Contemporary Educational Technology, 2026, **18**(3), ep653
ISSN: 1309-517X (Online)

OPEN ACCESS

Research Article

Teachers' ICT use, training, and benefits in preschool education for autistic children in Spain

Dulcenombre de María Fernández-Montoro [1]
0009-0004-8020-574X

Juan Manuel Trujillo-Torres [1]
0000-0002-2761-3523

María Dolores Benítez-Márquez [2]
0000-0001-8785-863X

Carmen Rocío Fernández-Fernández [1*]
0000-0002-8077-414X

[1] Department of Didactics and School Organization, University of Granada, Granada, SPAIN
[2] Department of Applied Economics (Statistics and Econometrics), University of Málaga, Málaga, SPAIN
[*] Corresponding author: carmenrocio@ugr.es

Citation: Fernández-Montoro, D. M., Trujillo-Torres, J. M., Benítez-Márquez, M. D., & Fernández-Fernández, C. R. (2026). Teachers' ICT use, training, and benefits in preschool education for autistic children in Spain. *Contemporary Educational Technology, 18*(3), Article ep653. https://doi.org/10.30935/cedtech/18514

ARTICLE INFO

Received: 8 Aug 2025
Accepted: 11 Apr 2026

ABSTRACT

This study addresses the training, benefits, and use of information and communication technology (ICT) by early childhood education (ECE) teachers working with children with autism in Andalusia, Spain. Specifically, it analyzes the impact of perceptions regarding the use and benefits of ICT on teacher training, in a context where digital transformations require specific skills and training. A snowball sampling method was used to collect data from 254 active teachers in early childhood education centers with autistic children. The data were analyzed using a partial least squares structural equation model. Additionally, control variables such as age, years of teaching experience, and years of experience with autistic children were included. The final model revealed that perceptions of the use and benefits of ICT have a positive impact on teacher training. Furthermore, years of experience in early childhood education with autistic children positively influenced training, while age had a negative impact. Teachers highlighted the need for equitable interventions and the importance of ensuring the presence of specialized teachers in autism in all educational centers. The study emphasizes the importance of teacher training in ICT to improve the education of children with autism. It highlights the need for specific resources, digital platforms, and specialized personnel in educational centers. It also underscores that, just like normotypical students, children with autism must be guaranteed access to quality education provided by qualified professionals.

Keywords: autism, information and communication technologies, teacher training, early childhood

INTRODUCTION

In autism, the usability of information and communication technology (ICT) helps and enhances the therapeutic effectiveness for the difficulties in autism of communication, social interaction (Jonkman et al., 2023), and memory issues (Kim & Kasari, 2023), and simultaneously, it constitutes a current resource (Durán Cuartero, 2021; Fletcher-Watson et al., 2016; Gallardo Montes et al., 2023; Mazon et al., 2019; Mukherjee et al., 2024).

In relation to communication difficulties, the combination of active methodologies such as gamification and emerging technologies like augmented reality is enhancing learning environments that facilitate the

development of essential skills (language, socialization, cognitive, among others) for students with autism spectrum disorder (ASD) (López-Bouzas et al., 2024). Specifically, augmented reality can help address daily life challenges by fostering autonomy in tasks such as dressing, personal hygiene, and others (Lledó et al., 2022). Simultaneously, a connection and coordination between external supports (associations, organizations, etc.) and the school is required (Maenner et al., 2020). All of these factors result in improved social skills when combined with traditional non-ICT games (O'Keeffe & McNally, 2023). Another resource to work on is accurately recognizing emotions; for example, considering that the facial expressions of the instructor are relevant for the students (Zhang et al., 2023).

However, prior assessment is required to determine each student's needs, after which touchscreen technology and voice recognition can be used to develop a set of human-computer interaction (HCI) games (Liu et al., 2022).

Finally, mobile applications hold great potential for skill development, with most focusing on executive functions, language, and entertainment, while a minority are dedicated to helping children connect with emotional aspects or time management (Gallardo Montes et al., 2023).

Literature Review

Implementation of ICTs in ECE

Regarding the implementation of ICTs in early childhood education (ECE) referring to neurotypical children, the systematic review of the literature by Jannah et al. (2026) analyzes how teachers carry out such integration of ICTs at this educational stage. On the one hand, Yusuf and Darmasnyah (2025) obtain both positive results (ICT reinforces children's cognitive, social and motor skills (cognitive, social and motor skills) as well as negative results (the integration of ICTs depends on teacher readiness, the digital infrastructure and the digital literacy of parents). On the other hand, Istiana and Widodo (2023) state that the quality of teacher training (teacher training), the state and availability of institutional educational infrastructures, and the commitment of all parties involved are factors that influence the success of ICT implementation. In this line, other authors establish that:

(1) the technological instruments used by teachers may be available, but those teachers may not be pedagogically prepared (Ertmer & Ottenbreit Leftwich, 2010; Mas'ud et al., 2022; Subekti et al., 2024),

(2) a lack of in-service training (a lack of in-service training) (Ertmer & Ottenbreit-Leftwich, 2010), and

(3) that low incentives are offered to improve digital competence (Ertmer & Ottenbreit-Leftwich, 2010).

The review by Jannah et al. (2026) summarizes these ideas by pointing out that the integration of ICTs in ECE must be accompanied by continuous training, supportive educational policies, provision of adequate infrastructure and pedagogical approaches for this educational stage. Furthermore, the review concludes that the fundamental challenge is not only the lack of teacher training, but the mismatch that exists between, on the one hand, the technological demand and the structural supply of technology, and, on the other hand, another mismatch between technological capacity or competence and pedagogical capacity (Dogan & Gogus, 2025). Finally, attention should be paid to the discrepancy between technology and its use in classrooms since according to Boude et al. (2024) most of the digital tools used in class have been designed by professionals not related to ECE, therefore, they do not take into account the requirements of these students in this age group (Boude et al., 2024). To summarize in one sentence, Jannah et al. (2026) highlight the idea that the integration of ICTs in ECE will be successful when digital readiness, pedagogical readiness and the infrastructure readiness of schools are balanced in each context.

Also in reference to the implementation of ICTs in ECE, it is highlighted that there are few qualitative studies. A sample of these studies is the research by Yang and Dong (2024) based on the TPACK model (technological, pedagogical and content knowledge), for neurotypical children and in ECE. In this regard, Brianza et al. (2022) adds as a factor influencing implementation the context where such ICTs are applied. In other words, the socio-cultural context is a factor to be taken into account, for example, the country and the city where the educational center is located or the economic status of the location of the educational center within the city (poor districts in the USA versus poor districts in China). In this sense, each teacher has a subjective interpretation regarding the context in which they are located (country, city and area of the city),

which leads to different uses of ICTs or to different ways of implementing the same ICT resources. Thus, from the observation of the qualitative study it follows that the results of the research cannot be standardized to all countries with reference to the implementation of ICTs. These authors conclude that the factors that influence the implementation of ICTs are technological competence, pedagogical competence, content knowledge and the subjective interpretation of the socio-cultural context where ECE takes place. We believe that the implementation of ICTs is a stage prior to use. At the same time, this implementation is a construct closely related to teacher ICT training, since one must be technologically trained to use this resource and continuous training is also required due to the rapidly changing nature of technology.

Regarding ICTs, it can be inferred from the previous section that the integration of ICTs can positively contribute to the digital transformation of schools, leading to effective and efficient changes within the educational institutions (Timotheou et al., 2023). However, ICTs require a certain level of teacher training, starting from early childhood education. In this regard, teachers report a satisfactory level of training in ICT literacy among most early childhood educators (Iancu, 2024). Additionally, ICTs provide unconditional support in the teaching-learning process. This means that their application and use require both the content of teaching and organizational aspects. Moreover, this implies the need for pedagogical support to enhance the information and communication skills of early childhood educators. In conclusion, digital transformation is a complex process that demands large-scale transformative changes that presuppose digital capability and readiness (Timotheou et al., 2023). It is emphasized that ICT training should be implemented from early childhood education and also in promoting the use of new digital methods and tools (Iancu, 2024).

Autism education

Several literature reviews highlight the importance of early autism identification, focusing on regular preschools and primary schools (Genovesi et al., 2022; Mukherjee et al., 2024). Additionally, Other review emphasizes the need for support and research in Asian countries concerning children and parents of all ages (Zakirova-Engstrand & Yakubova, 2024). Regarding diagnosis, there is extensive research on early autism diagnosis and limited research on late diagnosis. Indeed, some authors argue that it is necessary to identify the determinants of late diagnosis, as illustrated by a study conducted on students from preschool to secondary school (age 3 to age 14) in the United Kingdom (UK) (Hosozawa et al., 2020). Therefore, the importance of early detection is evident, aiming to explore the prevalence of intervention and predict the use of interventions (Jonkman et al., 2023).

Therefore, it is crucial to understand the level of ICT training, frequency of use, and types of digital resources to be utilized; despite this, it is occasionally insufficient (Gallardo Montes et al., 2023). Additionally, working and researching ICTs should consider the opinions and priorities of the autistic community. In this sense, a study from the UK reflects that autistic individuals are dissatisfied with the current lack of research focused on autism rather than other types of difficulties (Pellicano et al., 2014).

Other studies refer to the additional support from parents, caregivers, NGO workers, and people from foundations or associations collaborating with autism. In this regard, a study involving 280 autistic adults and their parents conducted in India concluded the need to develop different types of formal support to help parents cope with caregiving (Dey et al., 2024). The difficulty of accessing services faced by many parents due to limited availability and busy schedules is an additional challenge (Hermaszewska & Sin, 2021). A study conducted in Ethiopia on the perspectives and experiences of caregivers, professionals, and other stakeholders in an OMS caregiver skills training program highlights the relevance of such training, as it informs the adaptation and implementation for autistic individuals (Tekola et al., 2020). In this sense, teachers believe that community and healthcare training can help reduce stigma and facilitate family support (Lockwood et al., 2023). Regarding caregiver and facilitator training programs (people who are not specialized in autism but provide assistance), some scholars suggest simplifying the content and adapting the format of these programs according to contexts after gaining experience in an Ethiopian rural setting (Zerihun et al., 2024). Finally, for parents of autistic children to understand the effects of an intensive training program, an evaluation is required to benefit from practice and feedback to improve support for their children (Fang et al., 2022).

Another specific experience in the early childhood context is located in New Zealand (Tupou et al., 2024). In this case, educators conclude that there are similarities between the perspective of neurodiversity and

Māori perspectives on autism. Additionally, these educators identify a need for more training and resources based on a global view (beliefs, culture) available in the Māori language (Tupou et al., 2024).

On the other hand, Shin et al. (2023) emphasize the need for ongoing and long-term professional development regarding the use of educational technology and teaching methods, based on their recent study directed at primary school teachers in Korea. These academics stress that the production and exchange of teaching materials is a gap in the area of support for teaching and learning and is recognized as an area requiring priority support (Jin-ok Kim, 2022, cited in Shin et al., 2023), including budgetary support for content introduction and the provision of a platform for sharing content between schools.

In relation to the three constructs analyzed (use, benefit, and training in educational ICT), it is important to mention the autism research by Gallardo Montes et al. (2023). This empirical study includes a sample of 310 educators from Granada (Spain) from formal and informal education without specifying the level of education. In this case, innovative methodologies based on ICT are a tested and motivating option for working with people with autism. Their objective was to discover the training in ICT they had, its frequency of use, and the types of digital resources that they used. They administered the questionnaire, "demands and potentials of ICT and apps for assisting people with autism" (Rodríguez Fuentes et al., 2021) to 310 educators in the city of Granada (Spain). The participants belonged to schools and associations that worked with people with autism. Non-parametric inferential analysis and intra-factorial correlations analysis were carried out in this study (Gallardo Montes et al., 2023). Among other conclusions, they mentioned although the educators had ICT training for working with people with autism, it is insufficient. There were also statistically significant differences according to sex, gender, age, type of institution, and type of educator. Also, their data support statistically significant differences referring to age, sex, gender, type of institution, and type of educator. The major conclusion in ICT education in autism is that the educators had knowledge but it needs to be acquired and improved this specific knowledge.

Literature review with a critical and technical perspective related to autism

Available evidence consistently suggests that ICT can contribute to the development of communication, social interaction, and certain cognitive processes in students with ASD (Jonkman et al., 2023; Kim & Kasari, 2023). However, a critical examination of the corpus reveals a marked techno-optimistic orientation, characterized by the predominance of studies focusing on the instrumental potential of technologies rather than on the structural conditions that determine their effective implementation in real educational contexts (Durán Cuartero, 2021; Fletcher-Watson et al., 2016; Mukherjee et al., 2024). This asymmetry highlights a tendency to privilege technological innovation over pedagogical and organizational feasibility.

Within the domain of communication and social development, gamification and augmented reality have been identified as promising strategies for fostering functional autonomy and the acquisition of adaptive skills (López-Bouzas et al., 2024; Lledó et al., 2022). Nevertheless, most of these studies rely on short-term experimental designs, which limits their ecological validity and the transferability of findings to ordinary school settings. Furthermore, the literature acknowledges the need for inter-institutional coordination between schools and external support networks (Maenner et al., 2020), underscoring that technology alone lacks transformative capacity unless embedded within coherent pedagogical and organizational frameworks.

Human-computer interaction (HCI) technologies and mobile applications have shown effectiveness in supporting language development and executive functions (Gallardo Montes et al., 2023; Liu et al., 2022; Trujillo Torres et al., 2025). However, a closer analysis of the field reveals some thematic bias toward cognitive and linguistic domains, with comparatively limited attention to emotional regulation and time management. This imbalance suggests that the technological development agenda has been driven more by technical feasibility than by a holistic understanding of the educational needs of students with ASD.

Critical analysis of the state of the art research on early autism identification has expanded considerably (Genovesi et al., 2022; Mukherjee et al., 2024). However, this emphasis has generated a notable underrepresentation of late diagnosis and its educational implications (Hosozawa et al., 2020), thereby limiting longitudinal understanding of educational trajectories. In parallel, the digital transformation of schools is frequently portrayed as an inevitable structural process (Timotheou et al., 2023). Yet empirical evidence presents divergent findings regarding teachers' digital competence. While some studies report

satisfactory levels of digital literacy among early childhood educators (Iancu, 2024), others identify persistent deficits in pedagogical training and curricular integration of ICT (Gallardo Montes et al., 2023). This inconsistency reveals a gap between policy discourse on digitalization and the realities of educational practice. Of particular relevance is the critique raised by the autistic community regarding the limited alignment between research priorities and their actual needs (Pellicano et al., 2014). This criticism exposes epistemological limitations within the field and reinforces the need for participatory and user-centered research approaches. Moreover, research conducted across diverse cultural contexts highlights the central role of socio-familial, community, and cultural factors in the implementation of interventions (Dey et al., 2024; Tekola et al., 2020; Tupou et al., 2024). Despite this, such factors are often treated as peripheral contextual variables rather than as structural components of analysis. Teacher professional development repeatedly emerges as a key determinant of successful ICT integration (Shin et al., 2023). Persistent structural barriers include limited availability of shared resources, insufficient institutional support, and fragmented training policies (Jin-ok Kim, 2023). This fragmentation underscores the need to address ICT use, perceived benefits, and teacher training as interrelated constructs. The study by Gallardo Montes et al. (2023) further confirms this issue by showing that, despite the presence of basic digital competencies, specialized ICT training for autism remains insufficient and uneven, with significant differences across demographic and institutional variables. These findings highlight the importance of contextual factors as key explanatory variables.

Proposed Theoretical Model

This study partially refers to the validated questionnaire by Rodríguez Fuentes et al. (2021). Specifically, it uses the dimension of autism concerning the use, benefit, and training in educational ICTs (d Dimension II). It is based on their confirmatory analysis using CB-SEM in a context where the educational stage referenced by the perceptions of the 122 future educators (pre-service) and association collaborators interviewed was not specified. The confirmatory analysis concludes with positive pairwise covariances between use, benefit, and training. The goal of this study is to apply this model to the field of early childhood education for children with autism, with participants being professional teachers currently working in early childhood education with autistic children aged 3 to 6 years (teacher's in-service during the survey). In CB-SEM, a bidirectional direction is established through the use of covariance. In this case, unidirectional relationships are established, proposing a partial least squares-structural equation model (PLS-SEM) to predict ICT training for early childhood education professionals working with autistic children, distinguishing between dependent and independent constructs. Shin and Hong Jang (2023) for secondary school teachers in Korea also support the positive relationship between perceptions (understood to include benefits) and facilitation of ICT use.

Formally, the following hypotheses are established in the context of early childhood children with autism:

- **H1.** The benefits of educational ICT applications have a positive influence on the training in educational ICT.
- **H2.** The benefits of educational ICT influence positively the use of educational ICT.
- **H3.** The use of educational ICT positively impacts on the training in educational ICT.

Regarding the control variables for training, three control variables have been considered: professional educators' age, years of experience in education, and years of experience in autistic education in early childhood. Gender is not considered as a control variable because the majority of participants are women. Regarding age, some scholars in the field of music in Andalusia conclude that younger age is associated with greater use of ICT (Martos Sánchez et al., 2016).

From an exploratory perspective, given that the dependent variable is training, the hypothesis is proposed that age directly influences ICT training. Additionally, hypotheses are also proposed regarding the impact of years of experience in early childhood education and years of experience in early childhood education with autistic students on training. Thus, the following hypotheses are established:

- **H4.** Age influences teacher training.
- **H5.** Years of experience in early childhood education influence teacher training.
- **H6.** Years of experience in early childhood education with autistic students influence teacher training.

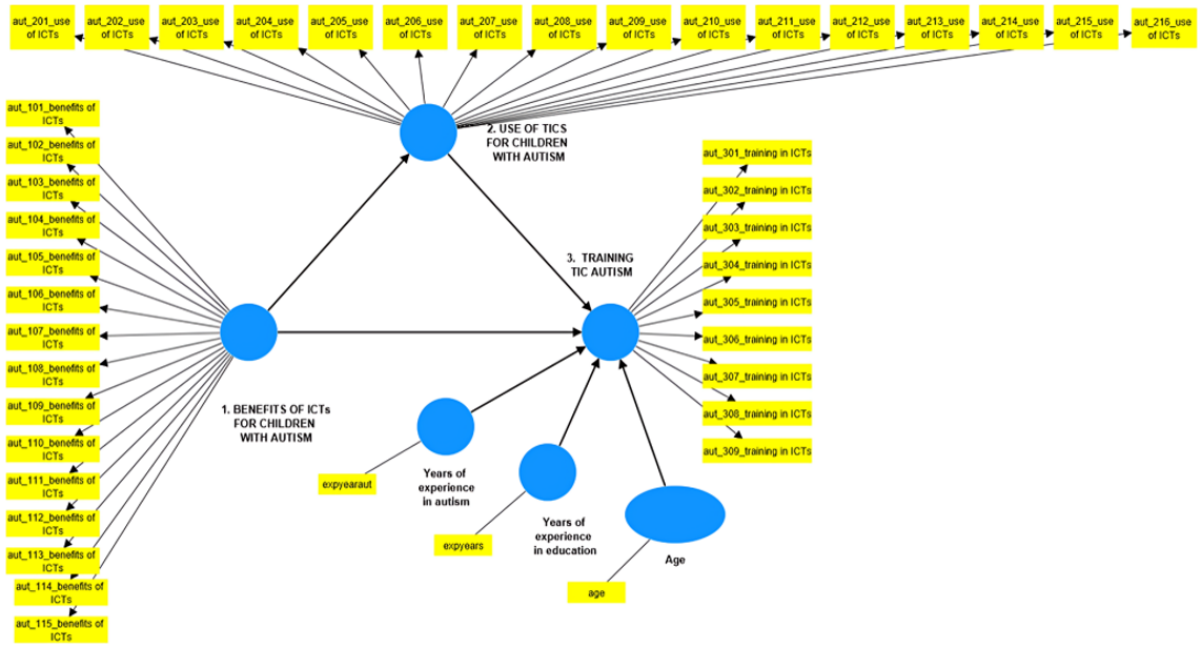

Figure 1. Proposed theoretical model (designed by the authors using Ringle et al. (2024))

The proposed theoretical model is shown in **Figure 1**.

METHODS

The Geographic Context and Participants of the Early Childhood Education System for Children with Autism

Regarding early childhood education in Andalusia (Spain), the number of professionals working in public schools amounts to 15,457, in private-concerted schools to 8,997, and in private schools to 1,197. Concerning professionals working in specific special education centers within public educational institutions, 294 professionals across Andalusia are dedicated solely to students with special needs, including autism (Junta de Andalucía, 2024). The professionals working with autistic students in educational centers in Andalusia are specifically classified under the following designations: teacher of therapeutic pedagogy for integration support (PTAI), teacher of therapeutic pedagogy for specific support (PTAE), technical support personnel for integration (PTIS), and teacher of therapeutic pedagogy in audition and language (PTAL).

Design

Data were collected from November 2022 to September 2023 using Google Forms, with a snowball sampling method. The research is quantitative, utilizing cross-sectional data.

Sample Size

There are various criteria for determining the minimum sample size suitable for multiple regression. The more complex partial regression has four dependent variables. Using the free online software G*power 3 (Faul et al., 2009) to detect effect sizes (f^2) of around 0.10, considering a significance level of 5%, a statistical power of 95%, and five independent variables, a minimum sample size of 158 participants is required. The final sample, after filtering out outliers and inconsistencies, includes 254 valid responses from Andalusian teachers specializing in early childhood education (age 3 to age 6) out of a total of 271 participants, exceeding the previously established size. Of the sample, 82.3% were women and 17.7% were men. The average age is 45.5 years with a standard deviation of 8.416 years.

Table 1. Descriptive statistics on participants' professional characteristics

		Frequency (n)	Percentage (%)	Cumulative percentage (%)
Years of experience	≤ 5 years	18	7.1	7.1
	6-10 years	29	11.4	18.5
	11-20 years	91	35.8	54.3
	21-30 years	81	31.9	86.2
	≥ 31 years	35	13.8	100
	Total	254	100	
Years of experience in autism	≤ 5 years	129	50.8	50.8
	6-10 years	81	31.9	82.7
	11-20 years	35	13.8	96.5
	21-30 years	7	2.8	99.2
	≥ 31 years	2	0.8	100
	Total	254	100	
Type of center	Private school	4	1.6	1.6
	Public school	249	98.0	99.6
	State-subsidized private school	1	0.4	100
	Total	254	100	
Type of escolarization	Ordinary classroom	160	63.0	63.0
	Part-time classroom	74	29.1	92.1
	Specific classroom	20	7.9	100
	Total	254	100	
Type of spectrum	Pervasive developmental disorders	59	23.2	23.2
	ASD	195	76.8	100
	Total	254	100	

Table 1 shows some characteristics of job positions and teachers related to their work. Regarding years of professional experience, 35.8% of teachers have between 11 and 20 years of experience.

Procedure for Data Collection

A non-probability snowball sampling was carried out. The center was contacted via email informing about the research proposal. Participation was voluntary and individual from the teachers to whom a link to the Google Forms questionnaire was sent, informing about the research. Subsequently, they were contacted by telephone to assist in case of doubts when answering the survey. Anonymity and confidentiality were guaranteed.

Indicators and Constructs

The percentage of public centers (state-funded centers) is 98%, and over 60% of the professionals work full-time, as can be inferred from the schooling model in Spain. Specifically, regarding experience in autism, the highest percentage is 50.8% with up to 5 years of experience, while the lowest percentage is 0.8% for those with more than 31 years of experience in autism. The number of manifest variables in the questionnaire is 40. The measurement scales for perceptions of benefits, uses, and training, all referring to educational ICTs for autistic individuals, were validated by Rodríguez Fuentes et al. (2021). The original scales include 15 indicators to measure the benefits of ICTs applied to early childhood autism (ICT_PERCEPT_AUT); 16 indicators to measure the uses of educational ICTs for children with autism (ICT_USES_AUT); and nine items to measure the ICT training of professionals for educating children with autism (ICT_TRAINING_AUT), considered reflective constructs or mode A. Each indicator was measured on a five-point Likert scale, with 1 being "strongly disagree" and 5 being "strongly agree." Subsequently, Rodríguez Fuentes et al. (2021) conducted a confirmatory analysis using M-Plus, establishing positive relationships between these scales. **Table 2** shows the indicators for each construct.

In this case, there is no missing data. Regarding normality, there are several criteria for assessing or detecting non-normality in the distribution of the indicators. One criterion is based on kurtosis, and another on skewness. Following Hair et al. (2017), absolute skewness and/or kurtosis values of greater than 1 are indicative of nonnormality. In this sense, some manifest variables exhibit skewness values exceeding the acceptable threshold of normality (±1), and similarly, skewness shows some absolute values greater than one. **Table 3** shows the descriptive statistics of observed variables.

Table 2. Constructs and indicators

LABEL CONSTRUCT/ Label manifest variable	DESCRIPTION OF INNOVERSABLE AND OBSERVABLE VARIABLES RELATED TO EDUCATION OF EARLYCHILDHOOD WITH AUTISM
1. ICT_BENEFITS_AUT (composite reflective) professional's perceptions on the benefits provided by ICT for people with autism –reflective	
aut_101_benefits of ICTs	Aut101 Increase motivation.
aut_102_benefits of ICTs	Aut102 Support learning.
aut_103_benefits of ICTs	Aut103 Improve learning.
aut_104_benefits of ICTs	Aut104 Facilitate autonomous learning.
aut_105_benefits of ICTs	Aut105 Increase active participation.
aut_106_benefits of ICTs	Aut106 Strengthen memory.
aut_107_benefits of ICTs	Aut107 Improve attention.
aut_108_benefits of ICTs	Aut108 Provide skills for relating to others.
aut_109_benefits of ICTs	Aut109 Help in recognizing emotions in others.
aut_110_benefits of ICTs	Aut110 Help to understand symbolic play.
aut_111_benefits of ICTs	Aut111 Increase skills related to vocabulary acquisition.
aut_112_benefits of ICTs	Aut112 Develop oral language in individuals with autism.
aut_113_benefits of ICTs	Aut113 Help to request something in an instrumental manner.
aut_114_benefits of ICTs	Aut114 Enhance skills related to reading and writing.
aut_115_benefits of ICTs	Aut115 Promote leisure and entertainment.
2. UE_ICT_AUT (composite reflective) professional's perceptions on the purposes the professional uses ICT for in their work with people with autism	
aut_201_use of ICTs	Aut201 Facilitate the perception of time.
aut_202_use of ICTs	Aut202 Foster communication and social skills.
aut_203_use of ICTs	Aut203 Develop communication.
aut_204_use of ICTs	Aut204 Develop oral language.
aut_205_use of ICTs	Aut205 Develop the understanding of emotions.
aut_206_use of ICTs	Aut206 Develop the expression of emotions.
aut_207_use of ICTs	Aut207 Manage time.
aut_208_use of ICTs	Aut208 Stimulate cognitive development.
aut_209_use of ICTs	Aut209 Develop autonomy.
aut_210_use of ICTs	Aut210 Perform tasks related to planning.
aut_211_use of ICTs	Aut211 Perform tasks related to organization.
aut_212_use of ICTs	Aut212 Perform tasks related to self-regulation.
aut_213_use of ICTs	Aut213 Perform tasks related to memory.
aut_214_use of ICTs	Aut214 Facilitate the learning of reading.
aut_215_use of ICTs	Aut215 Facilitate the learning of writing.
aut_216_use of ICTs	Aut216 Facilitate the learning of calculation.
3. ICT_TRAINING IN EDUCATIONAL ICTs (composite reflective)	
aut_301_training in ICT	Aut301 I know how to use specific software to create materials.
aut_302_training in ICT	Aut302 I am capable of making curricular adaptations using ICT.
aut_303_training in ICT	Aut303 They allow me to apply teaching strategies to facilitate their inclusion.
aut_304_training in ICT	Aut304 I can describe the main limitations that multimedia materials may have.
aut_305_training in ICT	Aut305 I know the possibilities of operating systems and browsers to modify accessibility, speed, font size, among other things.
aut_306_training in ICT	Aut306 I am aware of the difficulties that may arise in their use.
aut_307_training in ICT	Aut307 I consider myself competent to find specific materials online.
aut_308_training in ICT	Aut308 I know the possibilities that ICT offers.
aut_309_training in ICT	Aut309 I feel prepared to assist them with the use of technological supports and their application.
CONTROL VARIABLE	
age	Age
expyears	Years of experience
expyearaut	Years of experience in autism

Note. Prepared by the authors from Rodríguez Fuentes et al. (2021)

Methodology and Data Analysis

The technique of PLS-SEM is applied using the SmartPLS 4 software (Ringle et al., 2024). The model comprises three constructs—two predictors and two endogenous constructs (one precursor dependent variable and one final dependent variable), as well as three independent control variables.

Table 3. Descriptives statistics of observed variables

Label manifest variable	MS	Mean	MD	MI	MX	OM	OMX	SD	Kurtosis	Skewness
age	0	45.547	46	24	64	24	64	8.399	-0.546	-0.063
sex_w1m0	0	0.823	1	0	1	0	1	0.382	0.901	-1.701
expyears	0	3.476	3	1	6	1	6	1.315	-0.023	0.344
expyearaut	0	1.709	1	1	5	1	5	0.861	1.036	1.159
educenter_1to3	0	1.024	1	1	3	1	3	0.176	76.225	8.326
classtype_1to3	0	1.449	1	1	3	1	3	0.636	0.127	1.116
sprectum_1to2	0	1.756	2	1	2	1	2	0.430	-0.568	-1.199
aut_101_benefits of ICTs	0	4.500	5	3	5	3	5	0.566	-0.662	-0.588
aut_102_benefits of ICTs	0	4.512	5	3	5	3	5	0.559	-0.696	-0.59
aut_103_benefits of ICTs	0	4.417	5	2	5	2	5	0.651	-0.074	-0.765
aut_104_benefits of ICTs	0	4.280	4	2	5	2	5	0.662	-0.371	-0.462
aut_105_benefits of ICTs	0	4.205	4	2	5	2	5	0.662	-0.057	-0.417
aut_106_benefits of ICTs	0	4.362	4	2	5	2	5	0.701	0.265	-0.847
aut_107_benefits of ICTs	0	4.417	5	2	5	2	5	0.687	0.999	-1.057
aut_108_benefits of ICTs	0	3.953	4	1	5	1	5	0.840	0.181	-0.631
aut_109_benefits of ICTs	0	3.921	4	1	5	1	5	0.847	0.319	-0.708
aut_110_benefits of ICTs	0	3.768	4	1	5	1	5	0.854	0.011	-0.564
aut_111_benefits of ICTs	0	4.287	4	2	5	2	5	0.646	0.595	-0.623
aut_112_benefits of ICTs	0	4.067	4	1	5	1	5	0.726	1.217	-0.724
aut_113_benefits of ICTs	0	4.150	4	2	5	2	5	0.694	0.158	-0.495
aut_114_benefits of ICTs	0	4.142	4	2	5	2	5	0.690	0.191	-0.484
aut_115_benefits of ICTs	0	4.409	5	2	5	2	5	0.697	0.480	-0.971
aut_201_use of ICTs	0	3.913	4	1	5	1	5	0.828	0.118	-0.549
aut_202_use of ICTs	0	4.083	4	1	5	1	5	0.849	0.738	-0.934
aut_203_use of ICTs	0	4.228	4	2	5	2	5	0.810	0.119	-0.843
aut_204_use of ICTs	0	4.000	4	1	5	1	5	0.789	0.472	-0.630
aut_205_use of ICTs	0	4.008	4	2	5	2	5	0.748	-0.271	-0.354
aut_206_use of ICTs	0	4.020	4	2	5	2	5	0.755	-0.170	-0.419
aut_207_use of ICTs	0	3.902	4	1	5	1	5	0.824	0.124	-0.536
aut_208_use of ICTs	0	4.339	4	2	5	2	5	0.649	0.214	-0.645
aut_209_use of ICTs	0	4.276	4	1	5	1	5	0.750	1.600	-1.066
aut_210_use of ICTs	0	4.319	4	2	5	2	5	0.637	0.270	-0.580
aut_211_use of ICTs	0	4.213	4	2	5	2	5	0.738	-0.179	-0.598
aut_212_use of ICTs	0	4.150	4	2	5	2	5	0.743	-0.340	-0.481
aut_213_use of ICTs	0	4.39	4	2	5	2	5	0.665	0.232	-0.800
aut_214_use of ICTs	0	4.201	4	2	5	2	5	0.678	-0.201	-0.424
aut_215_use of ICTs	0	3.961	4	2	5	2	5	0.803	-0.486	-0.342
aut_216_use of ICTs	0	4.193	4	2	5	2	5	0.674	-0.500	-0.332
aut_301_training in ICT	0	3.543	4	1	5	1	5	0.954	-0.398	-0.371
aut_302_training in ICT	0	4.020	4	1	5	1	5	0.815	0.869	-0.869
aut_303_training in ICT	0	4.020	4	1	5	1	5	0.734	1.257	-0.752
aut_304_training in ICT	0	3.894	4	1	5	1	5	0.743	0.639	-0.522
aut_305_training in ICT	0	3.886	4	1	5	1	5	0.803	0.419	-0.617
aut_306_training in ICT	0	3.969	4	1	5	1	5	0.808	0.891	-0.754
aut_307_training in ICT	0	3.984	4	1	5	1	5	0.778	0.308	-0.527
aut_308_training in ICT	0	4.114	4	2	5	2	5	0.783	0.229	-0.699
aut_309_training in ICT	0	3.921	4	2	5	2	5	0.824	-0.461	-0.362

Note. MS: Missing; MD: Median; MI: Minimum; MX: Maximum; OM: Observed minimum; OMX: Observed maximum; & SD: Standard deviation; ident: Number of case; N: Sample size; N (initial) = 271; N (filtered) = 254. No missing values; & Prepared by the authors from Ringle et al. (2024)

The purpose of this model is prediction, which justifies the selection of this technique based on the maximization of explained variance. In covariances, bidirectional relationships are established based on covariance. A step towards advancing the understanding of the relationship between two constructs would be to consider unidirectional relationships. Thus, in this case, the final dependent variable is the training in educational ICTs.

In PLS-SEM, two evaluations are conducted: one for the measurement models and another for the structural model. On the one hand, in the measurement models (mode A or reflective mode with its indicators), internal consistency, individual reliability of each indicator, convergent validity, and, finally,

discriminant validity are assessed. In the structural model, the in-sample explanatory power (R^2), f^2, potential serious multicollinearity problems through variance inflation factors (VIFs), and the significance of path coefficients (or beta coefficients) are analyzed using bootstrapping. Finally, concerns related to common method bias (CMB) have been checked beforehand to evaluate the model.

RESEARCH AND RESULTS

Test of Common Method Bias

The survey was anonymous and adhered to ethical standards. Before proceeding to complete the questionnaire, the education professionals (participants) were informed of the purpose of the study, ensuring their identity and confidentiality on the first page of the questionnaire. This minimized CMB is related to survey studies. Kock (2015) proposed that obtaining VIF values greater than 3.3 indicates, on the one hand, serious collinearity problems and, on the other hand, that the model may present CMB. In this case, the VIFs for the internal model of the final estimated model are within the threshold, and therefore, the model is free from CMB.

Results of the Variance-Based Structural Equation Model

In the initially proposed model, two of the precursor constructs for ICT training did not exhibit discriminant validity. Additionally, the VIF of one of the three control variables showed serious collinearity problems (years of experience in education and age). Therefore, the variable with the highest VIF, which corresponds to years of experience, was removed.

The final proposed model includes the combination of teachers' perceptions regarding the use and benefits of educational ICTs for children with autism in early childhood as an exogenous precursor construct. Moreover, this model retains age and years of experience in autism. A two-tailed Student's t-test was conducted as it did not establish the direction of the relationship. Therefore, the hypotheses of the final model have been reformulated as follows:

- **H1.** The use and benefits of educational ICTs influence the training in educational ICTs.
- **H2a.** The teacher's age influences the training in educational ICTs (control variable).
- **H2b.** The years of experience in autism influence the training in educational ICTs (control variable).

Measurement models

Regarding the reliability of the indicators (individual indicator reliability), not all factor loadings (outer loadings) reach the recommended minimum threshold of 0.7, so they have been removed. **Table 4** shows the outer loadings.

Internal consistency reliability was evaluated using Cronbach's alpha (CA), composite reliability (CR) through the rho_A coefficient (Werts et al., 1974) and the Dijkstra-Henseler rho coefficient (rho_C) (Dijkstra & Henseler, 2015a, 2015b), and convergent validity through average variance extracted (AVE). All quality criteria have met the established thresholds: factor loadings > 0.707 (Carmines & Zeller, 1979); CA > 0.7; CR by rho_C: Dijkstra-Henseler rho_c (ρC) > 0.7 (Dijkstra & Henseler, 2015a, 2015b); CR (traditional) by rho_A or commonly known CR > 0.7 (Werts et al., 1974); and the last quality criterion, AVE > 0.5 (Fornell & Larcker, 1981) (**Table 5**). To evaluate if constructs measure distinct concepts for discriminant validity, two criteria are used: Fornell-Larcker criterion and heterotrait-monotrait (HTMT) ratio of correlations (Henseler et al., 2015) (**Table 6**).

Structural model

The SmartPLS software provides indices to measure overall goodness that are used in both CB-SEM and PLS-SEM and are frequently mentioned in the overall evaluation of the structural model, such as the standardized root mean square residual (SRMR) and the normed fit index (NFI). If the values of these coefficients are less than or equal to 0.08 (Hu & Bentler, 1999), the model could be considered satisfactory based on these indices. In this case, the values are SRMR = 0.066 and NFI = 0.746, indicating that the model is not confirmatory but exploratory.

Table 4. Outer loadings

	1	3	2A	2B	
aut_101_benefits of icts	eliminated				
aut_102_benefits of icts	eliminated				
aut_103_benefits of icts	eliminated				
aut_104_benefits of icts	eliminated				
aut_105_benefits of icts	eliminated				
aut_106_benefits of icts	0.719				
aut_107_benefits of icts	0.754				
aut_108_benefits of icts	0.787				
aut_109_benefits of icts	0.713				
aut_110_benefits of icts	0.743				
aut_111 _benefits of icts	0.796				
aut_112_benefits of icts	0.722				
aut_101_benefits of icts	eliminated				
aut_102_benefits of icts	eliminated				
aut_103_benefits of icts	eliminated				
aut_104_benefits of icts	eliminated				
aut_105_benefits of icts	eliminated				
aut_106_benefits of icts	0.719				
aut_107_benefits of icts	0.754				
aut_108_benefits of icts	0.787				
aut_109_benefits of icts	0.713				
aut_110_benefits of icts	0.743				
aut_111 _benefits of icts	0.796				
aut_112_benefits of icts	0.722				
aut_209_use of icts	0.773				
aut_210_use of icts	0.764				
aut_211_use of icts	0.759				
aut_212_use of icts	0.792				
aut_213_use of icts	0.782				
aut_214_use of icts	0.734				
aut_215_use of icts	0.772				
aut 216_use of icts	0.735				
aut_301_training in icts		0.805			
aut_302_training in icts		0.801			
aut_303_training in icts		0.792			
aut_304_training in icts		0.837			
aut_305_training in icts		0.779			
aut_306_training in icts		0.830			
aut_307_training in icts		0.846			
aut_308_training in icts		0.793			
aut_309_training in icts		0.864			
Age (control variable)			1.000		
Expyeareduc (control variable)					eliminated
Expyearaut (control variable)				1.000	

Note. 1. BENEFITS_AND USES_OF_EDUCATIONAL TICS FOR _EARLY CHILDREN_WITH AUTISM; 3.PROFESSIONAL TRAINING _ON EDUCATIONAL TICS_FOR CHILDREN WITH AUTISM; 2A. Control variable 1: AGE; 2B. Control variable 2: _YEARS OF EXPERIENCE _IN AUTISM EDUCATION; & Prepared by the authors from Ringle et al. (2024)

Table 5. Individual indicator reliability, internal consistency reliability, and convergent validity

Constructs	Individual indicator reliability	Internal consistency reliability			Convergent validity
			CR		
	Factor loadings (min.; max.)	CA (traditional criterion)	rho_a (ρ_A) reliability coefficient	rho_c (ρ_C) CR (traditional)	AVE
1. Benefits ICTs	(0.713; 0.820)	0.956	0.957	0.960	0.603
3. Training in ICTs	(0.779; 0.864)	0.937	0.939	0.947	0.667

Note. Factor loadings > 0.707 (Carmines & Zeller, 1979); CA > 0.7 (Cronbach, 1951); rho_A: Dijkstra-Henseler rho_a (ρa) > 0.7 (Dijkstra & Henseler, 2015a, 2015b); CR (traditional) rho_C or commonly known by CR > 0.7 (Werts et al., 1974); AVE > 0.5 (Fornell & Larcker, 1981); obtained from 95% confidence intervals; two tails t-student test; & prepared by the authors from Ringle et al. (2024)

Table 6. Discriminant validity approaches

Fornell-Larcker criterion and HTMT criteria		
Constructs	1	2
1. Benefits and use of educational ICTs	**0.655**	0.639
2. Training in educational ICTs	0.059	**0.216**

Note. The square roots of AVE in **bold** are located on diagonal; over diagonal HTMT correlations ratio and under diagonal construct's inter-correlations; & prepared by the authors from Ringle et al. (2024)

Table 7. Evaluation of the inner model

Composites or control variables	Explanatory power			Inner VIFs	f^2
	R^2	Adjusted R^2	R^2	VIFs	Constructs
1. Benefits and use of educational ICTs	-	-	-	1.002	0.706
2.A. Age of professional educators	-		-	1.061	0.084
2.B. Years of experience in education of autism	-		-	1.062	0.032
3. Training in educational ICTs	0.454*	0.441*	Moderate[a]	-	-

Note. Minimum cut-off $R^2 \geq 0.1$ (Falk & Miller, 1992); ≤ 0.25 weak, 0.25 ≤≤ moderate and ≥ 0.75 substantial; inner VIF ≤ 3.3 (Kock et al. 2021); *p < 0.05; **p<0.01; ***p < 0.001; test by bootstrapping 10,000 samples, percentile configuration, two tailed t-student test; [a]Classification according to Hair et al. (2017); & prepared by authors from Ringle et al. (2024)

Collinearity analysis with a random variable has been conducted using VIFs. As previously mentioned in the method of common bias, the resulting values show that there are no severe collinearity problems, as none exceed the maximum threshold of 3.3. Also, the VIFs of the inner model did not exceed this threshold (Kock, 2015; Kock et al., 2021) set by the most stringent authors, noting that there are other higher thresholds established by other researchers.

The coefficient of determination, R^2, which measures the goodness of fit or the R^2 of the model within the sample (in-sample) for the final dependent construct (R^2 for professional ICT training = 0.447) is considered a moderate value according to Hair et al. (2019) (**Table 7**). The estimated model is shown in **Figure 2**. **Table 8** shows the analysis of direct and mediating effects and the final decision.

DISCUSSION

Discussion on General Terms About Implementations of ICTs

According to Yang and Dong (2024), it is concluded not to standardize the results of the implementation of ICTs based on the subjective interpretation of teachers about the different ways of putting into practice the same digital resources, an opinion that is shared by the authors of this work. In addition, we propose another additional reason for not standardizing these results: the years of pedagogical training required of teachers may be different when comparing countries. By way of illustration, in China one can work in preschool with a Bachelor and in Spain a University degree is required.

The combination of the TPACK model and the ecological model applied in ECE by Yang and Dong (2024) on the factors that influence the implementation of ICTs (technological competence, pedagogical competence, content knowledge) and the subjective interpretation of the socio-cultural context where ECE takes place (Brianza et al., 2022) must be complemented. In the case of Spain, the acceptance of students with autism (as a type of functional diversity) is mandatory so that they are integrated into society in all public schools. Therefore, in Spain it should be mandatory for teachers to acquire knowledge about autism of the student who enters each educational center. The model would be called TPACK + ACASC (technological pedagogical and content knowledge + autism content and social-cultural context). Having knowledge of autism should be required of teachers who work with such students. In this regard, in the case of Andalusia and in public schools, to access working with students with ASD it is necessary to have knowledge and training regarding this specific group of students. This shows two ideas, that institutions consider it necessary to have such knowledge about autism and, on the other hand, the commitment acquired by institutions in relation to covering with quality the needs presented by autistic students. Therefore, educational institutions set the guidelines that must be followed at the level of Andalusia and teachers cannot refuse, it is regulatory compliance among teachers. This has led Andalusia to become aware of research on this type of autistic students in general, consolidating research teams on this topic. In fact, Spain is one of the countries that has

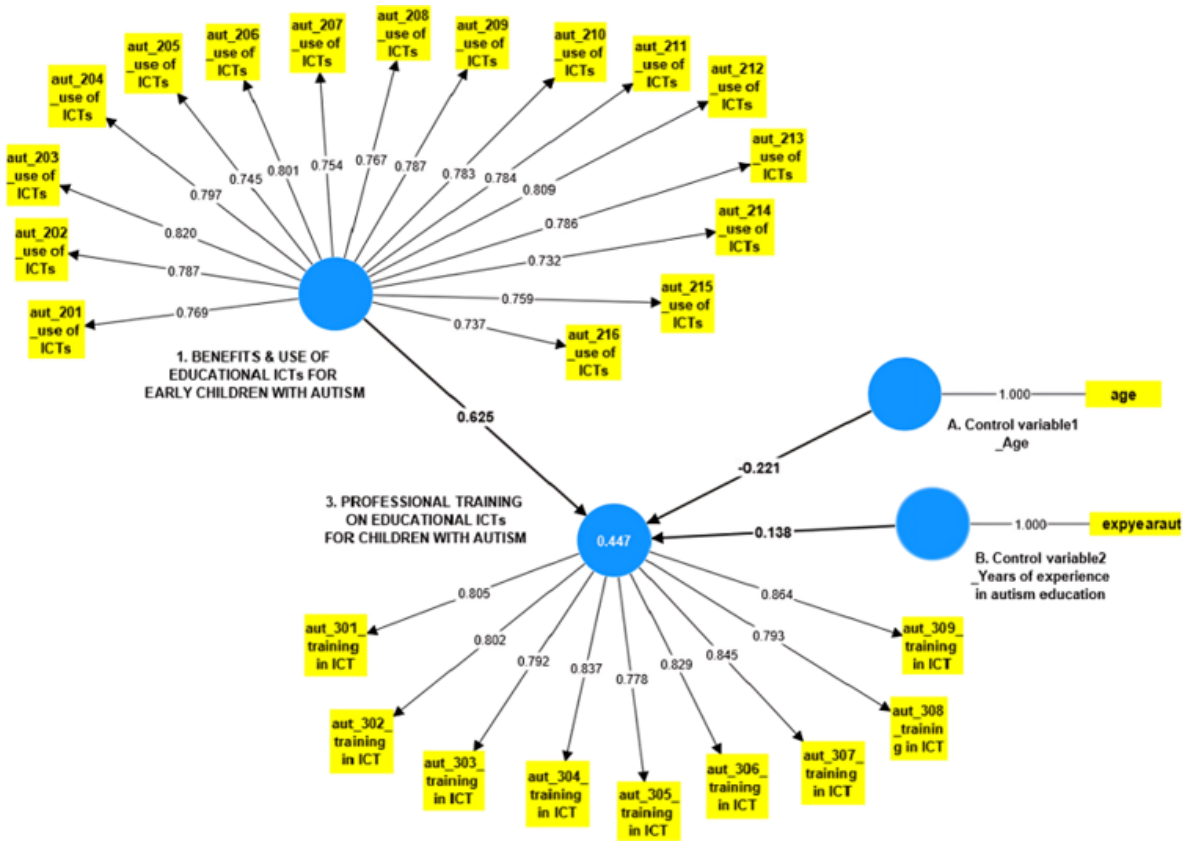

Figure 2. The estimated model (designed by the authors using Ringle et al., 2024)

Table 8. Analysis of direct and mediating effects and final decision

Hypothesis	Path	Direct effect	Significance	t-Student	p-value	2.5%	97.5%	Decision
H1	1 –> 3	0.625***	Yes	14.432	0.000	0.542	0.710	Support
H2a	2A –>3	-0.221***	Yes	4.705	0.000	-0.313	-0.129	Support
H2b	2B –> 3	0.138**	Yes	3.022	0.003	0.047	0.226	Support

Note. *p ≤ 0.05; **p < 0.01; ***p < 0.001; interval of confidence (percentile bootstrap); *p < 0.05; **p < 0.01; ***p < 0.001; & test by bootstrapping 10,000 samples, percentile configuration, two tailed t-Student test

published the most in recent years in ECE in general (Jannah et al., 2026) and, in particular, that develops more resources (apps) to help these ASD students in preschool (Trujillo Torres et al., 2025).

Discussion on the Model

Regarding the confirmatory analysis of the benefits, use, and training in educational ICTs by Rodríguez Fuentes et al. (2021), all bidirectional relationships based on covariance are positive. However, in our model, the perceptions of ICT use and benefits have been combined into a single composite construct because there is no discriminant validity, meaning that both can be considered to measure the same concept.

Regarding the measurement scales validated by Rodríguez Fuentes et al. (2021), all indicators of the ICT training model for children with autism in our model have been retained, which is consistent with the findings of these authors. In the two remaining measurement scales, the final estimated model does not retain the same indicators. These last two measurement scales have not been validated in the case of ECE, which was, therefore, one of the implicit purposes that we pursued when proposing the model.

Concerning the relationship between benefits and training, the direction of the relationship is positive. The established influence in our case is that perceptions of ICTs positively impact ICT training. The perceived utility of ICTs and the rapid updating of software could justify this positive relationship that enhances ICT training.

As for the control variables in educational ICT training, of the three control variables (professional educators' age, years of experience in education, and years of experience in autistic education in early

childhood), the estimated model includes only age and years of experience in early childhood education with autistic children. Also, the findings show that data support the notion that age negatively impacts ICT training, similar to the study on music education, which found a negative relationship between age and ICT use (Martos Sánchez et al., 2016). Besides, the data support the positive influence of years of experience in early childhood education with autistic children on ICT training. Since years of experience in specialized autism education is part of the total years of experience in education, our results align with the findings of these authors.

Discussion in General Terms About Autism From the Literature Review

The conclusions of Shin et al. (2023) regarding the production and exchange of educational materials between schools, sharing a work platform, the need for greater budgetary support, and the necessity for continuous teacher training in educational technology are relevant to their study on primary schools (in general) in Korea. These conclusions gain even greater significance in the context of early childhood education for children with autism.

The participating teachers in this study also highlight the importance of early assessment and intervention in the field of autism, an idea supported by the cited academic literature. In Andalusia, autism-specific classrooms are staffed with specialist autism teachers; however, not all schools have autism-specific classrooms. Therefore, we believe that not only is early detection and intervention necessary, but also that intervention should be equally distributed. When talking about equity, it means that all children have the same rights, meaning that just as students without any disorder have teachers for their education, students with autism must have guaranteed education with a specialized teacher, which many educational centers currently lack.

Although the results generally support the proposed relationships, several findings require further interpretation and the consideration of alternative explanations. In particular, the weak relationship observed between ICT training and perceived benefits suggests that the presence of training alone may not guarantee effective pedagogical integration of technology in early childhood education for autistic students.

One possible explanation is that teacher training programs may focus primarily on technical or instrumental digital skills rather than on pedagogical and inclusive applications of ICT. Previous research has highlighted that possessing digital competence does not necessarily translate into meaningful classroom integration (Timotheou et al., 2023). Therefore, training that is not specifically contextualized for autism education may have limited impact on perceived benefits. Another alternative explanation relates to the institutional and organizational context of early childhood education. Teachers may face structural barriers such as lack of time, limited or insufficient institutional resources support, which can reduce the practical impact of ICT training. This interpretation aligns with previous studies identifying systemic and organizational constraints as key barriers to ICT integration (Shin et al., 2023).

Additionally, the results may reflect the particular characteristics of early childhood education, where pedagogical approaches are strongly based on interaction, play, and sensory experiences. In this context, teachers may perceive traditional or hybrid approaches as more effective than purely digital strategies. This may explain why the perceived benefits of ICT are not as strongly associated with training as initially expected. It is also important to consider that educators' perceptions may be influenced by their previous experience with autism and by the availability of specialized resources. Differences across institutions and professional contexts may therefore moderate the relationship between ICT training and perceived benefits.

Finally, these findings suggest that ICT training should not be understood as an isolated factor but as part of a broader ecosystem that includes institutional support, collaborative networks, and pedagogical guidance. Future research should explore these contextual and organizational variables in greater depth in an extensive model.

CONCLUSIONS

Theoretical Implications

The specifically, the literature review reveals that early childhood education for children with autism is under-researched concerning the joint analysis of studied variables (benefits, uses, and training of educational ICTs related to teachers).

The reviewed reviews or research articles focus on autism and education, particularly in relation to the use, benefits, and training of teachers concerning educational ICTs. The reviewed literature can be classified by participant type and educational level into the following categories: early childhood (Fang et al., 2022; Fletcher-Watson et al., 2016; Panganiban et al., 2022; Tupou et al., 2024), early childhood-primary (Genovesi et al., 2022; Kim & Kasari, 2023; Hosozawa et al., 2020; Mukherjee et al., 2024; Tekola et al., 2020; Zerihun et al., 2024), children and adolescents (Mazon et al., 2019), autistic adults (Leung et al., 2024), autistic adults and their parents or parents with children or educators without referencing any specific educational stage (Dey et al., 2024; Hermaszewska & Sin, 2021; Jonkman et al., 2023; Lockwood et al., 2023; Zakirova-Engstrand & Yakubova, 2024), educators and professionals without referencing a specific educational stage (Rodríguez Fuentes et al., 2021), and finally, autistic adults, parents of autistic children, professionals, educators, and researchers (Pellicano et al., 2014).

To the best of our knowledge, it is novel to propose a PLS-SEM model for the education of autistic early childhood children, aiming to test the established relationships with the measurement scales validated by Rodríguez Fuentes et al. (2021).

Additionally, this study seeks to address gaps in knowledge within the context of early childhood education for autism, a context that has not been extensively researched, as noted earlier. The increasing number of children with these issues is raising concerns about the problem and the need for solutions, not only within Spanish society but also in other countries. As some authors point out, there is a need to support research in underserved areas where there might be more autism-related issues, as no measures are established to detect such students (Dey et al., 2024; Lockwood et al., 2023; Tekola et al., 2020).

PRACTICAL IMPLICATIONS

Most of the educational centers where the teachers work are public institutions in Andalusia (Spain). The rise in autism cases across Spain has led to increased prioritization of autism within the scope of functional diversity. Currently, the Junta de Andalucía (the Public Administration of Andalusia) provides tablets to public schools, but there are significant delays in receiving them and extensive bureaucracy involved in acquiring these tablets. However, public schools in Andalusia lack specialized web platforms for autism and sufficient human resources (professionals) to address the needs of all students enrolled in their centers. This results in a shortage of financial resources. The solution for the specific case of autism, which is currently prioritized, requires, first, streamlining the bureaucracy for obtaining tablets; second, equipping schools with specialized platforms on this topic or providing financial resources to implement such platforms; and third, hiring specialized personnel for ASD. Meanwhile, this manuscript is reviewing, at the beginning of March 2026, Andalusian institutions have provided new ICT resources for ASD classrooms (interactive digital classrooms) and additional financial support to help these students. Additionally, it is recommended to conduct follow-up studies among centers and researchers to act more efficiently in improving the quality of education for children with autism and individuals with autism in general.

Limitations and Future Research Lines

This study has several limitations. The data are cross-sectional and pertain to a specific region in Spain, Andalusia. At the theoretical model level, future research could propose extensions that include how economic resources of educational institutions impact teacher training across all types of educational centers. Additionally, other models related to educational ICTs could be proposed where the dependent variable is teacher training, including the implementation of ICTs among other variables. Meanwhile, this manuscript is reviewing, at the beginning of March 2026, Andalusian institutions have provided new ICT resources for ASD classrooms (interactive digital classrooms) and additional financial support to help these students.

Another potential line of research, particularly for Spain, would involve studying parents, educators, professionals, teachers, children, and adults with autism collectively, as has been done in other international studies, mainly through a complementary qualitative study. This would aim to transfer part of this knowledge to the use, benefits, and training of educational ICTs across the entire educational community. For instance, it could be examined whether the perceptions of parents, teachers, educators, and professionals regarding potential improvements are consistent with one another. In this sense, it is suggested to complement each quantitative empirical study with a qualitative study in order to understand in more detail each variable used in the model.

Finally, this study contributes to enhancing the understanding of teacher training and, consequently, helps society as a whole. It benefits autistic students, adults, parents, teachers, educators, and governments by fostering greater engagement with this issue. We would like to express our gratitude to the Andalusian Public Administration for its increasing involvement and to the associations, collaborators, foundations, and non-governmental organizations for their supportive work in addressing this disorder.

Author contributions: DMF-M, JMT-T, MDB-M, & CRF-F: conceptualization, data curation, supervision, and writing–review & editing; **DMF-M & JMT-T:** methodology; **DMF-M & MDB-M:** resources; **DMF-M:** writing–original draft; & **MDB-M:** formal analysis and investigation. All authors approved the final version of the article.

Funding: The authors received no financial support for the research and/or authorship of this article.

Ethics declaration: All procedures performed in studies involving human participants were conducted in accordance with the ethical standards of the institutional and/or national research committee, as well as with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

AI statement: The authors confirm that no generative AI or AI-based tools were used in the writing, analysis, or preparation of this manuscript.

Declaration of interest: The authors declared no competing interests.

Data availability: The data generated or analyzed during this study are available from the authors upon request.

REFERENCES

Boude, O., Vargas, A., & Choconta, J. (2024). Essential features for mobile applications to assist early childhood educators. *International Journal of Interactive Mobile Technologies, 18*(21), 41-58. https://doi.org/10.3991/ijim.v18i21.48325

Brianza, E., Schmid, M., Tondeur, J., & Petko, D. (2022). Situating TPACK: A systematic literature review of context as a domain of knowledge. *Contemporary Issues in Technology and Teacher Education, 22*(4), 707-753. https://citejournal.org/volume-22/issue-4-22/general/situating-tpack-a-systematic-literature-review-of-context-as-a-domain-of-knowledge/

Carmines, E. G., & Zeller, R. A. (1979). *Reliability and validity assessment*. SAGE. https://doi.org/10.4135/9781412985642

Cronbach, L. J. (1951). Coefficient alpha and internal structure of test. *Psychometrika, 16*, 297-334. https://doi.org/10.1007/BF02310555

Dey, I., Chakrabarty, S., Nandi, R., Shekhar, R., Singhi, S., Nayar, S., Ram, J. R., Mukerji, S., & Chakrabarti, B. (2024). Autism community priorities in diverse low-resource settings: A country-wide scoping exercise in India. *Autism, 28*(1), 187-198. https://doi.org/10.1177/13623613231154067

Dijkstra, T., & Henseler, J. (2015a). Consistent and asymptotically normal PLS estimators for linear structural equations. *Computational Statistics and Data Analysis, 81*, 10-23. https://doi.org/10.1016/j.csda.2014.07.008

Dijkstra, T., & Henseler, J. (2015b). Consistent partial least squares path modeling. *Management Information Systems Quarterly, 39*(2), 297-316. https://doi.org/10.25300/MISQ/2015/39.2.02

Dogan, B., & Gogus, A. (2025). The effect of the 'instructional technologies' course on the competencies of teacher candidates in using Web 2.0 tools: The case of early childhood education program. *Technology, Knowledge and Learning, 30*(2), 883-910. https://doi.org/10.1007/s10758-025-09842-w

Durán Cuartero, S. (2021). Technologies for teaching and learning of students with autism spectrum disorder: A systematic review. *Innoeduca. International Journal of Technology and Educational Innovation, 7*(1), 107-121. https://doi.org/10.24310/innoeduca.2021.v7i1.9771

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. *Journal of Research on Technology in Education, 42*(3), 255-284. https://doi.org/10.1080/15391523.2010.10782551

Falk, R., & Miller, N. (1992). *A primer for soft modeling*. University of Akron Press.

Fang, Z., Lachman, J. M., Zhang, C., Qiao, D., & Barlow, J. (2022). A virtuous circle: Stakeholder perspectives of a short-term intensive parent training programme delivered within the context of routine services for autism in China. *Autism, 26*(8), 1973-1986. https://doi.org/10.1177/13623613211070869

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. (2009). Statistical power analyses using G*power 3.1: Tests for correlation and regression analysis. *Behavior Research Methods, 41*(4), 1149-1160. https://doi.org/10.3758/BRM.41.4.1149

Fletcher-Watson, S., Petrou, A., Scott-Barrett, J., Dicks, P., Graham, C., O'Hare, A., Pain, H., & McConachie, H. (2016). A trial of an iPad™ intervention targeting social communication skills in children with autism. *Autism, 20*(7), 771-782. https://doi.org/10.1177/1362361315605624

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research, 18*(1), 39-50. https://doi.org/10.2307/3151312

Gallardo Montes, C. P., Rodríguez Fuentes, A., & Caurcel Cara, M. J. (2023). ICT training for educators of Granada for working with people with autism. *Heliyon, 9*(3), Article e13924. https://doi.org/10.1016/j.heliyon.2023.e13924

Genovesi, E., Jakobsson, C., Nugent, L., Hanlon, C., & Hoekstra, R. A. (2022). Stakeholder experiences, attitudes and perspectives on inclusive education for children with developmental disabilities in sub-Saharan Africa: A systematic review of qualitative studies. *Autism: The International Journal of Research and Practice, 26*(7), 1606-1625. https://doi.org/10.1177/13623613221096208

Hair, J. F., Hult, G. T., Ringle, C. M., & Sarstedt, M. (2017). *A primer on partial least squares structural equation modeling (PLS-SEM)* (2nd ed.). SAGE.

Hair, J. F., Hult, G. T., Ringle, C. M., Sarstedt, M., Castillo Apraiz, J., Cepeda Carrión, G. A., & Roldán, J. L. (2019). *Manual de partial least squares structural equation modeling (PLS-SEM)* (2nd ed.). OmniaScience. https://doi.org/10.3926/oss.37

Henseler, J., Ringle, C., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science, 43*(1), 115-135. https://doi.org/10.1007/s11747-014-0403-8

Hermaszewska, S., & Sin, J. (2021). End-user perspectives on the development of an online intervention for parents of children on the autism spectrum. *Autism: The International Journal of Research and Practice, 25*(5), 1234-1245. https://doi.org/10.1177/1362361320984895

Hosozawa, M., Sacker, A., Mandy, W., Midouhas, E., Flouri, E., & Cable, N. (2020). Determinants of an autism spectrum disorder diagnosis in childhood and adolescence: Evidence from the UK millennium cohort study. *Autism: The International Journal of Research and Practice, 24*(6), 1557-1565. https://doi.org/10.1177/1362361320913671

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1-55. https://doi.org/10.1080/10705519909540118

Iancu, A. (2024). Use of information technologies by pre-school teachers. *Euromentor Journal, 15*(1), 47-57.

Istiana, Y., & Widodo, M. (2023). A systematic review of technology integration in early childhood education. *Early Childhood Education Development and Studies, 4*(1), 31-26. https://ejurnal.undana.ac.id/index.php/eceds/article/view/11910

Jannah, H. N., Mariyana, R., & Hadi, M. S. (2026). Teachers' challenges in ICT integration for early childhood education: A systematic literature review. *Aulad: Journal on Early Childhood, 9*(1), 104-122. https://aulad.org/index.php/aulad/article/view/1500/627

Jonkman, K. M., Back, E., & Begeer, S. (2023). Predicting intervention use in autistic children: Demographic and autism-specific characteristics. *Autism: The International Journal of Research and Practice, 27*(2), 428-442. https://doi.org/10.1177/13623613221102748

Junta de Andalucía. (2024). Consejería de desarrollo educativo y formación profesional [Department of educational development and vocational training]. *Junta de Andalucía*. https://www.juntadeandalucia.es/educacion/portals/web/ced

Kim, S. A., & Kasari, C. (2023). Working memory of school-aged children on the autism spectrum: Predictors for longitudinal growth. *Autism: The International Journal of Research and Practice, 27*(8), 2422-2433. https://doi.org/10.1177/13623613231165599

Kock, F., Berbekova, A., & Assaf, A. G. (2021). Understanding and managing the threat of common method bias: Detection, prevention and control. *Tourism Management, 86*, Article 104330. https://doi.org/10.1016/j.tourman.2021.104330

Kock, N. (2015). Common method bias in PLS-SEM: A full collinearity assessment approach. *International Journal of e-Collaboration, 11*(4), 1-10. https://doi.org/10.4018/ijec.2015100101

Leung, F. Y., Shah, P., Mason, D., & Livingston, L. A. (2024). Re-examining the association between the age of learning one is autistic and adult outcome. *Autism: The International Journal of Research and Practice, 28*(2), 433-448. https://doi.org/10.1177/13623613231173056

Liu, X., Chen, J., Zhang, K., Xuan, R., Wang, G., & Zhang, R. J. (2022). The evaluation of the cognitive and language abilities of autistic children with interactive game technology based on the PEP-3 scale. *Education and Information Technologies, 27*, 12027-12047. https://doi.org/10.1007/s10639-022-11114-4

Lledó, G., Lledó, A., Gilabert-Cerdá, A., & Lorenzo-Lledó, A. (2022). The use of augmented reality to improve the development of activities of daily living in students with ASD. *Education and Information Technologies, 27*, 4865-4885. https://doi.org/10.1007/s10639-021-10805-8

Lockwood Estrin, G., Bhavnani, S., Arora, R., Gulati, S., & Divan, G. (2023). Caregiver perceptions of autism and neurodevelopmental disabilities in New Delhi, India. *International Journal of Environmental Research and Public Health, 20*(7), Article 5291. https://doi.org/10.3390/ijerph20075291

López-Bouzas, N., del Moral-Pérez, M., & Castañeda-Fernández, J. (2024). Communicative competence in students with ASD: Interaction and immersion in a gamified augmented environment. *Education and Information Technologies, 29*, 13175-13199. https://doi.org/10.1007/s10639-023-12319-x

Maenner, M. J., Shaw, K. A., Baio, J., EdS1, W. A., Patrick, M., DiRienzo, M., Christensen, D. L., Wiggins, L. D., Pettygrove, S., Andrews, J. G., Lopez, M., Hudson, A., Baroud, T., Schwenk, Y., White, T., Rosenberg, C. R., Lee, L. C., & Harrington. (2020). Prevalence of autism spectrum disorder among children aged 8 years–Autism and developmental disabilities monitoring network, 11 sites, United States, 2016. *Surveillance Summaries, 69*(4), 1-12. https://doi.org/10.15585/mmwr.ss6904a1

Martos Sánchez, E., Pérez-García, P., & Bernal Vázquez, J. (2016). Relación entre la edad del profesorado de música andaluz y el desarrollo de la Escuela TIC 2.0 [Relationship between the age of Andalusian music teachers and the development of the ICT 2.0 School]. *Revista Complutense de Educación, 27*(2), 757-777. https://doi.org/10.5209/rev_RCED.2016.v27.n2.48264

Mas'ud, S. H., Sumantri, M. S., & Dhieni, N. (2022). Analisis kompetensi digital guru pendidikan anak usia dini dalam jabatan (in-service teacher) [Analysis of digital competencies of in-service early childhood education teachers]. *Aulad: Journal on Early Childhood, 5*(2), 213-220. https://doi.org/10.31004/aulad.v5i2.328

Mazon, C., Fage, C., & Sauzéon, H. (2019). Effectiveness and usability of technology-based interventions for children and adolescents with ASD: A systematic review of reliability, consistency, generalization and durability related to the effects of intervention. *Computers in Human Behavior, 93*, 235-251. https://doi.org/10.1016/j.chb.2018.12.001

Mukherjee, D., Bhavnani, S., Lockwood Estrin, G., Rao, V., Dasgupta, J., Irfan, H., Chakrabarti, B., Patel, V., & Belmonte, M. K. (2024). Digital tools for direct assessment of autism risk during early childhood: A systematic review. *Autism: The International Journal of Research and Practice, 28*(1), 6-31. https://doi.org/10.1177/13623613221133176

O'Keeffe, C., & McNally, S. (2023). A systematic review of play-based interventions targeting the social communication skills of children with autism spectrum disorder in educational contexts. *Review Journal of Autism and Developmental Disorders, 10*, 51-81. https://doi.org/10.1007/s40489-021-00286-3

Panganiban, J. L., Shire, S. Y., Williams, J., & Kasari, C. (2022). Supporting peer engagement for low-income preschool students with autism spectrum disorder during academic instruction: A pilot randomized trial. *Autism: The International Journal of Research and Practice, 26*(8), 2175-2187. https://doi.org/10.1177/13623613221085339

Pellicano, E., Dinsmore, A., & Charman, T. (2014). What should autism research focus upon? Community views and priorities from the United Kingdom. *Autism: The International Journal of Research and Practice, 18*(7), 756-770. https://doi.org/10.1177/1362361314529627

Ringle, C. M., Wende, S., & Becker, J.-M. (2024). SmartPLS 4. *SmartPLS*. https://www.smartpls.com

Rodríguez Fuentes, A., Caurcel Cara, M. J., Gallardo-Montes, C. D., & Crisol Moya, E. (2021). Psychometric properties of the questionnaire "demands and potentials of ICT and apps for assisting people with autism" (DPTIC-AUT-Q). *Education Sciences, 11*(10), Article 586. https://doi.org/10.3390/educsci11100586

Shin, M., & Hong Jang, J. (2023). Plans to facilitate ICT use in schools: Focusing on the perception of middle school teachers, principals, and ICT managers. *Journal of Educational Technology, 39*(1),187-217. https://doi.org/10.17232/KSET.39.1.187

Shin, M., Yoo, H., & Hong Jang, J. (2023). Barriers and solutions of edtech integration in schools: Focused on leading teachers' perceptions. *Journal of Educational Technology, 39*(1), 219-250. https://doi.org/10.17232/KSET.39.1.219

Subekti, I., Fridani, L., & Nurjannah, N. (2024). Integration of information and communication technology (ICT) in center-based learning at laboratory schools. *Journal Pelita PAUD, 8*(2), 439-446. https://doi.org/10.33222/pelitapaud.v8i2.3847

Tekola, B., Girma, F., Kinfe, M., Abdurahman, R., Tesfaye, M., Yenus, C., OMS., W. C., Salomone, E., Pacione, L., Fekadu, A., Servili, C., Hanlon, C., & Hoekstra, R. A. (2020). Adapting and pre-testing the World Health Organization's caregiver skills training programme for autism and other developmental disorders in a very low-resource setting: Findings from Ethiopia. *Autism: The International Journal of Research and Practice, 24*(1), 51-63. https://doi.org/10.1177/1362361319848532

Timotheou, S., Miliou, O., Dimitriadis, Y., V. S., Giannoutsou, N., Cachia, R., Martínez Monés, A., & Ioannou, A. (2023). Impacts of digital technologies on education and factors influencing schools' digital capacity and transformation: A literature review. *Education and Information Technologies, 28*, 6695-6726. https://doi.org/10.1007/s10639-022-11431-8

Trujillo Torres, J. M., Fernández Montoro, D., Benítez Márquez, M. D., & Fernández Fernández, C. R. (2025). Análisis de apps utilizadas por profesores con alumnado autista en la etapa infantil en España [Analysis of apps used by teachers with autism students in early childhood in Spain]. *Pixel-Bit. Revista de Medios y Educación, 74*, art. 3. https://doi.org/10.12795/pixelbit.115588

Tupou, J., Ataera, C., Wallace-Watkin, C., & Waddington, H. (2024). Supporting tamariki takiwātanga Māori (autistic Māori children): Exploring the experience of early childhood educators. *Autism: The International Journal of Research and Practice, 28*(3), 705-717. https://doi.org/10.1177/13623613231181622

Werts, C., Linn, R., & Jöreskog, K. (1974). Intraclass reliability estimates: Testing structural assumptions. *Educational and Psychological Measurement, 34*, 25-33. https://doi.org/10.1177/001316447403400104

Yang, T., & Dong, C. (2024). What influences teachers' implementation of ICT in early childhood education? A qualitative exploration based on an ecological-TPACK framework. *Computers and Education Open, 7*, Article 100228. https://doi.org/10.1016/j.caeo.2024.100228

Yusuf, S., & Darmasnyah, D. (2025). Integration of technology in early childhood education. *Aulad: Journal on Early Childhood, 8*(2), 1034-1040. https://doi.org/10.31004/aulad.v8i2.1055

Zakirova-Engstrand, R., & Yakubova, G. (2024). A scoping review of autism research conducted in Central Asia: Knowledge gaps and research priorities. *Autism: The International Journal of Research and Practice, 28*(2), 342-354. https://doi.org/10.1177/13623613231170553

Zerihun, T., Kinfe, M., Koly, K. N., Abdurahman, R., Girma, F., OMS., W. C., Hanlon, C., de Vries, P. J., & Hoekstra, R. A. (2024). Non-specialist delivery of the WHO caregiver skills training programme for children with developmental disabilities: Stakeholder perspectives about acceptability and feasibility in rural Ethiopia. *Autism: The International Journal of Research and Practice, 28*(1), 95-106. https://doi.org/10.1177/13623613231162155

Zhang, R., Cheng, G., & Wu, L. (2023). Influence of instructor's facial expressions in video lectures on motor learning in children with autism spectrum disorder. *Education and Information Technologies, 28*, 11867-11880. https://doi.org/10.1007/s10639-023-11676-x