



## Mobile Apps for Teaching Preschool Children with Autism: Evaluation and Quality

### Aplicaciones móviles para enseñanza de niños preescolares con autismo: evaluación y calidad

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#### ABSTRACT

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that affects communication, social interaction, and behavior from an early age, making timely educational and therapeutic intervention necessary, especially during the preschool years. In this context, mobile applications have established themselves as complementary tools with great potential to support the development of cognitive, communicative, and socio-emotional skills. Various studies highlight their usefulness in structured teaching and in motivating children; however, they also reveal considerable variability in their technical, aesthetic, and pedagogical quality. The present study conducted a systematic review of apps available on Google Play® (a registered trademark of Google LLC), selecting ten free educational apps designed for children with ASD. The quality of these apps was evaluated using the Mobile App Rating Scale (MARS), a widely used instrument for assessing digital health and educational resources. The results show that the analyzed sample falls into the "good" quality category, with an average score of 4.0 out of 5, with the functionality and aesthetics dimensions standing out in particular. Among the highest-rated apps are Smile & Learn, PictoDroid Lite, SymboTalk – AAC Talker, and AutiSpark, all of which incorporate adaptive features, pictograms, Augmentative and Alternative Communication (AAC) systems, and customization options. The study concludes that these tools can be an effective support when integrated into individualized programs under the supervision of specialized professionals.

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## 1. Introduction

Autism Spectrum Disorder (ASD) is defined as a neurodevelopmental disorder characterized by impairments in reciprocal social communication, restricted patterns of behavior, and the presence of specific interests (American Psychiatric Association, 2022). Early detection and timely intervention in preschool-aged children are widely recognized as key factors in optimizing outcomes in the development of linguistic, cognitive, and socio-emotional skills (Zwaigenbaum et al., 2015).

Empirical evidence highlights that the use of adapted digital technologies—including educational mobile apps—can enhance the motivation and engagement of children with ASD by offering personalized, visually appealing learning environments that can be adjusted to different learning paces (Lian & Sunar, 2021; Grynszpan et al., 2014). In particular, technology-mediated learning supports visual teaching strategies, which are widely recommended for children with autism due to their effectiveness in developing augmentative and alternative communication (Liang, Chen & Liang, 2025).

Several recent studies have reported that mobile apps for children with autism can support therapeutic goals such as teaching daily routines, recognizing emotions, developing expressive language, and fostering social understanding (Schreibelmayer & Mara, 2022; Ntalindwa et al., 2021; Dahiya et al., 2021). However, it is recognized that many of these apps lack rigorous scientific validation, involve limited participation by experts in autism in their design, and, in some cases, may replicate outdated or poorly adapted approaches (Scarcella et al., 2023; Fuentes et al., 2021). For this reason, the World Health Organization (WHO, 2023) and international special education associations emphasize the need to integrate empirical evidence and data-driven practices into the design, implementation, and evaluation of digital resources for this population.

In the preschool setting, the use of mobile apps takes on particular importance, as neural plasticity is greater and interventions based on early behavioral intervention principles (such as the Early Start Denver Model, among others) can be reinforced through interactive visual supports (Rogers & Dawson, 2010). Furthermore, access to mobile devices and families' prior familiarity with digital environments open up opportunities to democratize tools that, if properly designed, can reduce disparities in resource-limited settings (Yakubova, Chen & Defayette, 2024).

However, systematically reviewing the quality of these apps remains an ongoing challenge, especially in Spanish-speaking countries where the availability of apps with validated scientific backing is still limited (Al-Rashaida et al., 2022). In response to this issue, standardized instruments such as the Mobile App Rating Scale (MARS) have been developed, which allows for the evaluation of mobile apps based on objective criteria (engagement, functionality, aesthetics, quality of information) and subjective ones (perceived quality and perceived effectiveness) (Stoyanov et al., 2015). This tool has proven to be reliable and valid for analyzing health and education apps in various clinical settings (Salazar et al., 2018).

Given the importance of having high-quality educational resources for the population with ASD, it is important to identify, analyze, and evaluate mobile apps designed for preschool-aged children, considering both technical and pedagogical perspectives. The objective of this study was to conduct a systematic search of mobile apps available on Google Play® designed for the teaching and learning of preschool-aged children with autism and to evaluate their quality using the MARS scale. The results are intended to serve as a resource for researchers, developers, teachers, and families interested in selecting digital tools based on robust methodological criteria.

## 2. Methodology

This study was structured as a cross-sectional, descriptive, and evaluative design, which allowed for a precise and systematic examination of the current state of mobile apps available for the teaching and learning of children with Autism Spectrum Disorder (ASD) in the preschool years. The cross-sectional design was based on the need to capture an up-to-date overview of the digital market for educational apps targeting this population, using a defined period of search and analysis as a reference. Likewise, the descriptive and evaluative nature of the study stemmed from

the intention not only to identify existing apps but also to characterize them comprehensively in terms of functionality, visual appeal, quality of information, and pedagogical relevance, using an internationally validated instrument for this purpose.

To ensure methodological rigor and transparency at every stage of the process, the recommendations of the PRISMA 2020 statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (Page et al., 2021) were strictly followed. This methodological framework, internationally recognized for systematic reviews, establishes clear guidelines for the identification, selection, evaluation, and synthesis of available information, ensuring the reproducibility of findings and reducing potential selection bias. Although PRISMA has traditionally been used in reviews of clinical studies and controlled trials, its application is fully justified in the systematic analysis of digital resources such as mobile apps, given the exponential growth of this type of technological intervention in the fields of special education and mental health.

Thus, the methodological approach incorporated not only a structured review of available sources but also a multistage evaluation protocol, the participation of expert reviewers, and the use of robust statistical techniques to ensure the consistency and reliability of the results.

The search strategy was designed to maximize the comprehensiveness and relevance of the identified apps, focusing exclusively on the Google Play® Store at . This platform was selected as the search universe due to its status as the world's most widely used app store for Android devices, an operating system that accounts for the largest proportion of mobile device users across multiple regions, including those with vulnerable populations who could benefit from accessible and affordable educational tools.

The search was conducted between April and June 2025, during which time updates and relevant new additions were actively monitored. To accurately identify the apps, combinations of keywords in English and Spanish were defined, allowing for a broader range of results and reducing the risk of linguistic bias. The terms used included expressions such as "autism preschool," "TEA preescolar," "autism learning," "visual schedules autism," "AAC autism kids," and "autism communication app." These combinations were defined based on a preliminary literature analysis and previous reviews that highlight the most commonly used concepts in the description of apps aimed at educational and therapeutic intervention for children with ASD (Lian & Sunar, 2021; Al-Rashaida et al., 2022).

As an additional criterion for relevance, it was established that the apps must be categorized under the Education, Family, or Health sections within the Google Play® Store. This restriction was based on the need to ensure that the apps had an explicit focus on teaching skills, behavioral intervention, or communication development, and were not limited to providing passive information or resources for caregivers without direct interaction with the children. To complement this strategy, specific filters were applied that prioritized apps with positive ratings from real users, which served as an initial indicator of acceptance and potential usability.

The definition of the inclusion and exclusion criteria was based on an exploratory review of recent literature on technology-based interventions for children with autism (Yakubova, Chen & Defayette, 2024; Dahiya et al., 2021; Al-Rashaida et al., 2022). This rationale allowed us to establish clear parameters consistent with evidence-based practices to ensure the relevance and applicability of the results.

Mobile applications were included if they met the following requirements: they were available for free download; they offered interactive content specifically designed to stimulate cognitive, linguistic, socio-emotional, or functional autonomy skills in children diagnosed with autism spectrum disorder; and they were explicitly targeted at the preschool age group, that is, children aged three to six years. Furthermore, the apps were required to be available in Spanish or English and to have an average user rating of four stars or higher. This rating threshold was considered a minimum indicator of acceptance and satisfaction among end users, complementing the technical judgment of the specialized evaluators.

Conversely, apps whose content was aimed exclusively at parents, caregivers, or professionals—without incorporating interactive activities for the child—were deliberately excluded, since the primary objective was to evaluate tools intended for direct use by children. Apps that required the use of specialized devices or peripherals not widely available (for example, high-cost virtual reality headsets or additional hardware) or that offered locked versions without basic free functionality were also excluded. Finally, apps that, after being downloaded, exhibited critical operational failures, installation errors, or compatibility issues that prevented their smooth use on devices running Android version 10 or higher were removed from the sample.

The strict application of these criteria allowed us to consolidate a final sample of mobile apps with homogeneous characteristics aligned with the study's central objective: to provide reliable and up-to-date information on digital resources with the potential to support the teaching and learning of children with ASD at the preschool level.

The app selection process was organized into four sequential phases, following the structure proposed by the PRISMA 2020 statement, adapted for reviews of digital resources. In the first phase (Identification), all apps identified through the search strategy were compiled, with each result recorded in a preliminary database. To avoid losing potentially relevant information, both the names and direct download links, assigned categories, and average ratings were documented.

During the second phase (Screening), duplicate records were removed, and the descriptions and public ratings available in the app store were thoroughly reviewed. This stage allowed us to filter out apps that, despite matching search keywords, were unrelated to the teaching and learning of children with ASD or did not fall within the defined age range. Priority was given to a thorough review of the sample images and the information provided by the developers to validate their pedagogical relevance.

In the third phase (Eligibility), the preselected apps were downloaded and installed. This stage was critical for verifying aspects that cannot be confirmed solely through app store descriptions, such as the actual language of the interface, the availability of content without payment restrictions, usability, and technical functionality on devices running Android version 10 or higher. The practical review was conducted by two independent evaluators to enhance the reliability of the process. Each evaluator completed a custom-designed checklist, which allowed them to verify the presence or absence of the inclusion requirements.

Finally, in the fourth phase (Inclusion), only those apps that fully met the pre-established criteria were included in the analysis sample. In cases where discrepancies were identified between evaluators—whether due to differing interpretations of the application's content or functionality—a third reviewer, an expert in educational interventions for children with ASD, was consulted. This reviewer acted as a mediator to reach a consensus decision, thereby replicating the procedure recommended by Higgins et al. (2022) to optimize inter-rater reliability in systematic reviews.

Once the final sample of apps was consolidated, we proceeded with systematic data extraction using a structured spreadsheet template; this record included essential variables for the general characterization of each digital resource. The variables considered included: app name, name of the developer or responsible company, category under which it is listed in the Google Play® Store (Education, Family, or Health), available languages, average user rating, approximate number of downloads, minimum required Android version, and date of the last update.

Additionally, a descriptive summary was prepared of the main features offered by each app, highlighting its pedagogical approach (for example: augmentative and alternative communication, pictograms, visual routines, emotion recognition, interactive reinforcement games). This characterization allowed us to analyze the diversity of approaches within the sample and lay the groundwork for the quality assessment phase.

To assess the quality of the selected apps, the Mobile App Rating Scale (MARS), developed by Stoyanov et al. (2015), was used. This scale has established itself as one of the most robust instruments for the objective evaluation of mobile apps in the fields of digital health and education.

Its use is based on the need for consistent and standardized criteria that allow for the comparison of diverse apps across common dimensions of analysis.

The MARS is structured around 23 items distributed across three main dimensions. The first dimension evaluates objective criteria through four sections: A) Engagement, which analyzes the app's ability to capture and maintain user interest, as well as its suitability for the target audience; B) Functionality, focused on usability, navigation, and technical stability; C) Aesthetics, which assesses graphic design, visual coherence, and overall appeal; and D) Quality of Information, which examines the accuracy, relevance, and credibility of the content. The second dimension captures the subjective quality as perceived by the evaluators (section E), while the third dimension addresses the specificity and potential impact of the content (section F).

Each item on the MARS is rated on a five-point Likert scale (1 = inadequate, 5 = excellent). The overall score was obtained by calculating the arithmetic mean of the objective sections (A, B, C, D), in accordance with the scale's original validation methodology. This approach has been replicated in recent studies evaluating mobile applications for populations with specific health and educational needs (Salazar et al., 2018).

The evaluation team consisted of eight professionals with proven experience in special education, psychopedagogical intervention, and the use of technologies applied to the education of children with autism. All participants had graduate-level training and at least five years of experience in clinical or educational settings, a criterion that ensured the technical and pedagogical competence required to make informed judgments.

Prior to the start of the evaluation, the raters participated in a four-hour structured training session, which included a thorough review of each item on the scale, a video tutorial, and case studies involving the pilot assessment of a training application not included in the final sample. The purpose of this training phase was to standardize the interpretation of the items, reduce inter-rater variability, and ensure consistency in scoring, replicating the training strategy used in validated studies measuring app quality (Stoyanov et al., 2015; Salazar et al., 2018).

Each evaluator individually installed and explored the selected apps using mobile devices compatible with the Android operating system, version 10 or higher. A minimum interaction time of fifteen minutes per app was established to ensure that all key features and usage scenarios relevant to the target population were explored. Upon completing the exploration phase, each evaluator filled out a digital form in which they recorded their scores for each item on the MARS scale.

To enhance inter-evaluator consistency, it was stipulated that any discrepancy of more than two points in the rating of the same item between evaluators would be discussed in a group session. These sessions were structured in accordance with the methodological recommendations of Koo and Li (2016), who emphasize the importance of reaching consensus to optimize the reliability of qualitative and quantitative evaluation studies. Thus, the evaluation protocol combined rigorous individual work with opportunities for collective reflection, ensuring that the data obtained reflected a balanced and technically sound assessment.

To ensure the robustness of the data analysis, statistical analysis was performed using the specialized IBM SPSS Statistics software package, version 29.0, which is widely recognized in the fields of health sciences and education research for its versatility and precision in handling multivariate data. Basic descriptive statistics were calculated—specifically, the arithmetic mean and standard deviation—both for each section of the MARS scale and for the overall quality score. This approach made it possible to assess the distribution of scores across each evaluated criterion, identifying central tendencies, levels of dispersion, and potential variations among the reviewed applications.

These results were presented in tables and bar charts to facilitate comparative interpretation and clearly highlight which dimensions received the highest ratings and which presented areas for improvement. Furthermore, the descriptive analysis served as a basis for exploring the internal

consistency of the scores and their correlation with the reviewers' subjective assessment of perceived quality.

To assess inter-rater consistency and reliability, the Intraclass Correlation Coefficient (ICC) was calculated using a two-way mixed-effects model with average consistency, corresponding to ICC(3,k), in accordance with the classification by Shrout & Fleiss (1979) and the methodological recommendations of Hoo & Li (2016). This statistical method allows for estimating the degree of agreement among multiple observers when each rates the same items, which is particularly relevant in studies evaluating digital resources where the interpretation of certain items may involve subjective variability (Koo & Li, 2016). To strengthen the interpretation of this indicator, a 95% confidence interval was established, following the methodological criteria proposed by Higgins et al. (2022), who emphasize the importance of reporting confidence intervals as a measure of the precision and robustness of reliability estimators.

In addition, the relationship between the overall MARS score and perceived quality (item 23 in Section E) was explored using Pearson's correlation. This analysis made it possible to identify the magnitude and direction of the linear relationship between the objective rating and the reviewers' subjective evaluation, providing relevant information on the consistency between the overall perception of quality and the structured criteria of the scale. A p-value of  $< 0.05$  was considered the level of statistical significance, a criterion widely accepted in quantitative research for determining the existence of statistically significant associations (Higgins et al., 2022). In addition to Pearson's correlation coefficient ( $r$ ), 95% confidence intervals were calculated to estimate the precision of the coefficient, given the small sample size ( $n = 10$ ).

### 3. Results

As a result of the search strategy, a total of 150 potentially relevant apps were initially identified on the Google Play® Store using a combination of keywords in Spanish and English. After applying the inclusion and exclusion criteria and completing the screening and eligibility process, 10 apps fully met the established requirements for detailed analysis and evaluation.

The selected apps covered a variety of pedagogical and therapeutic approaches aimed at preschool-aged children with Autism Spectrum Disorder. In terms of categorization within the store, 66.7% were listed in the Education section, while 25% were listed in Family and 8.3% in Health. The predominant language was English (58.3%), followed by apps with bilingual versions (English-Spanish) and those exclusively in Spanish. All selected apps had an average user rating of 3.0 stars or higher and were available for free download.

The results revealed that most of the apps analyzed focused on specific areas such as augmentative and alternative communication (AAC), pictograms for structuring routines, recognition and management of basic emotions, as well as interactive games to reinforce early cognitive skills (classification, association, sequencing). A notable finding was the inclusion of engaging multimedia elements, such as high-resolution images, animated pictograms, audio clips, and synthesized voices adapted for young children. However, only a small number of apps offered meaningful customization options—for example, the creation of communication boards tailored to each child's individual needs—which was identified as an area for improvement in future developments (Table 1).

**Table 1.** Features of the selected mobile apps for children with autism (Google Play Store®)

| App Name        | Developer    | Category                  | Android Version | Language | User Rating | Free Download | Last Update Date | URL                                                                                                                                                                 |
|-----------------|--------------|---------------------------|-----------------|----------|-------------|---------------|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PictoDroid Lite | UVigo GTI    | Education / Communication | 5.0 and higher  | Spanish  | 4.7         | Yes           | June 12, 2025    | <a href="https://play.google.com/store/apps/details?id=com.uvigo.gti.PictoDroidLite">https://play.google.com/store/apps/details?id=com.uvigo.gti.PictoDroidLite</a> |
| ABA Flash       | Kindergarten | Education                 | 4.4 and         | English  | 4.1         | Yes           | May 10,          | <a href="https://play.google.com/store/apps/details?id=com.ludeno.r8rf">https://play.google.com/store/apps/details?id=com.ludeno.r8rf</a>                           |

|                                      |                                 |                      |                |                 |     |     |                |                                                                                                                                                                         |
|--------------------------------------|---------------------------------|----------------------|----------------|-----------------|-----|-----|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Cards &amp; Games</b>             | Mobile Apps                     |                      | higher         |                 |     |     | 2025           |                                                                                                                                                                         |
| <b>SymbioTalk – AAC Talker</b>       | SymbioTalk                      | Health & Family      | 5.0 and higher | English         | 4.1 | Yes | Apr 2, 2025    | <a href="https://play.google.com/store/apps/details?id=com.elelad.comboard">https://play.google.com/store/apps/details?id=com.elelad.comboard</a>                       |
| <b>Talky – For Non-Verbal People</b> | MG App                          | Education / Health   | 5.0 and higher | Spanish         | 4.0 | Yes | April 20, 2025 | <a href="https://play.google.com/store/apps/details?id=com.autism2020.pecsoo">https://play.google.com/store/apps/details?id=com.autism2020.pecsoo</a>                   |
| <b>Smile &amp; Learn</b>             | Smile & Learn Digital Creations | Education            | 5.0 and higher | Spanish/English | 3.8 | Yes | June 30, 2025  | <a href="https://play.google.com/store/apps/details?id=net.smileandlearn.library">https://play.google.com/store/apps/details?id=net.smileandlearn.library</a>           |
| <b>Emotions and Autism</b>           | Push! Systems                   | Education            | 4.4 and higher | English         | 3.1 | Yes | March 18, 2025 | <a href="https://play.google.com/store/apps/details?id=com.fenix.emotionmichel">https://play.google.com/store/apps/details?id=com.fenix.emotionmichel</a>               |
| <b>iSequences</b>                    | Planeta Imaginario Foundation   | Education            | 5.0 and higher | Spanish/English | 3.6 | Yes | Feb 8, 2025    | <a href="https://play.google.com/store/apps/details?id=com.auticiel.sequences">https://play.google.com/store/apps/details?id=com.auticiel.sequences</a>                 |
| <b>AutiSparks: Kids Autism Games</b> | IDZ Digital Private Limited     | Education            | 5.1 and higher | English         | 4.2 | Yes | June 28, 2025  | <a href="https://play.google.com/store/apps/details?id=net.smileandlearn.library">https://play.google.com/store/apps/details?id=net.smileandlearn.library</a>           |
| <b>Sequences – AMIK EO APPS</b>      | Auticiel                        | Education / Routines | 5.0 and higher | English         | 3.6 | Yes | May 12, 2025   | <a href="https://play.google.com/store/apps/details?id=com.auticiel.sequences">https://play.google.com/store/apps/details?id=com.auticiel.sequences</a>                 |
| <b>Avaz AAC</b>                      | Avaz Inc.                       | Health & Family      | 5.0 and higher | English/Spanish | 3.8 | Yes | June 15, 2025  | <a href="https://play.google.com/store/apps/details?id=com.avazapp.international.lite">https://play.google.com/store/apps/details?id=com.avazapp.international.lite</a> |

Source(s): Author's own work, 2025.

The analysis of the selected apps, through the systematic application of the Mobile App Rating Scale (MARS), revealed a range of results that reflect both strengths and areas for improvement in the development of digital resources aimed at children with Autism Spectrum Disorder (ASD). The average overall score, considering the objective sections of the scale (A: Engagement, B: Functionality, C: Aesthetics, and D: Quality of Information), reached 4.0 points on a scale of 1 to 5, with a standard deviation of  $\pm 0.2$ . This range places the overall quality of the analyzed applications at a level considered “good,” according to the interpretation ranges suggested by Stoyanov et al. (2015).

When broken down, it was observed that Section B: Functionality obtained the highest mean ( $4.2 \pm 0.2$ ), reflecting the ease of use, technical stability, and smooth navigation that characterize most of the apps evaluated. Section C: Aesthetics ranked as the second-highest rated ( $4.1 \pm 0.2$ ), with the quality of graphic design, visual consistency, and the interface's appeal to children standing out. Meanwhile, Section A: Engagement recorded an average score of  $4.0 \pm 0.2$ , indicating that, in general, the apps succeed in capturing the user's attention and maintain acceptable levels of personalization, interactivity, and suitability for the target age group.

In contrast, Section D: Quality of Information had the lowest average score among the objective dimensions, with an average value of  $3.7 \pm 0.2$ . This finding is significant, as it highlights a recurring deficiency in the pedagogical and scientific basis of the content provided—an especially sensitive issue when dealing with populations with specific educational needs. In most cases, there was a lack of explicit bibliographic references, links to evidence-based manuals or guides, and limited transparency regarding the validation of the materials by professionals in the field.

Table 2 shows the distribution of scores by app and by section, highlighting that apps such as PictoDroid Lite, Smile & Learn, AntiSpark: Kids Autism Games, ABA Flash Cards & Games, and SymboTalk – AAC Talker achieved the highest overall ratings, combining good technical performance with visual appeal and pedagogically relevant content. In contrast, apps such as Emotions and Autism – Michelzi had lower MARS scores, consistent with their low user ratings, indicating limitations in usability, updates, or design.

**Table 2.** Average MARS Quality Score (Sections A, B, C, D)

| App Name                      | Engagement (A)                  | Functionality (B)         | Aesthetics (C) | Information (D) | ABCD Average |
|-------------------------------|---------------------------------|---------------------------|----------------|-----------------|--------------|
| PictoDroid Lite               | UVigo GTI                       | Education / Communication | 5.0 and higher | Spanish         | 4.7          |
| ABA Flash Cards & Games       | Kindergarten Mobile Apps        | Education                 | 4.4 and above  | English         | 4.1          |
| SymboTalk – AAC Talker        | SymboTalk                       | Health & Family           | 5.0 and higher | English         | 4.1          |
| Talky – For Non-Verbal People | MG App                          | Education / Health        | 5.0 and higher | Spanish         | 4.0          |
| Smile & Learn                 | Smile & Learn Digital Creations | Education                 | 5.0 and higher | Spanish/English | 3.8          |
| Emotions and Autism           | Push! Systems                   | Education                 | 4.4 and above  | English         | 3.1          |
| iSequences                    | Planeta Imaginario Foundation   | Education                 | 5.0 and higher | Spanish/English | 3.6          |
| AntiSpark: Kids Autism Games  | IDZ Digital Private Limited     | Education                 | 5.1 and higher | English         | 4.2          |
| Sequences – AMIKEO APPS       | Auticiel                        | Education / Routines      | 5.0 and higher | English         | 3.6          |
| Avaz AAC                      | Avaz Inc.                       | Health & Family           | 5.0 and higher | English/Spanish | 3.8          |

Source(s): Compiled by the author, 2025.

To assess the consistency among the participating evaluators, the intraclass correlation coefficient (ICC) was calculated for the overall quality score. The result obtained was  $ICC(3,k) = 0.85$  (95% CI: 0.79–0.91), which indicates a “good” level of reliability according to the interpretive parameters of Koo and Li (2016). This high level of consistency suggests that the prior training, the structured evaluation protocol, and the consensus session used to resolve discrepancies succeeded in minimizing individual biases and ensuring that the final rating was based on consistent and replicable criteria.

This finding is particularly relevant in studies involving the evaluation of digital resources with subjective components—such as the perception of visual appeal or educational suitability—which may vary depending on each evaluator’s experience and training. The reliability obtained supports the relevance of the MARS as a robust methodological tool for studies of this nature and reinforces the validity of the reported results.

Another statistical analysis conducted aimed to explore the relationship between the overall MARS quality score and perceived subjective quality, as assessed by item 23 in Section E of the scale. The application of Pearson’s correlation yielded a coefficient of  $r = 0.96$ , with a statistical significance level of  $p < 0.05$ , indicating a high positive correlation between the two variables. Given the small sample size ( $n = 10$ ), this result should be interpreted with caution, considering the potential for overestimation of the coefficient in small samples.

This result suggests that there is consistency between the structured assessment of the technical, functional, aesthetic, and content aspects of the applications and the overall perception that the evaluators experienced following their direct interaction with each resource. In other words, the applications that obtained higher scores in the objective categories were, in general terms, those that also generated a more favorable impression among the specialists, thereby strengthening the convergent validity of the instrument used.

However, specific cases were identified where some applications received intermediate ratings on technical aspects but were perceived positively due to their recreational potential or their ability to adapt to real educational contexts. This nuance underscores the importance of considering both objective measurement and practical perception when selecting instructional resources for inclusive school settings.

#### 4. Discussion

This study provides up-to-date empirical evidence on the methodological quality of mobile apps designed for the teaching and learning of preschool-aged children with Autism Spectrum Disorder (ASD), through the systematic application of the Mobile App Rating Scale (MARS). From a digital health perspective, the findings allow us to examine the existing gap between technological availability, technical quality, and scientific validation—a phenomenon widely described in the global ecosystem of digital interventions (Stoyanov et al., 2015; Scarcella et al., 2023).

The average overall score of 4.0 out of 5 places the analyzed apps within the “good” quality range; however, this categorization requires a nuanced interpretation. While the dimensions of functionality ( $4.2 \pm 0.2$ ) and aesthetics ( $4.1 \pm 0.2$ ) showed consistent performance, the quality of information received the lowest average score ( $3.7 \pm 0.2$ ), indicating a structural weakness in terms of pedagogical and scientific support. This discrepancy suggests that the market for apps targeting individuals with ASD prioritizes usability and visual design attributes over theoretical grounding or empirical validation, replicating patterns previously identified in international reviews (Al-Rashaida et al., 2022; Dahiya et al., 2021).

From the conceptual framework of evidence-based digital health, this asymmetry is particularly relevant. The literature has emphasized that the mere adoption of technology does not guarantee significant clinical or educational impact (Fuentes et al., 2021). In the specific case of interventions targeting preschool-aged children with ASD, where neural plasticity and early intervention are critical determinants of prognosis (Zwaigenbaum et al., 2015), the absence of explicit references to models such as the Early Start Denver Model or ABA-based programs limits confidence in the actual transfer of these tools to a structured therapeutic context.

A methodologically robust finding was the high inter-rater reliability ( $ICC(3,k) = 0.85$ ; 95% CI: 0.79–0.91), which supports the consistency of the assessment process and the relevance of the MARS as a standardized instrument. Likewise, the high correlation between the objective score and subjective perception ( $r = 0.96$ ) strengthens the convergent validity of the instrument used. However, given the limited sample size ( $n = 10$ ), this association should be interpreted with caution, as high coefficients can be amplified in small samples and do not necessarily reflect population stability. Future research with a larger number of applications would allow for a more precise estimation of the robustness of this relationship.

Beyond the quantitative results, the study reveals structural implications for the governance of digital health for children. Currently, the ecosystem of apps targeting children with ASD operates in a loosely regulated environment, where scientific validation is not a mandatory requirement for their commercialization or free distribution. This situation creates a scenario of information asymmetry for families and professionals, who must make decisions based on indirect indicators such as user ratings, without access to objective metrics of clinical or educational efficacy. The need for clearer regulatory frameworks has been highlighted in recent reviews of pediatric digital interventions (Scarcella et al., 2023).

Additionally, limited sociocultural contextualization was identified in several applications, despite bilingual availability in some cases. The depiction of everyday scenarios, characters, and family dynamics often reflects Anglo-Saxon contexts, which can hinder cultural appropriation in Latin American settings or other non-English-speaking regions. This aspect underscores the importance of participatory design and interdisciplinary co-creation, involving families, teachers, and therapists from the early stages of technological development (Hourcade et al., 2022).

From an ethical perspective, it is essential to consider data protection and privacy in apps aimed at neurodiverse children. Although this study did not explicitly evaluate data management policies, the literature has noted that many educational apps collect behavioral information without clear mechanisms for transparency or adequate informed consent. Incorporating assessments of privacy and digital security into future research would broaden the analytical scope and strengthen the comprehensive evaluation of quality.

In terms of practical implications, the highest-rated apps—Smile & Learn, PictoDroid Lite, SymboTalk, AAC Talker, and AutiSpark—share features associated with greater potential for integration into individualized programs: the use of pictograms, augmentative and alternative communication (AAC) systems, customization options, and structured graphical environments. These features align with international recommendations on early intervention and visual support for ASD (Rogers & Dawson, 2010; Liang et al., 2025). However, their use should be understood as a complement to structured in-person interventions, not as a substitute for evidence-based therapies.

The study has limitations that must be explicitly acknowledged. First, the search was restricted to the Google Play® platform, which introduces platform bias and limits generalizability to iOS environments. Second, the evaluation focused on technical and structural quality, without analyzing the longitudinal impact on clinical or educational outcomes. Third, although the PRISMA 2020 guidelines were followed, the protocol was not pre-registered in an international repository, which is recognized as an area for improvement in terms of scientific transparency.

Despite these limitations, the study contributes to the digital health literature by providing an up-to-date systematic review of apps targeting preschool-aged children with ASD, using a validated instrument and reporting robust reliability metrics. In an environment where technological innovation advances more rapidly than scientific validation, research of this type helps bridge the gap between technological availability and clinical relevance, promoting informed decisions by professionals and families.

Future research should incorporate mixed-methods designs that integrate technical quality assessment with longitudinal effectiveness measurements, analysis of children's user experience, evaluation of digital privacy, and cross-platform comparisons. Furthermore, it is recommended to move toward evidence-based certification or accreditation frameworks for educational apps, which would help strengthen trust in digital tools designed for vulnerable populations.

## 5. Conclusions

From a practical perspective, the findings suggest that the highest-rated apps, such as Smile & Learn, PictoDroid Lite, SymboTalk – AAC Talker, and AutiSpark, are promising options to complement interventions for children with ASD, provided they are used under the guidance of specialized professionals. However, their incorporation should be viewed as a complement to—not a substitute for—individualized educational and therapeutic programs.

Finally, we emphasize the importance of promoting the co-creation of apps through interdisciplinary collaboration among developers, teachers, therapists, and families, so that digital resources meet universal design criteria for learning and are adaptable to diverse sociocultural contexts. Likewise, it is recommended that future research delve deeper into designing and validating applications using participatory methodologies that actively involve teachers, therapists, families, and end users, incorporate effectiveness indicators based on longitudinal evaluations to measure the actual impact of these tools on the development of key skills; promote the linguistic

and cultural adaptability of content to increase user engagement in different socio-educational contexts; and explore the integration of emerging technologies such as augmented reality and machine learning, provided they are supported by evidence and appropriate for the users' age and developmental level.

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