study are centred on showing the benefits and didactic applications that apps have for people with autism, and the specific use that different specialists make of them on an international level. Finding out the professional perception of these digital resources is essential for guiding current educational practices toward more innovative and flexible learning models.

Funding

This research was supported by the University of Granada and the Spanish Ministry of Education, Innovation and Universities (aid for university teacher training [FPU19/00026]).

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5 | INDICIOS DE CALIDAD DE LOS ARTÍCULOS PUBLICADOS

Los trabajos realizados para esta tesis doctoral planteada por compendio de artículos cumplen con los requisitos establecidos por la Escuela Internacional de Posgrado de la Universidad de Granada. Se presentan a continuación los indicios de calidad de los artículos publicados, los cuales se encuentran en las bases de datos de Web of Science y Scopus.

5.1 Diseño de un sistema de indicadores para la evaluación y selección de aplicaciones para personas con Trastorno del Espectro Autista

Este artículo se publicó en el volumen 25, número 3, del año 2021 en la "Revista Electrónica Educare" (ISSN: 1409-4258).

Referencia: Gallardo-Montes, C.P., Caurcel, M.J. y Rodríguez, A. (2021). Diseño de un sistema de indicadores para la evaluación y selección de aplicaciones para personas con Trastorno del Espectro Autista. *Revista Electrónica Educare, 25*(3), 1-24. https://doi.org/10.15359/ree.25-3.18

Esta revista se encuentra indexada en la base de datos Scopus. Con un factor de impacto en Scimago Journal Rank (SJR) de 0,261 (Q3). Además, está presente en otras bases de datos relevantes en el panorama nacional e internacional como SciELO, Emerging Sources Citation Index (ESCI), Redalyc, Latindex, DOAJ, entre otras.

La "Revista Electrónica Educare" es editada y publicada por el Centro de Investigación y Docencia en Educación (CIDE) de la Universidad Nacional de Costa Rica. Se encuentra en la posición 821 de la categoría de *Educación* de un total de 1275 revistas.

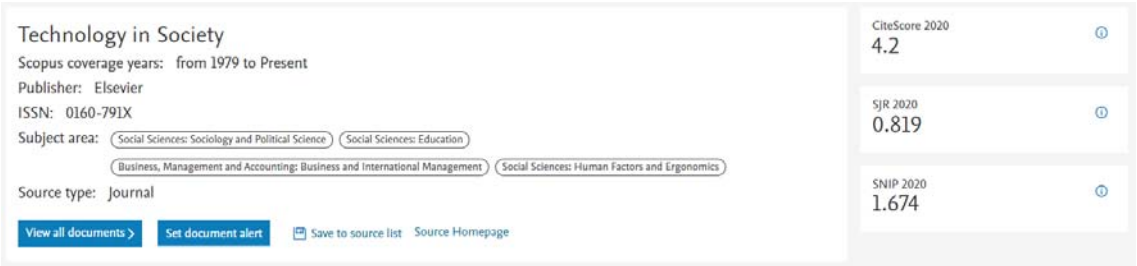
5.2 Apps for people with autism: Assessment, classification and ranking of the best

Este artículo se publicó en el volumen 64, con el número de artículo 101474, del año 2021 en la revista "Technology in Society" (ISSN: 0160-791X).

Referencia: Gallardo-Montes, C.P., Rodríguez, A. y Caurcel, M.J. (2021). Apps for people with autism: Assessment, classification and ranking of the best, *64*, 101474. https://doi.org/10.1016/j.techsoc.2020.101474

Esta revista se encuentra indexada en la base de datos Web of Science, con un factor de impacto en Journal Citation Reports (JCR) de 4,192 (Q1 y 1º Decil). También se encuentra indexada en la base de datos Scopus, con un factor de impacto en Scimago Journal Rank (SJR) de 0,819 (Q1).

La Revista "Technology in Society" es editada y publicada por la editorial ELSEVIER. Se encuentra en la posición 10 de la categoría de *Ciencias Sociales, Interdisciplinar* de un total de 110 revistas.



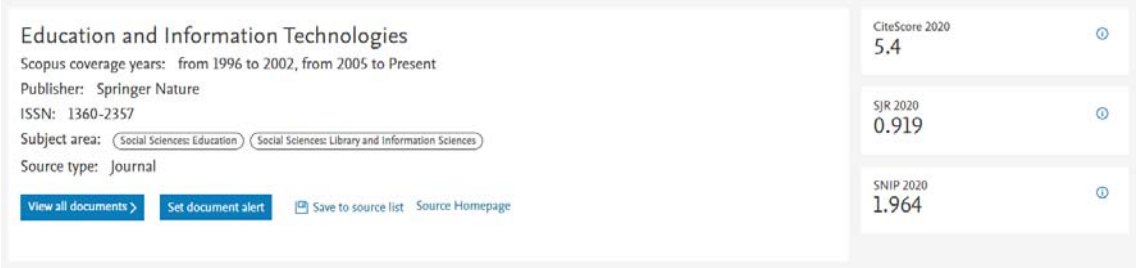
5.3 Technologies in the education of children and teenagers with autism: evaluation and classification of apps by work areas

Este artículo se publicó en el año 2021 en la revista "Education and Information Technologies" (ISSN: 1573-7608).

Referencia: Gallardo-Montes, C.P., Caurcel, M.J. y Rodríguez, A. (2021). Technologies in the education of children and teenagers with autism: evaluation and classification of apps by work areas. *Education and Information Technologies*. https://doi.org/10.1007/s10639-021-10773-z

Esta revista se encuentra indexada en la base de datos Web of Science, con un factor de impacto en Journal Citation Reports (JCR) de 2,917 (Q2). También se encuentra indexada en la base de datos Scopus, con un factor de impacto en Scimago Journal Rank (SJR) de 0,919 (Q1).

La Revista "Education and Information Technologies" es editada y publicada por la editorial Springer. Es el Diario Oficial del Comité Técnico de Educación de la International Federation for Information Processing (IFIP). Se encuentra en la posición 85 de la categoría de *Educación e investigación educativa* de un total de 265 revistas.



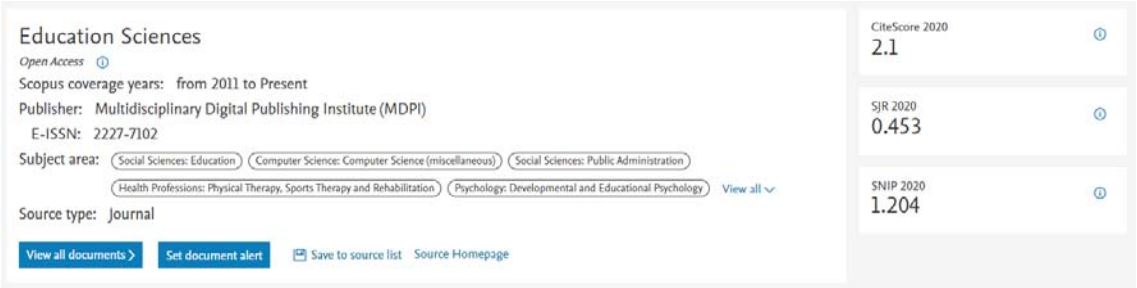
5.4 Psychometric properties of the questionnaire "Demands and potentials of ICT and apps for assisting people with autism" (DPTIC-AUT-Q)

Este artículo se publicó en el volumen 11, número 10, del año 2021 en la revista "Education Sciences" (ISSN: 2227-7102).

Referencia: Rodríguez, A., Caurcel. M.J., Gallardo-Montes, C.P. y Crisol, E. (2021). Psychometric properties of the questionnaire "Demands and potentials of ICT and apps for assisting people with autism" (DPTIC-AUT-Q). *11*(10), 586. https://doi.org/10.3390/educsci11100586 (Autora de correspondencia).

Esta revista se encuentra indexada en la base de datos Scopus. Con un factor de impacto en Scimago Journal Rank de 0,453 (Q2). También se encuentra indexada en la base de datos Web of Science, con un factor de impacto en Journal Citation Indicator (JCI) de 1,03 (Q2).

La "Education Sciences" es editada y publicada la editorial MDPI. Se encuentra en la posición 547 de la categoría de *Educación* de un total de 1275 revistas.



5.5 Functionality of apps for people with autism. Comparison between educators in Florence and Granada

Este artículo fue enviado a la revista "International Journal of Environmental Research and Public Health" (ISSN: 1660-4601) el día 22 de abril de 2022 y se encuentra en proceso de evaluación por parte del editor.

Esta revista se encuentra indexada en la base de datos Web of Science, con un factor de impacto en Journal Citation Reports (JCR) de 3,390 (Q1). También se encuentra indexada en la base de datos Scopus. Con un factor de impacto en Scimago Journal Rank de 0,747 (Q2).

La revista "International Journal of Environmental Research and Public Health" es editada y publicada la editorial MDPI. Se encuentra en la posición 42 de la categoría de *Public, environmental & occupational health* de un total de 176 revistas.

6 | CONCLUSIONES

6.1 Conclusiones según los objetivos propuestos

En cuanto al **primer objetivo** propuesto para el desarrollo de esta tesis doctoral: "Diseñar y validar un instrumento de evaluación de apps para personas con autismo", se creó el "Sistema de indicadores para la evaluación de apps para personas con Trastorno del Espectro Autista", cuya validación se encuentra publicada en la *Revista Electrónica Educare*. Se cuenta con la patente de este sistema de indicadores en el registro general de la propiedad intelectual con el Número de Asiento Registral 04/2021/3877.

El sistema de indicadores sometido a juicio de expertos resultó válido y fiable. Las dimensiones, los indicadores y subindicadores recibieron puntuaciones altas. El coeficiente de confiabilidad inter-jueces (ICC) fue excelente y el coeficiente *W* de Kendall mostró una concordancia significativa entre jueces en cuanto a la claridad, coherencia, relevancia y objetividad de la propuesta y, un alto índice de concordancia entre los rangos asignados. Por tanto, se puede concluir que el sistema era sólido, con indicadores con alto nivel de logro y unos niveles de consistencia interna excelentes.

Durante el diseño del sistema de indicadores, fueron floreciendo diferentes inquietudes acerca de la diversidad de aplicaciones existentes y los posibles criterios a valorar. Estos criterios han seguido un análisis en profundidad, de forma que se han seleccionado los que posibilitaban una evaluación de las aplicaciones lo más enriquecedora posible. Se pretendía, ante todo, que este instrumento fuera intuitivo y completo, ya que se partió de estudios previos con gran rigor científico.

Existe un amplio abanico de aplicaciones destinadas a personas con TEA, y realizar una exploración acerca de lo que cada una de ellas ofrece no es sencillo. Sin embargo, resulta imprescindible indagar en las funcionalidades que presentan cada una de ellas, ya que, al hablar de una necesidad especial, el proceso de aprendizaje es más particular. De esta forma, ser meticuloso en este aspecto y reflexionar sobre los materiales y herramientas ofrecidas a estas personas es relevante para ofrecerles la calidad de vida merecida. Dado que las TIC han avanzado y, a día de hoy, resultan enriquecedoras para las personas con TEA, hacer un uso adecuado de ellas supone un auge en su aprendizaje.

Es necesario contar con materiales y herramientas que faciliten al usuario la elección de las aplicaciones que mejor se adapten a las necesidades de la persona con TEA. En este sentido, siguiendo el sistema de indicadores la búsqueda por parte de

especialistas y familiares partirá de parámetros previamente establecidos y con criterios adecuados al ámbito que se quiera trabajar con la persona con TEA.

El **segundo objetivo** propuesto fue: "Evaluar las apps gratuitas de Google Play Store específicas para personas con autismo", que se materializa junto al **tercero**: "Determinar qué apps son mejores que otras según su calidad y conocer en qué áreas del desarrollo se centran". Estos objetivos se desarrollaron en los artículos de las revistas *Technology in Society* y *Education and Information Technologies*.

A través del sistema de indicadores anteriormente validado, se evaluaron de forma exhaustiva 155 apps para Android, disponibles de forma gratuita en el catálogo de Google Play Store. Para seleccionar las apps destinadas a personas con autismo se utilizó el término de búsqueda "autismo" en español e inglés. Las apps fueron evaluadas y puntuadas en torno a su diseño, contenido y su dimensión pedagógica. La evaluación concluyó ofreciendo un ranking de apps, diferenciando entre las altamente recomendables, recomendables y no recomendables. Solamente 14 apps obtuvieron puntuaciones notablemente superiores al resto: *#Soyvisual*, *Otsimo, Autism language and cognitive therapy with MITA*, *Smile and Learn: Juegos educativos para niños*, *CPA*, *SymboTalk - AAC Talker*, *Michelzhino - emoçoes e autism*, *Visual schedules and social stories*, *LEA: lecto escritura para autismo*, *Autastico*, *Juegos de niños para bebes de 2 a 5 años*, *Terapia Z Tabletem*, *Emociones, sentimientos y expresiones!* y *CommBoards - gratis terapia del autismo AAC*.

Tras la revisión de cada una de las apps ofrecidas de manera gratuita por Google Play Store se pudo apreciar como muchas de ellas no estaban destinadas a personas con autismo, sino únicamente a familias o profesionales, por lo que resulta esencial poder seleccionar aquellas creadas exclusivamente para personas con este trastorno, ya que el catálogo ofrecido superó las 450 apps (usando los descriptores "autismo" y "autism"). A su vez, muchas de las aplicaciones sugeridas no se centraban en las necesidades de personas con autismo, sino que surgían aleatoriamente al realizar la búsqueda, por lo que en una búsqueda arbitraria se encontrarían centenares de aplicaciones donde, a priori, las diseñadas específicamente para los usuarios serían escasas en relación con todas las que muestra el buscador.

Resulta sorprendente que ámbitos, tan necesarios de desarrollar desde edades tempranas en personas con autismo, como el emocional o la gestión temporal (rutinas, anticipación, planificación, organización…) tuvieran tan poca presencia en el catálogo de

apps. Tan solo hubo 24 apps pertenecientes al área de las emociones y 18 de gestión del tiempo. En cambio, para el resto de áreas revisadas, la presencia fue notablemente superior: funciones ejecutivas (n = 148), lenguaje (n = 91), ocio y entretenimiento (n = 82), comunicación (n = 72), habilidades instrumentales básicas (n = 63).

También cabe destacar que en la mayoría de apps no se especificaba la edad para la que estaba destinada. Sin embargo, es fundamental que aspectos de esta índole se muestren, ya que ayudan a seleccionarlas de manera más adecuada.

El **cuarto objetivo**, destinado a "Diseñar y validar un cuestionario para conocer la funcionalidad y aplicabilidad que encuentran los profesionales en autismo en las apps" concluyó con la creación del cuestionario DPTIC-AUT-Q, publicado en la revista *Education Sciences*. Se cuenta con la patente de este instrumento en el registro general de la propiedad intelectual con el Número de Asiento Registral 04/2021/4367.

El instrumento fue sometido a validación mediante juicio de expertos, Análisis Factorial Exploratorio (AFE) y Análisis Factorial Confirmatorio (AFC). Las consideraciones del comité de expertos, al pertenecer a diferentes ámbitos profesionales, aportaron mayor validez y fuerza en el proceso de esta investigación, contribuyendo a la rigurosidad del cuestionario. En esta validación, ninguno de los 125 ítems fue eliminado. La confiabilidad inter-jueces fue excelente por valores ICC por encima de 0,750 y una W de Kendall significativa. Por tanto, mostró una concordancia significativa entre los rangos asignados por los jueces para todas las subescalas del cuestionario y una adecuada validez de contenido.

En cuanto a la validez de constructo, antes de realizar el AFE, cinco ítems fueron eliminados por sus índices de asimetría y curtosis superiores a -2,5 y 2,5. Tras el AFE, en la Subescala 3 se observaron problemas de saturación en un ítem, por lo que fue eliminado. La forma definitiva del cuestionario constó de 119 ítems repartidos en cuatro subescalas: Subescala 1. Opinión, formación y usos de las TIC por parte del profesional para atender a personas con diversidad funcional; Subescala 2. Formación y usos de las TIC por parte del profesional para atender a las personas con autismo; Subescala 3. Usos y beneficios de las apps en la atención de las personas con autismo; Subescala 4. Usos y posibilidades de las apps específicas para las personas con autismo.

La estructura factorial de la Subescala 1 mantuvo las tres dimensiones planteadas, extrayendo tres factores: "Opinión", "Requerimientos y posibilidades" y "Formación TIC

para Diversidad Funcional". La validez de dicha estructura fue posteriormente corroborada con el AFC, con excelentes índices de bondad de ajuste del modelo.

Para la Subescala 2, el AFE reveló una estructura con tres factores latentes, que se correspondía con las tres dimensiones planteadas: "Formación para autismo", "Beneficios TIC para autismo" y "Usos TIC en autismo", que fue corroborado por el AFC, mostrando valores de ajuste del modelo adecuados.

La Subescala 3 quedó conformada por dos factores, coincidentes con las dos dimensiones planteadas: "Beneficios de las apps para autismo" y "Usos apps en autismo", y mediante procedimientos confirmatorios han mostrado un ajuste adecuado del modelo propuesto.

Por último, la estructura factorial de la Subescala 4 fue de tres factores, subdividiendo la dimensión IX sobre posibilidades de las apps específicas para personas con autismo en dos: "Funcionalidad", "Aplicabilidad"; y manteniendo la dimensión X sobre "Usos de las aplicaciones específicas para autismo" (Factor 3). Esta estructura fue corroborada por el AFC, mostrando valores de ajuste del modelo adecuados.

En cuanto a la consistencia interna, los resultados obtenidos fueron satisfactorios en cuanto a los coeficientes alfa de Cronbach y la fiabilidad compuesta (FC) para todos los factores.

Los resultados presentados mostraron una calidad psicométrica satisfactoria del cuestionario diseñado DPTIC-AUT-Q. Permitiendo concluir, según las evidencias empíricas, que puede utilizarse con garantías en condiciones similares a las aquí presentadas.

Para el **quinto objetivo** planteado, "Indagar en la frecuencia de uso de las apps por parte de los distintos profesionales y los motivos que los llevan a su empleo", se realizó un análisis comparativo entre educadores de Florencia y Granada, a los que se les administró la Subescala 4 (Usos y posibilidades de las apps específicas para las personas con autismo) del cuestionario DPTIC-AUT-Q.

Para este estudio se contó con 1261 profesionales, de los cuales 286 trabajaban con apps. Se analizó la opinión de los educadores pertenecientes al ámbito de la educación Formal y No Formal sobre los beneficios y aplicabilidad de las apps, la frecuencia de uso y el tipo de apps empleadas para personas con autismo.

Los educadores granadinos encontraron más beneficios y aplicabilidad en las apps y manifestaron un uso ligeramente superior a los de Florencia. En término generales, los participantes de ambos países encontraron que las apps eran beneficiosas porque podían usarse como complemento a los medios tradicionales de trabajo, para afianzar y reforzar conceptos trabajados con anterioridad y, además, eran un recurso motivador. Se hallaron menos beneficios en el empleo de apps vinculados al aprendizaje de la lectura y al fomento de la socialización y el ocio. En cuanto a los usos que los educadores hacían de las apps, mayormente se orientaban como medio para mantener la atención durante más tiempo, para facilitar la comunicación, desarrollar la autonomía y alentar el aprendizaje del cálculo. Un menor uso de apps se vinculó al desarrollo y expresión de emociones y a la realización de tareas relativas a la gestión del tiempo, organización, planificación y autorregulación.

Por otra parte, se apreció un mayor desempeño en el uso de apps en cuanto a la ciudad, sexo, edad, años de experiencia, lugar de trabajo y tipo de educador, principalmente a favor de los profesionales de Granada.

En definitiva, podría decirse que las apps apoyaban significativamente el desarrollo de competencias clave, facilitando el acceso al currículum escolar y siendo un apoyo de asistencia durante las terapias cognitivas.

6.2 Limitaciones

La investigación desarrollada presentó algunas limitaciones a lo largo del proceso, las cuales se intentaron abordar desde un primer momento:

Desaparición de apps. Si las apps no cuentan con el éxito suficiente o las descargas esperadas, terminan por desaparecer del catálogo de aplicaciones, ya que a menudo, el desarrollador/ora finaliza su mantenimiento, actualización y soporte. Para contrarrestar esta limitación, se dejaron las apps instaladas en el dispositivo Smartphone durante semanas, o incluso meses, por si era necesario consultar o revisar algún indicador evaluado. Ejemplo de ello es el subindicador “envío de notificaciones”, ya que este suponía valorar si la app notificaba al usuario sobre alguna tarea nueva, una actualización concreta o un recordatorio. También, como las apps *Altamente Recomendables* serían

empleadas en estudios futuros se mantuvieron instaladas para consultarlas de manera rápida y eficaz.

Dificultad de acceso a una muestra superior de educadores de Granada y Florencia que utilicen apps. El empleo de apps no estaba muy extendido en el ámbito educativo y de asistencia a personas con autismo, por lo que el acceso a una muestra superior se veía dificultado. Por ello, se decidió realizar dos estancias de investigación en Florencia, una a principios de 2020 y otra a finales de 2021 para abarcar el mayor número de educadores. De esta forma, se equiparó la muestra de Granada, más accesible por realizarse la tesis doctoral en esta ciudad, en conjunto con la de Florencia.

Escasez de estudios previos con los que comparar los resultados obtenidos en cuanto a la edad, el sexo o la experiencia profesional con personas con autismo. La investigación actual sobre el uso de apps en personas con autismo aun es prematura y pese a que fueron muchos los profesionales que centran su carrera en mostrar los beneficios de las apps con personas con autismo, no se reflejaban las dificultades tras su uso, la frecuencia de empleo o la motivación o beneficios encontrados. Para ello, la búsqueda de investigaciones abordó diversidad de palabras clave (Eye Tracking, Realidad Aumentada, Apps, Tablet, Smartphone, colegio, educación especial, autismo, TEA, etc.), contextos (medicina, terapia ocupacional, logopedia, educación infantil, primaria, superior, adultos, etc.), países (Jordania, India, España, Italia, México, Malasia, etc.) y profesiones del ámbito de la Educación Formal y No Formal (psicólogos, logopedas, maestros, profesores, médicos, etc.).

6.3 Prospectiva de investigación

Dado que esta línea de investigación que ahora se inicia, no se había desarrollado en profundidad hasta el momento, se plantean diferentes vías por las que ampliar el conocimiento existente acerca de esta temática.

Sería interesante evaluar y valorar las apps resultantes introduciendo nuevos términos de búsqueda como “Pictograms”, “Augmentative and Alternative Communication (ACC)” o “Visual Schedules” en español e inglés. De esta forma, se permitiría hacer un barrido completo por todo el material que se ofrece a las personas con autismo y distinguir aquellas apps que mejor se adapten al ámbito de trabajo deseado.

Asimismo, realizar una nueva búsqueda y valoración de apps con los descriptores "autism" y "autismo" tras la primera realizada en 2019, con el fin de reevaluar las apps y comprobar si ha habido cambios, si las apps específicas para personas con autismo han aumentado o disminuido, si las puntuaciones derivadas del sistema de indicadores de evaluación han mejorado tras los años y si se ha ampliado el número de apps centradas en las emociones y la gestión del tiempo

Igualmente, sería revelador conocer por qué los educadores de los ámbitos de la educación Formal y No Formal utilizan las apps con menos frecuencia que otros recursos (programas de ordenador o pantalla digital interactiva) pese a la existencia de estudios que corroboren los beneficios de su uso. Esto puede venir motivado por un mal uso de los dispositivos electrónicos, por una escasa formación en tecnología educativa, por la falta de recursos digitales o por otros motivos relacionados con la propia labor profesional. A su vez, dado que esta tesis se ha desarrollado siguiendo el método cuantitativo, aportaría gran valor continuar reflexionando en la perspectiva del educador a través de entrevistas en profundidad, añadiendo así la importancia y validez de la investigación cualitativa.

Para continuar con la línea de investigación desarrollada, sería enriquecedor administrar el cuestionario DPTIC-AUT-Q a profesionales de otras ciudades y países con el fin de conocer los motivos que los llevan a su uso y la aplicabilidad que encuentran en las diferentes apps específicas para personas con autismo. La idea sería comparar si la tendencia en el uso de apps cambia según el país, a la vez que, si difiere según los años de experiencia, el tipo de educador o la etapa de trabajo.

6.4 Conclusiones y consideraciones finales

Los Smartphone y las Tablets se utilizan con frecuencia en el proceso de enseñanza-aprendizaje, en la terapia y en el contexto familiar de los niños, adolescentes y adultos con autismo. El uso de dispositivos electrónicos es una opción alentadora y atractiva para las personas con este trastorno, debido al formato auditivo, visual e interactivo que ofrecen.

Ante la inminente proliferación tecnológica de contenidos diseñados de manera específica para ellos, es necesario analizar qué es lo que realmente se está ofreciendo a este colectivo, ya que muchos profesionales y familias utilizan a diario dispositivos de

este tipo y emplean las apps para fomentar el desarrollo de habilidades en las que a menudo se presentan dificultades (comunicación, lenguaje, emociones, gestión del tiempo, habilidades instrumentales básicas, funciones ejecutivas y ocio/ entretenimiento).

Este estudio ha permitido comprobar que había centenares de apps específicas para personas con autismo y que cumplían de manera general con los criterios deseables de usabilidad, ergonomía, accesibilidad y disponibilidad. Sin embargo, de las 155 apps revisadas, tan solo 14 de ellas exhibieron un mejor desempeño que el resto, situándose en el grupo de apps *Altamente Recomendables*. Por fortuna, 132 se posicionaron en el grupo de las *Recomendables*, dejando solo 9 en el de *No Recomendables*. Estos resultados fueron alentadores y permitieron ofrecer a familias y especialistas en autismo una amplia variedad de apps de calidad con un diseño, contenido y aspectos pedagógicos diseñados específicamente para usuarios con este trastorno.

A su vez, las apps presentaron contenidos orientados a las necesidades más concretas de las personas con autismo, encontrando un gran número de apps destinadas a las funciones ejecutivas (n = 148), el lenguaje (n = 91), el ocio y entretenimiento (n = 82), la comunicación (n = 72) y las habilidades instrumentales básicas (n = 63). Cabe destacar que el ámbito emocional y la gestión del tiempo tuvieron muy poca presencia de apps en el catálogo de Google Play Store, por lo que se espera que estas áreas se aborden en mayor medida, ya que son parte esencial del desarrollo integral y de la atención temprana.

En cuanto a los beneficios que los distintos educadores encontraban en las apps para la atención de personas con autismo, se halló que estas eran un recurso motivador, que podían usarse como complemento a los medios tradicionales de trabajo y que eran útiles para afianzar y reforzar conceptos trabajados con anterioridad. Con respecto a la aplicabilidad de las apps, los educadores manifestaron que las usaban principalmente para mantener la atención durante más tiempo, para facilitar la comunicación, desarrollar la autonomía y alentar el aprendizaje del cálculo. De manera general, la frecuencia de uso de apps entre los distintos educadores analizados se posicionó entre las opciones “a veces” y “bastante”, lo que aun deja mucho margen a un uso más extendido y frecuente de apps.

Las TIC y, concretamente las apps, como se ha ido vislumbrando, son una opción innovadora y a la orden del día, tanto en el ámbito educativo como en el social. Es práctico y esencial que desde el entorno de la atención a la diversidad se for
tecnologías y se eduque hacia su uso, dado que están presentes en el contexto diario de cualquier

persona. Conseguir que los educadores de centros educativos y asociaciones que trabajan con personas con autismo adquieran los conocimientos necesarios para aplicar metodologías apoyadas en TIC es una ardua tarea, pero valiosa, de cara a un desarrollo íntegro de las personas con diferentes capacidades.

No debe pasarse por alto la importancia del trabajo conjunto de programadores y equipos especializados en la atención de personas con diversidad funcional, dado el énfasis actual en la accesibilidad universal y los avances desarrollados por la W3C para garantizar dicho principio.

6 | CONCLUSIONS

6.1 Conclusions and final considerations

Smartphones and tablets are frequently used in the teaching-learning process, in therapy and in the family context of children, adolescents and adults with autism. The use of electronic devices is an attractive and encouraging option for people with this disorder, due to the auditory, visual and interactive formats they offer.

Faced with the imminent technological proliferation of content designed specifically for people with autism, we need to analyse what is really being offered to them, since many professionals and families make daily use of these types of devices and use apps to enhance the development of the skills they often have difficulty with (communication, language, emotions, time management, basic instrumental skills, executive functions, and leisure/entertainment).

This study has made it possible to show that there are hundreds of specialized apps for people with autism and that, in general, they meet the desired criteria of usability, ergonomics, accessibility and availability. However, of the 155 apps reviewed, only 14 of them reached a level of performance that was above the rest. These 14 comprised the group of *Highly Recommendable* apps. Fortunately, 132 apps were rated as *Recommendable*, leaving only 9 to make up the group of *Not Recommendable* apps. These results were encouraging and made it possible to provide families and autism specialists with a wide variety of quality apps that had their design, content and pedagogical aspects created specifically for users with this disorder.

At the same time, the apps presented content oriented to the more specific needs of people with autism. A large number of apps focused on the executive functions (n = 148), language (n = 91), leisure and entertainment (n = 82), communication (n = 72), and the basic instrumental skills (n = 63). It is worth mentioning, however, that the emotional sphere and time management were barely tackled in apps in the Google Play Store catalogue, and it is therefore to be hoped that these areas are given greater attention, since they are an essential part of an integrated development and early care.

Regarding the benefits that the different educators found in the apps for assisting people with autism, it was observed that they were a motivating resource that could be used as a complement to traditional working media, and that they were useful for consolidating and reinforcing concepts that had been worked on previously. In terms of

the apps' applicability, the educators revealed that they used them mainly to hold attention for longer, to enhance communication, develop autonomy and encourage the learning of calculus. Generally speaking, the frequency of use of apps by the different educators analysed was located between the response options of "sometimes" and "quite a lot", which still leaves plenty of margin for more widespread and frequent use.

ICT and, specifically, apps are, as I have made clear, an innovative option that is very much the order of the day, both in education and in the social sphere as well. It is both practical and vital that, working in an environment that caters for diversity, there is training in technologies and education regarding their use, given that ICT is present in the daily life of everyone. It is an arduous but absolutely worthy task for the professionals from schools and associations that work with people with autism to acquire the necessary knowledge to apply methodologies based on ICT, as this will help achieve the integrated development of people with different capabilities.

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