

Digital screens for diverse childhoods

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Abstract


Families and teachers from all around the world dedicate big efforts to find digital resources to help their children to play and learn, today especially games and Apps for smartphones and tablets. For all educators, it is important the access of quality resources, but it is even more important for those who work with children with functional diversity because they also need very specific resources and the market offers them different materials but not always with the adequate quality needed by these children. There are several studies on the potential of these digital materials in learning processes during childhood, but these studies contrast with the results of research about the real quality of Apps and video games for children. It is necessary to advance in the evaluation of the content quality and the interactive design of the games and Apps for all kids. This article shows the results of four different analyses on the quality of Apps for children under 8, with optimal development and with special educational needs (SEN), using different methodologies; and presents proposals to guide the selection and creation of interactive Apps that allow all children to play and learn. Because the purpose of this line of research is to determine the quality of interactive resources aimed at early childhood considering the content but also its form, the design of this content.

Keywords: Apps. Childhood. Diversity.

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Resumo**Telas digitais para diversas infâncias**

Famílias e professores de todo o mundo dedicam grandes esforços para encontrar recursos digitais (hoje especialmente jogos e aplicativos para smartphones e tablets) para ajudar meninos e meninas a brincar e a aprender. Para todos os educadores, é importante o acesso a recursos de qualidade, mas é ainda mais importante para quem trabalha com crianças com diversidade funcional, pois precisam de recursos muito específicos. O mercado oferece diferentes materiais para essas crianças, mas nem sempre com a qualidade adequada. Existem vários estudos sobre o potencial desses materiais digitais nos processos de aprendizagem durante a infância, mas esses estudos contrastam com os resultados de pesquisas sobre a qualidade real de aplicativos e jogos de vídeo para crianças. É necessário avançar na avaliação da qualidade do conteúdo e no design interativo dos jogos e aplicativos para todas as crianças. Este artigo mostra os resultados de diferentes análises sobre a qualidade do Apps para crianças menores de 8 anos, com ótimo desenvolvimento e com necessidades educacionais especiais, utilizando diferentes metodologias; e apresenta propostas para orientar a seleção e criação de aplicativos interativos que permitem que todas as crianças brinquem e aprendam. O objetivo desta linha de pesquisa é determinar a qualidade dos recursos interativos voltados para a primeira infância (0-8 anos), considerando o conteúdo, mas também a forma, o design deste conteúdo.

Palavras-chave:

Apps.
Infância.
Diversidade.

Resumen**Pantallas digitales para infancias diversas**

Familias y maestros de todos los países dedican esfuerzos en encontrar recursos digitales (hoy sobre todo juegos y *Apps* para dispositivos móviles) que ayuden a sus niños y niñas a jugar y a aprender. Para todos los educadores es importante acceder a recursos de calidad, pero todavía lo es más para aquellos que trabajan con niños con diversidad funcional, porque necesitan además recursos muy específicos y el mercado les ofrece materiales diversos, pero no siempre con la calidad adecuada. Diversos estudios sobre las potencialidades de estos materiales digitales en los procesos de aprendizaje durante la infancia de los menores con o sin necesidades educativas especiales, contrastan con los resultados de investigaciones acerca de la calidad real de los recursos existentes. Ello requiere de un necesario avance en la consideración del diseño interactivo de los juegos y *Apps* para este *target*. Este artículo muestra los resultados de cuatro diferentes investigaciones sobre la calidad de *Apps* para niños y niñas menores de 8 años, con desarrollo óptimo y con necesidades educativas especiales; y plantea propuestas que orienten una creación de *Apps* interactivas que permitan a todos jugar y aprender. Porque la finalidad de esta línea de investigación es determinar la calidad en los recursos interactivos orientados a la primera infancia (0-8 años), considerando el contenido, pero también su forma, el diseño de este contenido.

Palabras clave:

Apps.
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Introduction and the state of play

All children want to play, learn and grow. And everyone should have the opportunity to do so from their skills and from their strengths. That is why families and educators around the world spend a lot of time searching and selecting quality resources that help children in their cognitive, psychomotor and emotional development. This selection takes place in different areas (educational resources, games and toys, books, music, ...) but, especially today with digital resources such as Apps and games for mobile devices (tablets and smartphones).

Our children have embraced these tools and have integrated them into their lives like no other generation has ever done before with any technology (READ & MARKOPOULOS, 2013). They are the most passionate users of mobile phones, Apps, and videogames, but, nevertheless, they are also the least expert and critical of the resources they use.

The data indicates that the use of mobile devices, almost always connected to the Internet, has grown unstoppably in families around the world since 2010 with the irruption of the first tablets (iPad) on to the market. As early as 2014, various studies in America and Europe showed a growing trend in the use of mobile devices in homes and by children. Data from the EU Kids online report (2014) on the adoption of technologies in Europe by children and young people revealed daily Internet connection, from wherever, with various devices (but especially mobiles) and increasingly at a younger age (MASCHERONI & CUMAN, 2014; EU KIDS ONLINE, 2014). In addition, the same year, the study by the Reynolds Journalism Institute (FIDLER, 2014) showed that households with children had more mobile devices than households without children. These results match those found by Vincent (2015), which revealed how the number of children regularly connecting to the Internet from mobile devices had doubled in most countries in two years (between 2013 and 2015).

And year after year, this trend has continued. The *Mobile Kids Report* from the Nielsen Group (2017), which surveyed 4,646 families with children between 6 and 12 years old, showed that almost half (45%) get their first mobile between 10 and 12 years old, however, there are also children under 10 years old with their own mobile. A total of 72% of these children have all the services included (voice, messages and data). Despite the fact that parents are responsible for all this, 71% of them expressed concern and 68% found it alarming the fact of not controlling the content that their children can access from their mobile phones. The study also showed that all the children had access to the Internet, played with Apps on their devices, and 59% of the children installed the Apps themselves on their smartphones without the need for parental control.

The latest study by *Global Kids online* has been carried out since 2017 in different European countries and including countries that do not belong to the European Union such as Brazil, Argentina, Chile, Serbia, South Africa, the Philippines, Bulgaria and Montenegro.

In Brazil, the latest survey (*ICT Kids Online Brazil 2017*) estimates that approximately eight out of ten children (85%) between 9 and 17 years old are Internet users, corresponding to 24.7 million users across the country. This data is relevant because this proportion was 82% (approximately 23 million) in 2016. The survey also shows an increase in the use of mobile phones among children to access the Internet in recent years. In 2012, 21% of children connected by mobile phone, while in 2017-18, this percentage was 93%, equivalent to 23 million Brazilian children that connect to the network from a mobile phone. And at the same time, there is a 37% decrease in the use of other devices, such as computers and tablets, to access the Internet, from 90% of children in 2013 to 53% in 2018. The survey also estimates that 44% of children that are Internet users connect exclusively through a mobile phone, representing 11 million young people in the country. Mobile phones are the main device for Internet access for children in rural areas (57%), in the north of the country (59%), and in low socio-economic levels (67%).

These figures are not a problem in themselves. Like all media, digital ones are potentially an opportunity. They are tools that can support children's learning and development, as the current literature indicates. Compared to traditional media that keep children passive when consuming audio-visual content, different studies have shown that the use of interactive technologies (from computers to touch screens) by young children promotes learning in a significant way (LAURICELLA *ET AL.*, 2010; KIRKORIAN & PEMPEK, 2013; FLEWITT, MESSER & KUCIRKOVA, 2014). Children who use interactive games have greater problem-solving skills than those who do not use technology (CLEMENTS & SAMARA, 2003; VERNADAKIS *ET AL.*, 2005). In addition, Kirkorian & Pempek (2013) observed that 2 to 3 years olds progress more quickly, make fewer mistakes, and learn more in front of interactive screens compared to those that keep them passive (such as television).

In light of this, the constant search by parents and educators for these interactive resources that help children learn, play and be entertained (TROSETH, RUSSO & STROUSE, 2016) feeds the production and floods the market with these devices. The offer of interactive content, especially Apps, for children has grown exponentially in recent years, and the digital industry creates digital resources for children at a frenzied pace (today, there are more than 80,000 Apps for children in the Apple Store alone).

The fact that Apps have a "child" classification even if they have an "educational Apps" label imposed by the developers of them, as underlined by Zosh et. al (2016), does not mean anything since it does not correspond to reality. The "educational" label should imply some proven benefit from these resources, but, on the contrary, nobody undertakes this check when including the qualifier in an App, that goes for developers, users, and even independent committees of experts.

Often families and educators, in order to find quality educational resources, turn to specialised databases with evaluations ordered by subject matter and age. These focus on the contents of games and applications, but today we know that audiovisual and interactive design also determines the interaction of the child with the Apps (CRESCENZI & GRANÉ, 2019).

The classification of Apps and interactive games by age has a long history of standardisation even at international level, but are they sufficient to prescribe an appropriate and quality selection?

Interactive Apps and games for early childhood; international ratings

In 2013, the *International Age Rating Coalition* (IARC) implemented an age classification system at international level for digital products, such as videogames and mobile applications with the aim of “protecting” young people. This system is used to rate all games and Apps for computers, tablets and smartphones. The classification varies in accordance with the country of the developers. In Europe, the *Pan European Game Information* (PEGI) classification is applied, which, for example, uses Google Play for the classification of Apps, although in the United States the *Entertainment Software Rating Board* (ESRB) is more common and, used by Windows Store; and in addition, Apple Store has created its own *Apple Rating* system. Beyond these global classifications, some countries such as Brazil apply the IARC system by means of *Classificação indicativa* (CLASSIND).

CLASSIFICATION	CONTENTS TO BE EVALUATED	CRITERIA
PEGI Pan European Game Information	Presence or absence of content such as: drugs, nudity, sexual behaviour or references, physical violence, foul language, fear, discrimination, gambling, online gambling.	Contains Does not contain
ESRB Entertainment Software Rating Board	Presence or absence of content such as: mild or unrealistic violence, explicit violence, intense violence, foul language, strong language, blasphemy, indecent themes, raw humour, minimal or abundant blood, gambling, sexual content, drugs.	Does not contain Infrequent Frequent Intense
Apple Rating	Presence or absence of content such as: episodes of realistic or unrealistic violence, frequent or intense violence, blasphemy, indecent content, scenes of horror, medical content, use of alcohol, tobacco or drugs, sexual content or nudity, gambling, unrestricted access to external webs.	Does not contain Infrequent Frequent Intense

Fig. 01. Summary table of the three international classifications

How the three systems classify the suitability for each age group can be seen from their detection of negative content: foul language and/or blasphemy; discrimination, alcohol, tobacco and drug use (references or explicit use); fear; nudity and sex; violence; unrestricted Internet access; gambling. The PEGI rating is based on the simple presence or absence of this content (drugs, nudity, sexual behaviour or references, physical violence, foul language, fear, ...). So, in case of absence of these contents, the game is considered suitable for all ages and is catalogued as PEGI 3. In other words, the PEGI age-based system does not really take age into account since it does not consider the level of difficulty or skills needed to play, nor does it analyse the presence of interference (advertising, commercial messages, etc. that are activated during the game), nor the presence of mechanisms to protect children when connected to the Internet, or to protect personal data (photos, videos, geo-location, etc.).

None of the three systems consider the adequacy of the objectives or content (apart from the exclusion of the negative ones), and none of them consider the quality and the adequacy of the interactive and/or audio-visual systems of the Apps.

These international models for the rating of Apps do not go beyond the previous systems of videogame ratings, but rather reproduce them. They consider only one aspect of the content, the absence of harmful content, completely overlooking the suitability of the content for potential recipients and excluding the analysis of interactive and audio-visual systems, and their adaptation for the gamers.

Thus, although the ratings are aimed at determining a minimum age for use, they do not guarantee that the recipients of the App will be able to access or interact with it, nor that it will bring any benefit (even if it is defined as “educational”) or that it will be detrimental for reasons more subtle than the presence of nudity or blasphemy, such as the perpetration of gender or race stereotypes. They do not provide any information about the quality of the applications and games, and they set the age of the recipients arbitrarily from the proposal of the developers.

Hence, they are insufficient for rating content in terms of age and they do not contribute information on the quality of the content and the interactive design of the application.

Apps for early childhood, studies in quality evaluation

For digital resources to be potentially appropriate tools for children’s play and learning, they need to be of **quality**. The quality of children’s interactive content is directly related to whether it is age-appropriate, and specifically to the moment of the child’s development (GUERNSEY, 2012). But due to the lack of information regarding the needs and peculiarities of very young children, digital game developers often do not take into account the specific characteristics of each age and moment of the child’s development, which has a negative impact on the quality of their products. In this vein, as stated in previous studies, the content of audio-visual and multimedia material is not separated in their format, on the contrary,

information needs design, and the interactive design of applications for mobile devices determines access to content by users (GRANÉ & CRESCENZI, 2016).

The LMI (*Learning, Media and Social Interactions*) inter-university research group is working on a line related to **childhood and screens**, whose purpose is the search for quality interactive resources for early childhood with the aim of providing guidance to developers as creators and to educators as selectors and prescribers of materials. To this end, four different studies have been carried out to advance this search for quality.

The evaluation of the quality of the Apps can be undertaken using different technologies, but it specifically covers two paradigms, the **heuristic analysis** of the materials where usability experts define how the screens for children should be designed and what aspects should be considered in interactive design, and the **evaluations with users** that are carried out by means of tests with potential users, in this case with children under eight years old.

Creation of a theoretical model for the analysis of quality

Following this premise, the universal design principles directly implicated in interactive environments (GRANÉ, 2012) such as Apps, videogames and web environments were analysed in depth. Once the analysis was completed, a **preliminary study** was drawn up on the design criteria applied directly to children's Apps as well as an exploratory observational analysis of the evaluation and rating systems of the "best educational Apps" for children under 8 years old, proposed by educators and experts and presented in seven prominent international portals and blogs (GRANÉ & CRESCENZI, 2016).

In the second phase of this study, an instrument was developed to observe the quality of children's Apps with 108 items organised in eight dimensions: **Content and Activity**, **Visual Design** (composition, distribution, attention, visual simplicity), **Interaction** (usability, support, feedback, simplicity), **Navigation and Consistency Systems**, **Accessibility**, **Mental Models and Cultural References**, **Legibility** and **Sound**.

This initial study verified the need to integrate design into the evaluation of the quality of children's digital resources, highlighting first the visual dimension by considering the balanced composition of the screens, the number of elements and their layout to meet the child's focus on play. Secondly, an adequate control of the visual complexity of the screens, as well as the cognitive load of the actions, and the adaptation of the mental models and cultural references of children under 8 years old were taken into account. And finally, the relevance of avoiding interference in early childhood Apps (such as messages or advertisements, as well as unnecessary or distracting elements).

Secondly, an adequate control of the visual complexity of the screens was undertaken, as well as the cognitive load of the actions, and the adaptation to the mental models and cultural references of children

under 8 years old. And finally, it was important to study the relevance of avoiding interference in early childhood apps (such as messages or advertisements, as well as unnecessary and distracting elements).

From this preliminary study, other related research has been carried out, where the analysis of the Apps and child-machine interactions from the field of HCI-CCI (*Human Computer Interaction – Children Computer Interaction*) has been defined.

Heuristic analysis of the best Apps for early childhood

In this way, a **second study** consisted in the analysis of 100 Apps that are considered to be educational for children under 8 years old selected through a theoretical sampling technique that included the “best educational Apps” presented by educators and experts in the seven prominent international portals and blogs identified in the exploratory study (CRESCENZI & GRANÉ, 2016). These online databases are the main source of information for families and educators in their choice of children’s digital resources.

Based on the observation sheet designed in the preliminary study, a procedure was followed for the validation of the tool that included the participation of four researchers. A first and only researcher conducted an initial analysis, the observations of whom were then recorded on a spreadsheet and a descriptive data analysis was undertaken using the SPSS statistical analysis program. Subsequently, intercoder reliability with the observations of a second researcher/encoder who independently analysed 10% of the Apps and measured intercoder-reliability using Kappa de Cohen (Cohen’s Kappa) and finding a concordance of more than .61, high, according to the classification of Landis & Koch (1977) for all variables. Finally, one month after the first analysis, the same first researcher analysed 5% of the Apps again of the sample and the results indicated a total concordance between the responses.

Once the instrument was validated, the 100 Apps for children under 8 years old were analysed, and the results of the analysis can be seen from three key perspectives:

Firstly, under the dimensions corresponding to **content**, the predominance of curricular content was clearly evident, focusing on key contents that are common throughout the West, undermining other dimensions of learning related to aspects such as socio-affective, artistic, creative and the construction of knowledge. In addition, the presence of stereotypes and the lack of diversity of characters in the Apps analysed were observed.

Secondly, the dimensions related to the **visual design** revealed problems related to the layout and organisation of elements on the screen that do not allow one to perceive a visually satisfactory overall design. In 22% of the Apps, enhancement systems were not considered to highlight active elements in the game and it was also evident that there were contrast problems with regard to figure-background in more than 14% of the Apps. And despite the fact that most applications sought visual simplicity, in more than 78% of the Apps, the objective of the game was not clear, nor was it intuitive or clearly indicated. Likewise,

one of the problems, which was already detected in the first study, was the presence of interferences, such as advertisements (50%), unnecessary texts (36%), and the appearance of messages with external links (9%).

Regarding the dimensions of the **interaction design**, there were significant difficulties in attention to simplicity, due to the high presence of distractors and active elements on the screen, which are often unnecessary. More than half of the sample included more than four simultaneous active elements, with an average of 18 and reaching 39 in some games. Support systems were also analysed of which 25% were found to be unnecessary and 32% of which were in a format inconsistent with the age of the recipients (e.g. text messages). Despite the fact that many of the Apps were aimed at children under 5 and under 3 years old, text was an ever-present element, even appearing from the initial screen in 96% of cases and being necessary to play 23% of the Apps. Similarly, text was even used as an element of feedback in 23 of the 100 Apps analysed. And in the analysis of the adaptability to the target (children under 8 years old), it was observed that only 22% of the educational Apps presented different game options, with the possibility of different gestures. Finally, in terms of accessibility for the interaction of minors with functional diversity, the absence of adaptations of any kind exceeded 90% of the sample.

Summing up, the results showed that, from the perspectives of visual and interactive design, adaptability, structure and navigation, those considered “tops 100 Apps” showed poor quality and adaptation to child development (CRESCENZI & GRANÉ, 2016).

Analysis of Apps with children under five years old

These two studies highlighted the need to make progress in the research on the quality of resources, from a heuristic (from experts) model to a user-centred model; i.e., children.

Previous research (NACHER, ET. AL., 2014; ABDUL-AZIZ, 2013; HINIKER ET. AL., 2015) in the field of the CCI has studied the suitability of technologies for pre-school children by analysing their understanding of interactive content, and observing that children under 6 years old, and especially those under 3 years, are unable to understand instructions on digital screens, not even verbal instructions; and that they carry out fewer actions that are offered by applications and videogames.

This is particularly the case with the gestures that young people make in their interaction with screens. In the study of the 100 “educational” Apps, it has been observed that the gestures suggested in them were many: *tap*, double *tap*, press and hold, draw a line, vertical *scroll*, horizontal *scroll*, circular stroke, drag and drop, scratch, slide, rotate, use more than one finger, use both hands, zoom in and out with two fingers, pinch, etc. However, previous research that had experimented with the gesture of children in front of screens (ABDUL-AZIZ, 2013; VATAVU, CRAMARIUC & SCHIPOR, 2014; CRESCENZI, PRICE & JEWITT, 2014; CRISTIA & SEIDL, 2015; NACHER, JAEN, NAVARRO, CATALÀ &

GONZALEZ, 2015) showed a much smaller variety of gestures carried out by them in their digital interactions.

From that perspective, we carried out a **third study** in the search to provide empirical knowledge regarding the processes of interaction of children under 3 years old. The objective focused on **exploring the interaction** of preschool children with visual creation Apps (drawing or colouring), studying their spontaneous interaction and the gesture that the children make in front of the screen without instructions or orientations, interferences, or time limits; all this in a family and school environment and with non-invasive observation elements.

The research methodology was based on a sequential mixed design, framed in a pragmatic paradigm, composed of two studies:

A first study **analysing the interactive design of the 32 Apps** geared to children under 3 years old for drawing and colouring, using the tool validated in the previous research. And a second one through **observing 21 children between 14 and 33 months while interacting with Apps** for tablets. For this purpose, two activities were chosen that the children knew and normally carried out on paper using finger-paint: on the one hand, drawing, studying the spontaneous and free gesture on the blank screen; and, on the other hand, colouring a figure to observe the possible differences of the gesture and in the use of tools.

The results of this research (CRESCENZI & GRANÉ, 2019) revealed that the Apps related to drawing and painting presented various interactive design problems in the same way as had been indicated in the previous analysis of Apps with various contents and activities; they also placed the tools in spaces on the screen that did not enable a possible gesture from the participants; and finally they proposed a large number of tools and options that were completely different from the actions and gestures that children under three years of age actually carry out in their spontaneous interaction with the environment.

The results of the children's observations in front of the screens were even more revealing. The participants mostly initiated the interactions in the central area of the screen, but adapted their gesture to the content of the App (drawing on an empty screen or colouring a large figure determines the area they use and the gesture they make). A predominance of the gesture *tap* was not found and there was even a less variety of gestures observed during the spontaneous interaction than in the previous research undertaken by other researchers. In fact, the 21 participating children used only three types of gestures: *stroke*, *tap* and *press*.

It is interesting to highlight that the gestures and actions observed were not uniform among the participants, but evolve with age. And this evolution of the gesture is an essential aspect to take into account in the creation of Apps and the need to simplify the design adapting it to the age of the users.

Analysis of Apps for children with special educational needs, attention to diversity

Once the heuristic and user studies had been carried out, two challenges were put forward.

Firstly, the need for **more empirical evidence on the spontaneous interaction of young children in front of screens**, with the purpose of improving digital resources.

And, secondly, the **need to focus on children who are functionally diverse** or have special educational needs. This is due to the fact that the problems with the interactive design of children's Apps become more evident and stronger when they are used by those who have difficulties or need to approach the materials in another way.

The possibility of interactive design for children closer to a universal design model would allow all children to learn from their strengths, so this field strongly reinforces the purpose of research in the field of CCI.

This paradigm of **Universal Design** of information and communication technologies proposes to use a "one size fits all" visual and interactive design of the Apps, meaning that it is accessible and adaptable to all children; those with typical development and those with special educational needs. The concept is not directly related to the Universal Design for learning perspective, but rather refers to achieving optimal levels of accessibility so that a game can be played by all children.

It is a term synonymous with the concept of accessibility or barrier-free design or inclusive design (HASSAN & MARTIN, 2004). The initial idea of accessibility lays out that designs should be usable by different people with different abilities without having to be adapted. In short, it means that any person can perceive, see, understand, navigate, interact, ... with the interactive material. This is one of the key ideas in any digital design and it becomes more relevant when we talk about designing resources for children, because accessibility has always been treated as a concern for people with functional diversity, but it is increasingly clear that many adaptations can be quality designs for everyone.

For this reason, a **fourth study** was carried out, the results of which are currently being published. **A preliminary analysis** was used in order to know all the available Apps oriented towards children with special educational needs through a systematised online search in four languages (Spanish, English, French and Italian) until reaching independent and international ratings and evaluations made by experts. Subsequently, 55 Apps explicitly aimed at children with different functional skills were selected through a non-probabilistic sampling by quotas, from all those considered to be great by the experts.

The **analysis of the content** was carried out using the structured observation sheet described in a previous study (CRESCENZI & GRANÉ, 2016) adapting it to the objectives of the research. The results revealed a very heterogeneous sample and only in some cases did the material aim to improve a specific educational need or support a specific difficulty. Apps with an optimal design could not be detected in all the dimensions studied on content and activities, visual design and interactive design. On the contrary,

needs were found for adaptation to the age and development of the recipients; in addition to insufficiencies in the options for group play; likewise, the continued predominance of text as a communication system on screens with large and unused audio-visual possibilities was also observed; and finally the scarce development of accessible options that would allow adjustments in each case for diverse users was identified.

Conclusions and future prospects

These studies coincide in concluding that applications for children do not always take into account the age, cognitive singularities and specific development of the target audience, and many of the designs not only do not allow interaction, but even make it difficult. In this sense, it should be pointed out that technologies should not be a problem for children but an opportunity to play, create and learn from their strengths and from their skills beyond their difficulties.

The research carried out so far also shows that there are no defined criteria for the design and creation of children's Apps, so it is clear that there is still a long way to go to reach a quality educational and interactive design. At this point, some considerations can be made, among others, that are necessary.

- Promote the quality of visual design, specifically to ensure visual simplicity, proper screen composition and design of user attention to key elements of the screen.
- Work on the aesthetic care of all the screens and their elements.
- Plan the visual design of the interface according to the size and number of elements necessary for each activity in order to adapt to the cognitive and motor development of the end-users.
- Take care of the musical, sound and voice-over elements in the same way as the visual design, in addition to programming visual and vibration alternatives to the sound messages, but also conversely.
- Avoid external interferences (advertisements) and internal interference (unnecessary screen elements or distractors), as well as the need for reconfiguration during the game.
- Use extrinsic motivation elements (gamification, rewards, achievements, ...) oriented to learning in learning applications.
- Promote the autonomy of the child in gaming and use of the application, through intuitive and natural designs that do not require assistance, or through accessible support systems that respond to different audiovisual formats.
- Consider different gestures and use of devices (tap, press, pinch, flick, ...) and enable their adaptation according to the age of the recipients and functional diversity.
- Enable the adaptation of the orientation of the device (portrait or landscape).

- Expand the possibilities of adjustment and adaptability of the systems in: speeds, difficulties and levels; but also, in the format (verbal, textual, sound, visual, and audiovisual) of the messages, instructions, and trial/error feedbacks that the child receives.
- Take care of the treatment of emotions throughout the application, from the instructions, the elements and characters, the narration and the feedbacks.
- Create navigation systems appropriate to each age and different skills and abilities.
- Consider the mental models and cultural references of children in the approach of themes, stories and characters; but also in the use of iconic images in the screens of the game.
- Work with diversity including diverse characters and elements, which can be personalized, ensuring the representation of the races, gender, etc.

But despite these considerations, the need for a reliable and effective model of analysis and selection of applications for children must be highlighted, which ensures that the content and formal design are adapted to the mental models and perceptive processes of the target audience. This will be possible as progress is made in the study of the interaction of children with screens. Studying not only the gesture but also the emotions, the understanding, the accomplishment of objectives during game time, attention and focus during action, and even verbalisation and interaction with peers, will allow further progress in achieving quality resources for children.

References

- ABDUL-AZIZ, N.A.B. Children's Interaction with Tablet Applications: Gestures and Interface Design. **International Journal of Computer and Information Technology**, v. 2, n. 3, 2013.
- CLEMENTS, D.H. & SAMARA, J. Young Children and Technology: What Does the Research Say? **YC Young Children**, v. 58, n. 6, p. 34-40, 2003.
- CRESCENZI, L., JEWITT, C., & PRICE S. The role of touch in preschool children's learning using iPad versus paper interaction. **The Australian Journal of Language and Literacy**, v. 37, n. 2, p.86-95, 2014.
- CRESCENZI, L. & GRANÉ, M. Análisis del diseño interactivo de las mejores Apps educativas para niños de cero a ocho años. / An Analysis of the Interaction Design of the Best Educational Apps for Children Aged Zero to Eight. **Comunicar**, v.46, p. 77-85, 2016. Disponible en: <http://dx.doi.org/10.3916/C46-2016-08>
- CRESCENZI, L. & GRANÉ, M. Touch Gesture Performed by Children under 3 Years Old When Drawing and Coloring on a Tablet. **International Journal of Human-Computer Studies**, v. 124, 2019. Disponible en: <https://doi.org/10.1016/j.ijhcs.2018.11.008>
- CRISTIA, A. & SEIDL, A. Parental Reports on Touch Screen Use in Early Childhood. **PLoS ONE**, v. 10, n.6, 2015. Disponible en: <https://doi.org/10.1371/journal.pone.0128338>
- EU KIDS ONLINE. **EU KidsOnline: findings, methods, recommendations**. LSE, London, UK, 2014. Disponible en: <http://eprints.lse.ac.uk/60512/>

FIDLER, R. Tablets Are Now Commonplace in Households with Children. **2014 RJI Mobile Media Research Report**. Donald W. Reynolds Journalism Institute (RJI), Mobile Media Poll, 2014. Disponible en: <http://goo.gl/cIdYHn>

FLEWIT, R., MESSER, D., & KUCIRKOVA, N. New directions for early literacy in a digital age: The iPad. **Journal of Early Childhood Literacy**, v. 0, n. 0 1–22, 2014. Disponible en: <https://doi.org/10.1177%2F1468798414533560>

GRANÉ, M. & CRESCENZI, L. Modelo teórico para el diseño y evaluación de la calidad en las Apps infantiles (0-8 años). **Digital Education Review (DER)**, 29, 2016. Disponible en: <http://revistes.ub.edu/index.php/der/issue/view/1360>

GRANÉ, M. **El disseny interactiu a la xarxa**. Barcelona: Publicacions de la Universitat de Barcelona, 2012.

GUERNSEY, L. **Screen Time: How Electronic Media - From Baby Videos to Educational Software - Affects Your Young Child**. NY: Basic Books, 2013.

HASSAN, Y. & MARTÍN, F.J. Propuesta de adaptación de la metodología de diseño centrado en el usuario para el desarrollo de sitios web accesibles. **Revista Española de Documentación Científica**, v. 27, n.3, p. 330-334, 2004.

HINIKER, A., SOBEL, K.; HONG, S.R., SUH, H.; IRISH, I., KIM, D. & KIENTZ, J.A. Touchscreen Prompts for Preschoolers: Designing Developmentally Appropriate Techniques for Teaching Young Children to Perform Gestures. **IDC 2015 Medford**, MA, USA, 2015.

KIRKORIAN, H.L., & PEMPEK, T.A. Toddlers and touch screens: Potential for early learning? **Zero to Three**, v. 33, n. 4, p. 32-37, 2013.

LAURICELLA, A. R., PEMPEK, T. A., BARR, R., & CALVERT, S. Contingent computer interactions for young children's objects retrieval success. **Journal of Applied Developmental Psychology**, v. 31, n.5, p. 362-369, 2010.

LANDIS, J., & KOCH, G. The Measurement of Observer Agreement for Categorical Data. **Biometrics**, v.33, p. 159-174, 1977.

MASCHERONI, G., & CUMAN, A., **Net Children Go Mobile: Final Report** (with country fact sheets). Deliverables D6.4 and D5.2. Milano: Educatt, 2014.

NACHER, V., JAEN, J., & CATALA, A., Exploring visual cues for intuitive communicability of touch gestures to pre-kindergarten children. In: Conference: **ACM International Conference on Interactive Tabletops and Surfaces**. At Dresden. 2014.

NACHER, V., JAEN, J., NAVARRO, E., CATALA, A., & GONZÁLEZ, P., Multi-touch gestures for pre-kindergarten children. **International Journal of Human Computer Studies**, v. 73, p. 37-51, 2015.

NIELSEN GROUP. Mobile Kids: the parent, the child and the smartphone. **Nielsen's fourth-quarter 2017 Mobile Kids Report**. 2017. Disponible en: <https://www.nielsen.com/us/en/insights/article/2017/mobile-kids-the-parent-the-child-and-the-smartphone/>

NÚCLEO DE INFORMAÇÃO E COORDENAÇÃO DO PONTO BR. **TIC Kids online Brasil**, Pesquisa Sobre o Uso da Internet por Crianças e Adolescentes no Brasil. 2017. Disponible en: http://globalkidsonline.net/wp-content/uploads/2018/11/tic_kids_online_2017_livro_eletronico.pdf

READ, JC. & MARKOPOULOS, P. Child-computer Interaction. **International Journal of Child Computer Interaction**, v.1, p. 2-6, 2013.

TROSETH, G., RUSSO, C., STROUSE, G. What's next for research on young children's interactive media? **Journal of Children and Media**, v. 10, n. 1, p. 54-62, 2016. Disponible en: <https://doi.org/10.1080/17482798.2015.1123166>

VATAVU, R. D., CRAMARIUC, G., & SCHIPOR, D. M. Touch interaction for children aged 3 to 6 years: Experimental findings and relationship to motor skills. **International Journal of Human-Computer Studies**, v.74, p. 54-76, 2015.

VERNADAKIS, N., AVGERINOS, A., TSITSKARI, E., & ZACHOPOULOU, E. The use of computerassisted instruction in preschool education: Making teaching meaningful. **Early Childhood Education Journal**, v. 33, n. 2, p. 99-104, 2005.

VINCENT, J. Mobile opportunities: Exploring positive mobile opportunities for European children. **POLIS**, LSE, London, UK, 2015.

ZOSH, J.M., HIRSH-PASEK, K., GOLINKOFF, R. M., & PARISH-MORRIS, J. Learning in the Digital Age: Putting Education Back in Educational Apps for Young Children. **Technology In Early Childhood Education**. p. 1-5, 2016.