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CHOOSING A SERIOUS GAME AS AN EDUCATIONAL TOOL FOR CHILDREN WITH TEA BASED ON THE HIERARCHICAL ANALYSIS METHOD (AHP)

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Abstract: This article aims to seek, in the context of the use of Information and Communication Technologies presented in the format of Serious Games, an alternative that appears as the most appropriate for the cognitive development of children with Autism Spectrum Disorder (ASD). This document seeks to define the most suitable Serious Game for use, through the survey of primary data, which will be established within the multi-criteria decision environment, based on the Hierarchical Analysis Method (AHP - Analytic Hierarchy Process).
Keywords: Autism Spectrum Disorder; Serious Games; Information and Communication Technologies; Hierarchical Analysis Method.

INTRODUCTION

It is noticeable how much technology is intrinsic to our daily lives with each passing day. The popularization of devices, allowing access to technologies – from the most traditional to the most pervasive – has enabled the advancement of creation and innovation of technological tools, as well as the refinement and sophistication of their uses. Making a cut to the educational context, it is necessary to take a closer look at the use of Information and Communication Technologies, more widespread as ICTs, which today represent a large part of the teaching-learning process - whether in the school or domestic context, especially in this period when remote teaching is not only on the rise, but also necessary.

It is understood that ICTs consist of all the technical means used to process information and assist in communication. According to Oliveira and Moura [9] ICTs make it possible to adapt the context and situations of the learning process to the diversities in the classroom. Technologies provide didactic resources suited to the differences and needs of each student.

And just as ICTs allow for more immersive learning, these aspects also need to be observed in how they affect specific groups, such as children who have Autism Spectrum Disorder (ASD). For example, how they impact on the educational and experience process of children with ASD, but also reflect on their relational interconnections, such as their parents, teachers, family members and their closest circle of coexistence. According to Cordioli [1], Autism Spectrum Disorder is characterized by persistent deficits in social communication and social interaction in multiple contexts, including deficits in social reciprocity, in non-verbal communication behaviors used for social interaction and in skills to develop, maintain and understand relationships. In addition to deficits in social communication, the diagnosis of autism spectrum disorder requires the presence of restricted and repetitive patterns of behavior, interests, or activities.

This article deals with the use of technologies for groups of people who have ASD, and it is noticeable that, although it is something that is in its initial phase, that is, there is still little production regarding this path, there is a small variety of ramifications that it is interesting to highlight, which symbolizes the diversity of perspectives on a topic that provides many questions, but also many possibilities. For example, the work of Stephenson and Limbrick [12], who present in their study a more realistic perspective of the critical needs in the research of mobile technologies designed for people with ASD. They claim that with a well-structured network of contacts and communication, and a well-architected project, it is possible to develop and explore more adequately mobile software aimed at education and learning. According to them, the use of mobile devices grows rapidly, which creates a field of research for this market, thus allowing an advance in the

number of studies that explore the potential of these devices for use with people in this context.

Regarding devices, a study that deserves to be highlighted is the one addressed by Lorah et al. [5], who talks about the use of portable multimedia devices and tablets as Speech Generating Devices (SGD), for individuals who have ASD, as a tool, both hardware and software, which serves not only as a socializer for individuals with difficulties in verbal communication, but also as a driver and developer of this skill. Approximately 30% of people diagnosed with ASD have difficulties in developing verbal communication skills [14], which makes it necessary to incorporate the use of Augmentative and Alternative Communication (AAC). To this end, speech and communication facilitators can be seen as facilitators of the process of inclusion and development of verbal communication skills, as well as other support systems for Augmented and Alternative Communication (AAC), including the exchange or exchange of images. (PE - Picture Exchange), the Picture Exchange Communication System (PECS - Picture Exchange Communication System), and Voice Output Communication Aids (VOCA - Voice Output Communication Aids).

It is in this scenario that this article aims to approach the use of these technologies for children who have ASD, within the educational context and with a focus on Serious Games, in order to observe the potential of this field for the development of cognitive and cognitive skills. interactions of this target audience, as well as observing the usability, feasibility and effectiveness of these tools. And finally, define the best tool that can guide the search for this result in the most effective way, a definition that is made through a reliable method and that guarantees the solidity of the choice, through multicriteria methods and that can evaluate decisions not only quantitative, but also qualitative.

The following steps run sequentially with an approach and contextualization of Autism Spectrum Disorder and ICT and Serious Games, going through the definition and description of the chosen methodology and culminating in the application of the Multicriteria Hierarchical Analysis (AHP) method, evaluating the selected applications. focusing on Serious Games for people with ASD and defining the best alternative that applies for the purposes of this study.

AUTISM SPECTRUM DISORDER

To better understand how assistive technologies, especially ICTs and Serious Games, can serve as evolutionary tools in the educational process of children with Autism Spectrum Disorder, it is necessary to understand a little about this profile. In his meta-analysis, McCleery [7] brings us a very adequate panorama, in which he states that one of the great challenges for the application of technologies to people with ASD is the great diversity in the autistic phenotype, which presents variations in intellectual abilities, severity in social interaction, motivation, executive functions, among others. He also mentions that, parallel to this heterogeneity, there is the large and fast growth in the range of devices and technologies available, and the variety of skills and environments in which each technology can intervene in an assistive way.

In this context, Grossard et al. [3] corroborate what was explained by Cordioli [1]. According to the authors, they understand ASD as a developmental disorder that affects the individual to different degrees, and that the main symptoms include deficiencies in communication and social interactions, with deficits in socio-emotional

reciprocity, in non-verbal communication and in the development and maintenance of relationships. relations. All this under the umbrella of the term social skills, which also includes the verbal and non-verbal behavior. Such behaviors need to be combined to achieve social goals, which are complex, such as initiating social interaction or choosing topics of conversation appropriately. In the educational aspect, the study warns that such limitations of these skills can hinder the integration (and interaction) of people with ASD in the school environment and in society, and that teaching such skills is a challenge. As an alternative, the study points to the use of ICT in therapies, since children with ASD, like all other children, have affinities with video games and electronic devices.

An educational alternative commonly used to reinforce communication with children with ASD is the use of PECS. Within the context of verbal behavior, Skinner [11] indicates that it is not how the child with ASD disseminates the message that matters, but whether it is properly received. In this context, PECS are presented as an alternative of Augmented Alternative Communication, categorized as an image exchange communication system. In the PECS system, the speaker communicates through the exchange of images or words written on cards that can symbolize tangible images, activities, an answer, a sentence, etc. This can appear as a main means of Augmented Alternative Communication, paving a fundamental way for the use of technologies in the communication and verbal and non-verbal behavior of children with ASD.

About this path, Odom et al. [8] conclude in their study that technology has been used to provide models and applications that seek to reinforce and assist behaviors that need to be learned, as well as providing performance feedback or self-monitoring, and serving as a tool to systematically teach skills or concepts through of software, whether they are presented in a traditional way (desktop) or for use in mobile technologies.

ICT AND SERIOUS GAMES

And on this path to assisting children with ASD, technology has taken some tools that are successful in fitting the educational – and also experiential – context of this audience. ICTs present themselves as tools that bring to education a new way of approaching the teaching-learning process, making it much more attractive and bringing models that allow enrichment in several aspects, such as visual, exploratory, expository, sensorial, among others. Thus, with this range of possibilities that permeate the use of these tools, work with children with ASD can be developed more comprehensively and, consequently, more efficiently.

The use of ICTs in education, according to Oliveira and Moura [9] provides resources that enable the didactic adaptation to the differences and needs of each student, that is, with the use of ICTs it is possible to identify and work pedagogically with the specificities of the students, adapting the context and situations of the teaching-learning process to the diversities of the classroom. The study also points out the need to adapt and incorporate the traditional way of education to the new current models, which make use of ICTs on a larger scale, and that it is also necessary to take into account the knowledge brought by the students, promoting the construction of new knowledge, and consequently, the construction of a more dynamic curriculum.

Combining the use of ICT with ASD, this fact can be reinforced by Grossard et al. [2], who find that ICTs have enabled new ways to assist people who belong to this framework.

According to their study, these technologies allow the creation of real-life situations in a controlled environment and can offer different clinical supports. In addition, the way the information can be presented can be adapted to the specifics of each individual. Studies also point to the interest of people with ASD – especially children – in ICTs.

The authors also report in another study [3], that ICT-based interventions can be classified into three main categories: a) applications for tablets and handheld devices, which focus on facilitating aspects of social life; b) ICT interventions that include the use of robots, focused on social skills training; and c) serious games, which can be described as "digital games and equipment that have an educational design program that goes beyond entertainment". Among the listed ICT categories, this study sought to focus on the use of Serious Games.

Serious Games, or Serious Games, can be characterized as a simulation in which the structure of a video game is used, or an action that goes through the gamification process, which has the purpose of developing and achieving some intellectual, pedagogical, engine or behavioral, being able to develop individual or collective skills and strategies, and do not focus on entertainment or leisure. Lau et al. [4] define serious games as games that do not have entertainment, fun or leisure as their main purpose, and that the main purpose of serious games are education, training, human resource management and health improvement, and may or may not be digital. Like [4], this study will use the same definition cut to deal with serious games: games that are intended for education, training and behavioral changes, while working on these skills in a playful way.

Regarding the use of serious games by people with ASD, especially elementary school children, Whyte, Smyth and Scherf [13] state in their study that there is an emerging field of research aimed at improving cognitive and social skills, with the greater aim of improving psychosocial outcomes, both in the area of mental health and developmental disorders. With regard to ASD, computer-based interventions are being used to improve facial emotion recognition skills, as well as language and social skills. In this study, the authors also argue that computerized interventions for people with ASD may be more successful if learning can be personalized by taking advantage of the principles of "another emerging field" that is serious games in educational research. In this regard, it is reinforced that the use of well-designed serious game interventions can provide opportunities for cost-effective teaching tools that can be used at home, in the classroom, or in other forms of therapy that can complement traditional teaching methods, and warns that future research must focus on evaluating the cost effectiveness of Serious Games and other computer-based interventions.

HIERARCHICAL ANALYSIS METHOD: THE SELECTION OF SERIOUS GAME BASED ON THE MULTI-CRITERIA METHOD

Understanding the concept of TEA, ICT and Serious Games, it is now necessary to understand how the ICT/Serious Game tool will be defined. The approach to the use of assistive technological tools, such as ICTs and Serious Games aimed at people with ASD, has always shown to be promising and suitable for treatment and intervention in the process of developing social and communication skills. The usability and attractiveness of the devices and applications by the focus groups were positive, whether software or hardware, as well as the indirect assimilation, which involved their circle of coexistence, such as

family members, therapists and educators. More specifically on the use of serious games in therapy, the literature analyzed also shows a promising picture, and that future research could increasingly refine this process already identified as efficient.

Thus, for there to be an assertive choice, the definition of an adequate method that analyzes not only quantitative criteria, but also qualitative criteria is relevant, which implies a more in-depth approach that considers multi-criteria.

It is in this context that the Hierarchical Analysis Process (AHP - Hierarchical Analysis Process) meets the needs of this proposal. The AHP method was designed to solve complex multi-criteria problems. This method seeks to hierarchically divide the problem into sub-criteria to facilitate the understanding and evaluation of the whole, allowing the decision maker to establish priorities in the identification of alternatives that make it possible to contribute to each criterion for better decision making. The process of applying the method involves, in general, the construction of hierarchies, which aims to promote a better understanding and evaluation of what you want to choose. In this process, the construction of levels and sub-levels allows the decision maker to have a more complete view of the problem at hand. It is important to highlight that both the criteria and the alternatives defined by the proposer can (and must) be structured in a hierarchical way, with the first level destined to the main problem of the proposal, the second level destined to the criteria and finally, the third level destined to the alternatives [6].

TOOL DEFINITION

Once the method has been established and how it works, the next obvious step is its applicability. For this, this article has segmented the process of choosing the tool to be used in steps that will be described below. Based on what has already been contextualized and elucidated throughout the study, it is emphasized that the object in question is an assistive technology application, identified as an ICT and classified as a Serious Game. For this tool to be viable and easy to use for future studies, it was defined that this will be a mobile application, and that it must be distributed by the official store and free of charge. Another parameter that excludes selection is that the application must be in Brazilian Portuguese (PT-BR), or offer this language as a possibility of access.

The choice for a cell phone application and not other types of ICT or Serious Games, such as physical games, internet pages or specific hardware, is due to the practicality and popularity of access to them by the target audience and their close universe, such as parents. and teachers. Cell phone use is increasingly present in everyday life and strongly represents the zeitgeist that follows. Web pages, although they can be accessed by cell phone or tablet, have connectivity as a limiting factor and not all sites are responsive, also limiting portability.

METHODOLOGY

With the parameters established for choosing the tool – in this case, a mobile application, the hierarchical structure must first be established, identifying the problem, as well as its criteria and alternatives, forming a decision tree. This step allows a complete view and brings more clarity to the decision maker.

The next step is the comparison between the first level elements (criteria) defined in the hierarchy. The comparison will be based on the Saaty Fundamental Scale [10], the basic principle of the AHP.

Importance degree	Definition	Explanation
1	The same importance	Both activities contribute equally to the objective.
3	Little importance of one over the other	Experience and judgment favor one activity over another.
5	Great or essential importance	Experience or judgment strongly favors one activity over another.
7	Very great or demonstrated importance	One activity is very strongly favored over the other. Can be demonstrated in practice
9	Absolute importance	Evidence favors one activity over another, with the highest degree of certainty
2,4,6,8	Intermediate Values	When looking for a compromise condition between two definitions.

Table I. Escala fundamental de Saaty.

In this step, the analysis of the second level criteria is carried out. Here, the criteria are compared and normalized through the matrices, and the corresponding weights are provided so that the listed criteria can be compared. Having defined such criteria that will enable the best decision making for the alternatives present, a weight is assigned according to the scale of preference or comparative pairing between rows and columns of the generated criteria worksheet.

Then, the generated matrices are compared. A square matrix of paired comparisons is elaborated, which allows, through mathematical calculations, to establish priorities. This process provides an excellent approximation of priorities in a summarized way, and since the matrix from which the verification will be carried out will give us as results a vector with the different weights, which will indicate its importance taking into account that each of the criteria, has differentiated importance according to the resulting weight. Next, there is the compared matrix of alternatives in pairs according to criteria, in which the matrices of alternatives are constructed by comparing them according to each criterion. Here, the mathematical calculations established in the AHP method are performed, a result that gives us the weighting of the alternatives according to their criteria and importance.

The next step consists of making a decision according to the resulting matrix. The evaluation of the resulting or final vector is performed, which indicates the value of each alternative, allowing to choose the best one. Finally, consistency analysis is performed, in which degrees are established. These values indicate whether the comparison matrix has logical qualifications or not.

It is important to mention here the Consistency Ratio (RC), which is obtained by the formula: RC = IC / IA, where IC is the Consistency Index and AI is the Random Consistency Index. The CI is given by the following formula, where n is the number of criteria.

$$IC = \frac{\lambda_{max} - n}{n-1} \qquad (1)$$

The Random Consistency Index (AI) is given through a specific Table. In this Table IR values are defined for square matrices of order n. RC 0.1, which represents a maximum of 10%, the level of consistency is considered acceptable.

1	2	3	4	5	6	7	n
0.00	0.00	0.58	0.90	1.12	1.24	1.32	…

Table II. Values: IA.

The following steps are defined by the comparative matrix of alternatives according to each criterion (third level), which ultimately leads to decision making based on a hierarchical result.

RESULTS

Based on what was defined in the previous topic, applications were selected that fit the established premises. Emphasizing, such applications had to be free and provided by the official store of the chosen mobile operating system (Google Play), as well as be available in Portuguese.

For the purposes of standardization and facilitation of this study, the versions available for Android devices and applications available on Google Play will be used. The choice for the Android platform is due to its popularity and market penetration, which implies greater access by the general public.

Within these parameters, a search was carried out in the applications offered in the virtual store and primarily selected those that had the highest general quantitative rating (evaluation given by general grade and stars). Applications with a grade of 4.0 were selected.

In order to define the profile of the applications that would be selected, in addition to being characterized as ICT and Serious Games, we chose to base ourselves on the study by Grossard et al. [3] and select games that aim to teach social interactions. Such games can focus on the development of social skills (such as attention, collaboration and adaptation to the social context) and the recognition and production of emotions (in oneself or in the other). With emphasis on the use of PECS. Therefore, the following applications were defined, as shown in the Table below.

Alternative	Application
A1	Matraquinhaa[1]
A2	Face-ABAb[2]
A3	Michelzinho: Emotions and Autism [3]

Table III. List of alternatives for evaluation.

Once the applications that make up the list of alternatives that will be analyzed are defined, it is necessary to define the criteria by which they must be judged. To this end, three judgment criteria were defined.

The first criterion is the design and visual presentation of the application. In this criterion, the visual appeal of the application is observed, as well as the clarity with which the user is able to identify the imagery language and the general communication of the platform.

The second criterion is the ease of handling and navigation of the application. In this criterion, the ease with which the user navigates through the application exploring the content is observed, in the most fluid and self-guided way possible.

The third criterion is the educational content of the application. In this criterion, the main content that the application offers is observed, if it meets the expectations established by these studies, as well as extra content that may be made available.

A fourth criterion would be based on connectivity/portability. However, as all selected applications primarily work without the use of mobile data and have similar functions in this sense, there was no need for a comparison for this criterion.

The quantitative criterion cost did not enter the discussion agenda because it was decided that only free applications would be used. Applications that had a free trial period or limited functionality in the free profile package were discarded, that is, that for all their functionalities to be released, there must be some type of payment.

Thus, the criteria were thus established, as seen in the Table below.

1. https://play.google.com/store/apps/details?id=com.phonegap.matraquinha&hl=pt_BR&gl=US
2. https://play.google.com/store/apps/details?id=ifma.faceaba&hl=pt_BR&gl=US
3. https://play.google.com/store/apps/details?id=com.fenix.emotionmichel&hl=pt_BR&gl=US

Item	Criterion
C1	Design
C2	Navigaiton
C3	Content

Table IV. List of alternatives for evaluation.

Once the multi-criteria decision hierarchy is constructed, based on the definitions of its alternatives and criteria, the next step is to compare the elements of this hierarchy. Its criteria are based on the Saaty Fundamental Scale [10], as explained in a previous topic. Next, the matrix was normalized so that the priority vector was defined. The compared and normalized matrices can be seen in Table V.

Obtaining the priority vector, it was possible to observe that the most prominent criterion was Content, followed by Navigation, and finally Design, as shown in the Table below:

C1 – Design	0,093
C2 – Navigation	0,221
C3 – Content	0,685

Table VI. Vector (w) Weight of variables (Priority of Criteria).

It is worth mentioning that the consistency ratio (CR) for this was approximately 5% (0.0467), which is considered acceptable. In addition, the consistency index (CI) was 0.0271 and the random consistency index (RI), based on the Table of IR values for square matrices of order n (Table II), for presenting 3 criteria, was 0.58.

Once the criteria's priorities have been defined, the next step is the construction of the parity comparison matrix for each criterion, which must take into account each of the individually selected alternatives. Tables VII to IX present the comparison matrices defined for the criteria, as well as the normalized matrices.

Regarding the consistency ratio (RC), it was established as follows: a) for the matrix presented in Table VII, it was 2% (0.016); b) for the matrix presented in Table VIII it was 5% (0.046); and c) for the matrix presented in Table IX it was 1% (0.008).

Having the comparison and normalized matrices built, it was possible to define the relative priority for each of the alternatives according to each criterion, which was established as observed in the Table X below.

Thus, the decision hierarchy tree was defined as follows the Figure 1.

Criteria Comparison Matrix				Normalizaded matrix			
	C1	C2	C3		C1	C2	C3
C1	1,00	0,33	0,17	C1	0,100	0,063	0,118
C2	3,00	1,00	0,25	C2	0,300	0,188	0,176
C3	6,00	4,00	1,00	C3	0,600	0,750	0,706
SUM	10,00	5,33	1,42	SUM	1,000	1,000	1,000

Table V. Square matrix of second-level criteria.

C1 – Design				C1 – Normalized design			
C1	A1	A2	A3	C1	A1	A2	A3
A1	1,00	0,33	0,17	A1	0,100	0,063	0,118
A2	3,00	1,00	0,25	A2	0,300	0,188	0,176
A3	6,00	4,00	1,00	A3	0,600	0,750	0,706
SUM	10,00	5,33	1,42	SUM	1,000	1,000	1,000

Table VII. Comparison matrix and normalized matrix for the Design criterion (C1).

C2 – Navigation				C2 – Normalized navigation			
C2	**A1**	**A2**	**A3**	**C2**	**A1**	**A2**	**A3**
A1	1,00	0,33	0,17	**A1**	0,100	0,063	0,118
A2	3,00	1,00	0,25	**A2**	0,300	0,188	0,176
A3	6,00	4,00	1,00	**A3**	0,600	0,750	0,706
SUM	10,00	5,33	1,42	**SUM**	1,000	1,000	1,000

Table VIII. Comparison matrix and normalized matrix for the Navigation criterion (C2).

C3 – Content				C3 – Normalized Content			
C3	**A1**	**A2**	**A3**	**C3**	**A1**	**A2**	**A3**
A1	1,00	0,33	0,17	**A1**	0,100	0,063	0,118
A2	3,00	1,00	0,25	**A2**	0,300	0,188	0,176
A3	6,00	4,00	1,00	**A3**	0,600	0,750	0,706
SUM	10,00	5,33	1,42	**SUM**	1,000	1,000	1,000

Table IX. Comparison matrix and normalized matrix for the Content criterion (C3)

PRIORITY	C1 Design	C2 Navigation	C3 Content
A1 – Matraquinha	0,557	0,544	0,587
A2 – Face-ABA	0,123	0,110	0,089
A3 – Michelzinho	0,320	0,346	0,324

Table X. Square matrix of relative priority of the alternatives listed.

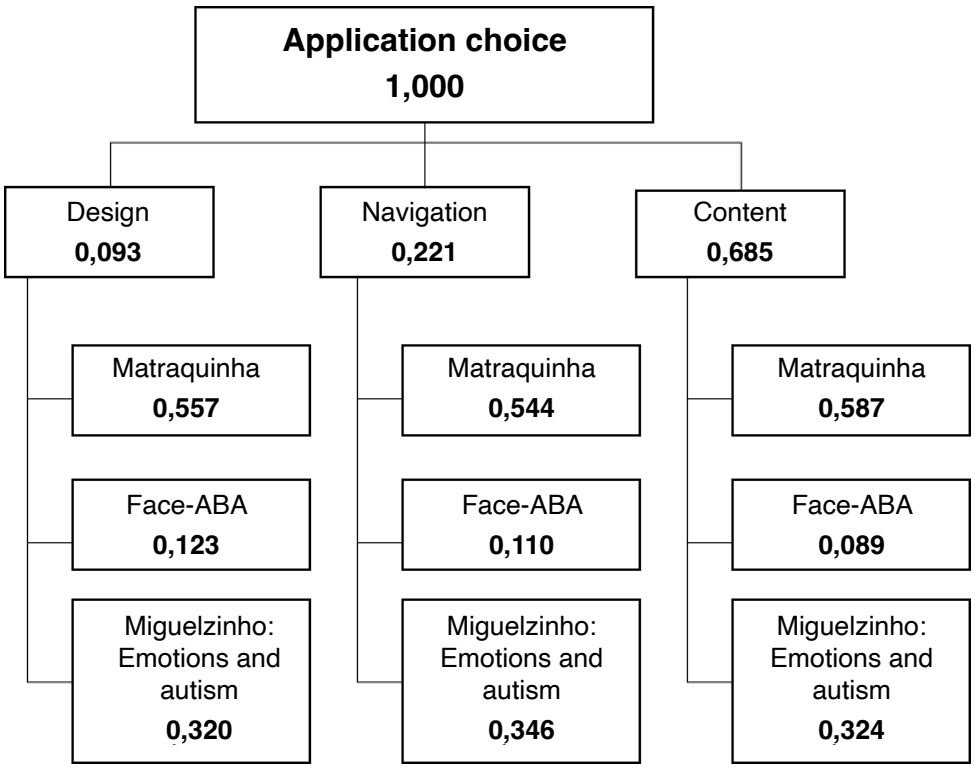

Figure 1. Hierarchical decision tree with defined priorities.

Once the stages of building the hierarchy matrices are over and the relative priorities for each listed alternative are defined, the final step to be performed is the definition of the composite priority. Through this result, it will be possible to analyze the best alternative to meet the proposal of the study in question. The definition of the composite priority is done through the product of the matrix of relative priorities and the matrix of priority of the criteria. This can be better elucidated by Table XI.

Therefore, the hierarchical priority scale for the alternatives is defined as follows Table XII.

CONCLUSION

Throughout the entire process of applying the method, it was possible to define solid criteria that made it possible to base the selection of suitable alternatives, always maintaining coherence with the study proposal.

Analyzing the construction of the comparison matrices that led to the definition of priorities, it can be concluded that, based on the final composite priority, the most suitable alternative to be used in the application of the study is alternative A1, the Matraquinha application, which appears first in the decision hierarchy.

Grossard et al. [3] state that the use of ICTs in therapies can offer new perspectives for the individual treatment of people with ASD, since such tools can be used in different ways and settings, in addition to being attractive to patients. They also state that for the training of social skills, serious games are promising, as they can train different skills and favor interactions in different contexts and situations.

Saaty [10] says that it is necessary to look for new ways to achieve better answers, not holding on to patterns when there is no need, which is clearly transported to his multi-criteria method and which observes qualitative aspects.

Therefore, it is possible to affirm that, in the context of this article, the appropriate tool, selected precisely, can effectively contribute to the continuity of these studies, contributing, albeit in a small portion, so that technology can bring more and more more answers to this still little explored topic that is the development of people with ASD.

Composite Priority Matrix							
	C1	**C2**	**C3**		**Criteria Priority**		**Composite Priorities**
A1	0,557	0,544	0,587	**X**	0,093	=	0,575
A2	0,123	0,110	0,089		0,221		0,097
A3	0,320	0,346	0,324		0,685		0,328

Table XI. Creation of the composite priority matrix.

AHP		
ALTERNATIVE	**PRIORITY**	**HIERARCHY**
A1 – Matraquinha	0,575	1
A2 – Face-ABA	0,097	3
A3 – Michelzinho Emotions and Autism	0,328	2

Table XII. Result of applying the AHP method.

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