AssociAR: Gamified Process for the Teaching of Children with Autism Through the Association of Images and Words

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***Abstract*—Autism spectrum is a disorder that offers a lot of difficulties and challenges to people with it and related to. As for the learning process of these children, it is known that the use of consistent repetitions helps in the learning of people with autism and, in addition, that combinations of images with words are one of the main means of aid in learning for autistic people. Augmented Reality (AR) is a digital resource that acts as a way of visualizing virtual elements, often three-dimensional (3D), together with the real environment. AR offers "enormous educational potential" when used in conjunction with gamification. This work aims to implement a gamified project using augmented reality to assist in the learning process of children with Autism Spectrum Disorder (ASD). The project was implemented in "Cri.Ativa", the psycho-pedagogical care room of a child development center that provides multidisciplinary care for children with atypical development (especially for children on the autism spectrum) in Palmas, Brazil. In general, it is considered that the objective of the work was achieved because the desired process was gamified and the results obtained by its implementation were positive. However, it is important to highlight that, due to the huge number of possible characteristics for children with ASD, this result does not demonstrate that the application of the described process will have equally positive outcomes in all contexts.**

***Index Terms*—Autism Spectrum Disorder, Autism, Augmented Reality, Gamification.**

I. Introduction

The Autism Spectrum Disorder (ASD) is a disorder that has the possible symptoms: deficient language; cognitive problems; repetition of words without context (echolalia); extreme passivity or hyperactivity; deficient visual contact; absence of social interaction; and stereotyped interests [1]. Regarding the learning process of these children, it is known that the use of consistent repetitions helps in learning and, also, that combinations of images with words are one of the main means of aid in learning for them [2].

Augmented Reality (AR) is a digital resource that acts as a way of visualizing virtual elements - often three-dimensional (3D) - together with the real environment [3]. Through AR utilization, the knowledge acquisition becomes more efficient and enjoyable because this technology makes the interaction of the learner with objects related to learning more practical and engaging. For such reasons this resource offer "huge educational potentialities" when used in joint with a gamification [4].

Thus, this work aims to implement a gamified project using augmented reality to support the learning process of children with ASD. This project was implemented in "Cri.Ativa", the psycho-pedagogical attendance room of a child development center that offer multidisciplinary attendance for kids with atypical development (speciality for kids in autistic spectrum) in Palmas, Brazil.

This work aims to gamify an activity already used in the clinic and which, according to the references mentioned above, is one of the main means of aid in the learning of children on the autistic spectrum: the association of images and words.

II. Background

A. Autism Spectrum Disorder

As described by Goldberg [5], the first published scientific work internationally recognized describing a set of symptoms under the name "autistic disorder of effective contact" was written by Kanner [6] which described the cases of children who had as common characteristics the inability to develop interpersonal relationships; extreme isolation; delay in language development and non-communicative use of it; repetitions of

simple patterns of toy activity and the presence of isolated skills. These characteristics are commonly associated with the disorder now known as ASD (Autism Spectrum Disorder). This disorder, according to Monte and Santos [1], include a list of possible symptoms, such as: deficient language; cognitive problems; repetition of words without context (echolalia); extreme passivity or hyperactivity; deficient visual contact; absence of social interaction; and stereotyped interests.

Furthermore, as stated by Trindade [7], children with ASD usually suffer from disorders related to visuomotor coordination, which represents the ability to perform body movements corresponding to visual stimuli. The author also states that this problem can cause the affected person to have difficulty drawing lines, picking things up, hitting targets or following trajectories.

Due to factors like these, according to Pelin [8], teaching children and teens with ASD and with special educational necessities continue being a challenging experience that can lead to the review and questioning of concepts about competence, normality and development.

Regarding the difficulties that children with ASD suffer in learning, Passerino [9] affirms that the use of digital environments of learning in the development process is proven relevant. As for form of teach kids with this disturb (using this artifice or others), Nottohm [2] states that the use of consistent repetitions helps in the learning process of these children.

The inclusion process of a child with ASD can be hard, since this person has too much difficult to interact with the teachers and learning through commons methods. There is no only approach that is fully effective for all children at all different stages of life, that is, a specific intervention can have a good result in a certain period of time and different (bad) results after some time. Therefore, children with ASD need an unique and individual planning that has different actions and methods according to their development and how they are progressing [10].

B. Augmented Reality

The Augmented Reality (AR) is a digital resource that acts as a way of displaying virtual elements - often three-dimensional (3D) - together with the real environment [3]. Regarding the capabilities of the Augmented Reality, to make the manipulation of objects in a natural way, virtual reality allows to implement three-dimensional interfaces providing visualization and manipulation similar to actions in the real world, however, requiring special devices, such as gloves and helmets, among others [11].

Recently, scientific and technological evolution has enabled the viability of Augmented Reality. This tool brings virtual computer games to the computer space allowing its direct manipulation with the hands or through elements that are familiar to most people, such as: paper; wooden plates; and cubes [12]. To interact with the AR environment, the user can use everything from markers to your own hands to manipulate virtual objects in the real world [13]. The interaction is always in real time, no matter the means used to interact [13].

When using AR, the knowledge acquisition becomes more efficient and enjoyable from the moment that its visualization becomes possible, that is: the theoretical is applied in a practical way and the results, which were previously obtained on paper, can be visualized through movements and images. That process becomes possible and evident when using the computer, and more specifically the use of Augmented Reality, which today is gaining prominence in different areas of knowledge. The use of this technology stimulates and facilitates the acquisition of knowledge by the practitioner, helps the teacher in his practices educational activities, in addition to enabling different ways of teaching [4].

Regarding the use of Augmented Reality in education, it's known that the use of educational tools based on augmented reality can contribute to a new way of learning, in which three-dimensional objects and images, interactive exploration and tactile and audible information are used combined to offer more effective teaching. The incorporation of such resources to the tools of learning and teaching allows better qualification of these individuals for the job market and for society [14].

C. Gamification

The concept of gamification emerges linked to the world of games. This one consists of using elements of the mechanics of games; styles of games; and the way of thinking of games, in contexts that are not games as a way to solve problems and engage those involved. This concept has been adopted by the area of education, enabling the construction teaching and learning situations capable to engage teachers and students involved in a pleasant way contributing to rethink the formal educational context [15]. The application of game elements, mechanisms, dynamics and techniques in the context outside of the game, that is, in the reality of the individual's daily professional, school and social life is gamification [16].

Gamification has seven primary elements: scores, levels, ranking tables, badges, challenges / missions, initial engagement and other engagement cycles. The main idea behind a gamified system is that the "player" can use intrinsic stimuli (such as competition and cooperation) and extrinsic stimuli (such as points, levels, missions, ranking) to carry out the proposed tasks [17].

Fardo [18] noticed that gamification finds in education a very fertile field for its application. Cause unlike what happens with games, our experience in the traditional classrooms has shown us the lack of interest of most students [19].

The use of Gamification in the education of new generations is a natural option (from elementary school to higher education) since it's an active learning methodology in which students can become apprentices engaged and motivated in learning activities [20].

It is important to make it clear, as emphasized Fardo [18], that gamification does not imply creating a game that addresses the problem recreating the situation within a virtual world, but rather using the same strategies, methods and thoughts used to solve those problems in the virtual worlds in real-world situations.

D. Related Works

Currently, there are several works and projects aimed at the context of gamification in education. Among these, we can highlight Animasom, a multiplatform game that, through the association of images of animals with the sounds produced by them, aims to assist in the process of developing phonological awareness in children with ASD [21].

Another work aimed at children on the autism spectrum is the G-TEA [22]: the game seeks to work on the learning of colors with these children through the association of the word color.

With the objective of gamifying subjects in the juvenile curriculum we have the project: Rompe Cabezas [23]. It was developed by Aline Falconeri, and aims to use gamification in the mathematics subjects, from which the project developer teaches her classes. According to Falconeri [23] "through games, i propose motivating, challenging and interesting teaching situations in which my students interact in groups or collectively with the object of study and, above all, significantly building the knowledge of the subject addressed and studied in the classroom".

III. Methodology

To make the proposed project real, first there was a stage of studies on related topics (gamification, Augmented Reality, Education and Autism) in articles obtained from online databases.

Due to the problems and restrictions mentioned earlier, the development of children with autism is extremely complicated and, for this reason, the professionals responsible for the clinic defined to participate in the project decided to carry out an initial case study with only two children.

Then, a questionnaire about children with ASD was applied to the therapeutic attendants who work directly with them, this strategy was also adopted due to the limitations faced by children with ASD. The questionnaire was built over the core drives of the framework Octalysis: each question tried to represent one of them and, in total, the questionnaire had 8 questions (1 per core-drive), being them: Would the children help others without charging anything in return? (C1); How much do the children like challenging activities? (C2); Do the feedbacks they receive during an activity help them to engage and continue? (C3); How attracted they are to collectibles items? (C4); How much would children like to help their peers achieve something important? (C5); How much patience would the children have to wait for an appointment even though there were 50 people in front of them? (C6); Would the children be curious enough to go to unknown places even if unpredictable things could happen? (C7); How distressed are you in dangerous situations? (C8).

With the result of the questionnaire it was possible to identify the core drives of biggest influence (being them: Ownership; Development and Achievement; and Empowerment) and prepare the gamification proposal in this work, which, due to the inclusive educational nature, needed to be validated with the specialist in the field responsible for the clinic.

The core drives together form the eight ends of the octagon that represents the framework Octalysis. These are motivating points of human behavior, that is, feelings that can make a person like or dislike a certain process. When applying questionnaires to identify these points in users, the applications focus on the three most influencers in the target audience. In the end, to have a system that pleases and leaves users engaged and satisfied with the use of the gamified process [24], they are: meaning; accomplishment; empowerment; ownership; social influence; scarcity; unpredictability; and avoidance.

The proposed gamification process is based on the framework Octalysis. This tool helped the planning of the application and has the function of maintaining or increasing the engagement of the project's personas [24].

For the development of the application used in the process, the Unity game engine was used, which is a software for creating the world's leading games [25]. The animals files used were found in Sketchfab [26] and Free3D [27], websites where several free 3D models can be found.

The QR Codes present in the cards - which can be read and interpreted by the application - were made with Photoshop CC, an image and design application, where it is possible to create and enhance photos, illustrations and 3D illustrations; create websites and applications for mobile devices, simulate paintings in real time and much more [28].

In order for the aforementioned reading and interpretation to be possible, Vuforia was used a development kit for creating applications with augmented reality [29].

IV. Development

A. Gamified Process

To develop an effective gamification strategy for learning through digital media, a thorough analysis must be carried out that includes the following steps: determining the characteristics of the learners; define learning objectives; creation of educational content (interactive, engaging and rich in multimedia elements) and gamification activities; and adding game elements [30].

Thus, to ensure that the gamification strategy used in this process is effective, the model adopted by Kiryakova et al. [30] was followed. To define the characteristics of the learning, it was necessary for a domain specialist to answer a questionnaire in order to identify the profile of children who were submitted to the process. In this questionnaire, questions were asked that users used to execute core drives.

The questionnaire was implemented using the Likert scale, according to Aguiar et al. [31] it is a self-report scale that consists of a series of questions about the respondent, where it is selected among several (five in this case) options that represent a scale.

The result of the applied questionnaire helped to identify which core drives that most influence the target audience of this project. Such results are shown in Figure 1, where the most influential core drives have a larger portion of blue, thus, the association of the most influential main units becomes easier to understand.

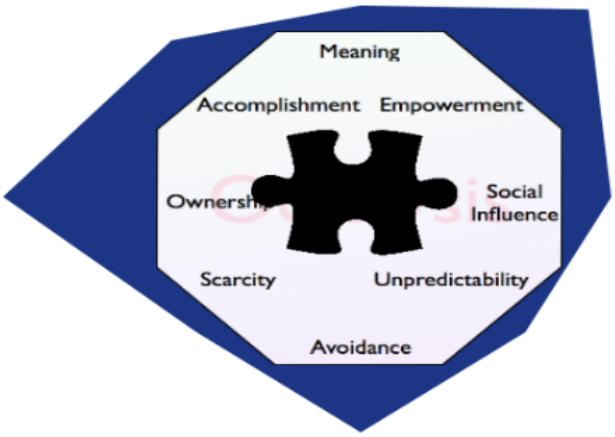

Fig. 1. Octalysis Result

The three cores of greatest influence on the persona of the project were the Property and Possession, where the trigger is to make the user feel the owner of something and, therefore, responsible for taking care of it and making it the best possible. of greatest influence was Empowerment, which is the stimulus that allows the user to grow by creating plans and learning from their own mistakes, through experimentation. Finally, it was the Development and Realization core, where the objective is to make the user feel that he is evolving in some aspect of his life [24].

Based on the results presented in Figure 1 and the relationship of game techniques with core drives made by Chou [24], the following are chosen as gamification techniques for this project:

- Collection Set: this technique is part of the core drive of ownership and possession. It is when several items of the project are related to the same theme. In the case of the Associate, all cards relate to animals;
- Monitor Attachment: also from the core drive owned and owned. This gambling technique allows people to have more properties in relation to something. In the present work, the ability to associate words with images must be developed;
- Evergreen Mechanics: belongs to the empowerment core drive. Where game design doesn't need to continually add more content to keep the activity engaging;
- Real-Time Control: still from the core of empowerment. It allows players to control their options in real time towards a goal; and
- Instant Feedback: this technique is present in two core drives, empowerment and development and achievement. The aim is to allow the player to immediately recognize the results of his work.

The learning objective is the association of words with images; educational content is delivered through the mobile application and the cards used for projecting AR images; and the game elements used are the visual (of digital games) and the short goals to be achieved.

To achieve the proposed objective, a mobile application was built where children can, while performing association activities, view animals with augmented reality through a tablet or smartphone; each animal will have a card with its image and another with its name; children, when carrying out such activities, must associate the card containing the animal's name with the other marker that (through the application) displays a three-dimensional (3D) model of the creature contained in it.

Also during this process, goals should be used, which should be short because, according to the domain specialist, children in the target audience of this work are unable to associate long-term goals. Considering that the interests of a child with autism are usually specific, the prize for a hit goal should be chosen according to the child and his interests.

To measure the current state of the association skill in the children who was subjected to the gamified process, processes were applied - by the responsible professionals - to mark the percentage of associations made successfully immediately after the professional showed how it should be done, in the same way. Thus, the percentage of successful associations was subsequently measured without the professional showing the children how to do it.

It is noteworthy that these measurements were made from processes that did not use digital environments or any other gamification elements, as they are currently done.

After the application of the necessary actions, the professionals responsible for the measurement reported that, in a child with mild autism, the success rate in an associative activity was only thirty percent when the professional did not show how the association should be made (at first attempt) and seventy percent when the professional responsible for the evaluation gave tips to the child on how to make the association (for example, when speaking the first letters of the name of the animal in question) before submitting such individual to the process.

The process in question consisted of presenting images printed on A4 sheets and leaving words written on sheets of paper next to the images so that the child could associate these elements.

B. Technical Development

The library utilized for the development of the application with AR was Vuforia [32]. Even though 3D object modeling is possible, for this work we used only prefabs found at Sketchfab [26], a platform that offers free models for non-commercial models.

For the development of the application, the engine Unity3D [25] was used. It was chosen for its easy integration with the Vuforia [32] library, in addition to being free for non-commercial applications.

Another necessary element in the application are the cards because, as previously mentioned, the three-dimensional models that will be viewed by the children through the mobile application, will be presented on cards. The markers that will be stored by Vuforia and read by the application made in Unity.

Photoshop (PS), also used in this project, is a tool "where you can do everything you can imagine" [28], it is the best image and design application, where you can create and enhance photos, illustrations and 3D illustrations. The software in question was developed by Adobe and can be tested free of charge for a certain amount of time. PS was used to create the cards that will accompany the application. You can see how they looked in Figure 2, where the cards of two animals and their images projected on them are displayed.

Fig. 2. Model of Cards of Words and Representation in AR

Vuforia [32] allows the developer to create an account in their system to register the mappings that are being done. The library will map by each image the "important dots", as shown on Figure 3. By reading these dots the app will identify the image.

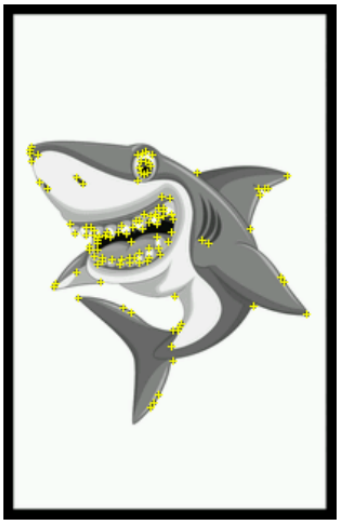

Fig. 3. Display of the points on the card that the camera will map to display the animal in 3D

In each image used as a marker in the application, it is necessary that there are strokes in unique positions so that Vuforia can identify them and use them as a map to identify which 3D model will project when viewing a marker.

The more points the library identifies in the image, the better the level of increase of this marker, that is, the projection of the three-dimensional model on the card will be faster and more flexible. These images can be download through the mentioned tool which allows user to choose exporting format between Unity and Unreal Engine formats.

The downloaded file contains all the necessary materials so that the Unity library can map the markers and display, through the camera of the mobile device that reads the image, the three-dimensional models corresponding to each image. Within the chosen engine, connections are made for each 3D model with its respective marker. This way, Vuforia will know - when viewing an image - which model to project.

With 3D objects already created and exported for use, you must also have an environment that uses these objects and actually creates the game. For that, it is necessary to use an engine like Unity's, Unity3D, which is a software for creating the world's leading games [25].

Unity3D is a paid application for companies, if the purpose of use is only personal and non-profit, it is possible to use Unity3D free of charge. The entire project was developed on this engine. This choice was due to the fact that it has a great integration with the Vuforia library, making the process simpler and more practical.

C. Utilization Flow

This section is in charge of explaining the flow of use of the gamified process its relationship with the developed application and the concepts employed.

During the gamification process, as previously mentioned, those responsible for the treatment of children with ASD will use the application developed in this process.

To start the process, the caregiver responsible for the treatment session of the child with autism will record - however he wishes - how many associations the child must make during this session. Also before the session, the professional in question must select a prize to be given to the child treated at the end, if he/she complies with the established goals.

After performing such actions, the responsible person should open the AssociAR application where, as soon as the it's loaded, the initial screen of the application will be presented - as seen in Figure 4. As can also be seen in the same figure, the game's initial screen will show (in the upper right corner), the game logo; a background image containing some cards that will be used in the game and the "Start" button, shown in the center of the screen.

Fig. 4. Home screen of the application

When the ”Start” button, shown in Figure 4, is clicked by the user (who at this moment must still be the professional responsible for monitoring the treatment), the system will start the associations screen, which uses the mobile device camera to generate the environment and map the markers.

Once the association screen is started, it will be up to the person responsible for monitoring - as he understands the domain and specifics of each child treated - the decision to keep the cell phone with him or to hand it over to the child.

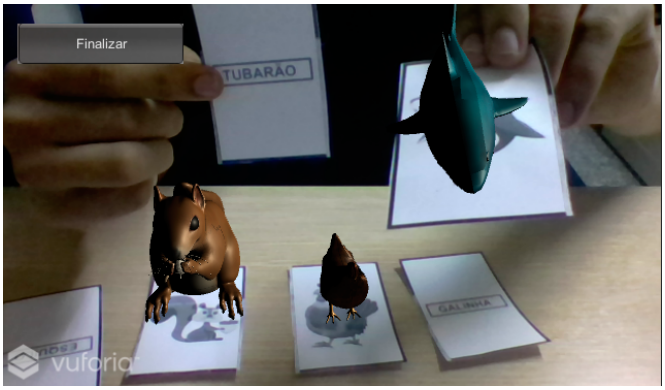

Fig. 5. Associations screen with Augmented Reality

As can be seen in Figure 5, the associations screen contains an image of the external environment to the cell phone obtained through the device’s camera. This image will reflect all points outside the application as they are captured.

There will also be a button on the screen shown in Figure 5 with the text ”Finish” which, when clicked by the system user, will end the memberships session and take the user back to the system’s home screen - previously shown in Figure 4.

With the explanations related to items present on the screen of the mobile application, still on the screen represented by Figure 5, there will be, if any card previously registered is identified in the captured image, the 3D model corresponding to the card found projected.

Once the user finds the application open on the mobile device and with the elements described above on the screen, the association session must start and, during this session, the child submitted to such session must perform the associations without interference. external and, only if such activity does not seem to have any effect, the attendant responsible for the follow-up can give more tips or help.

The aforementioned tips and other forms of assistance will exist and will be at the discretion of the professional who accompanies the session as he/she has knowledge about the specificities of the treated child.

Throughout this process, the professional must record information related to wrong associations (so that the number of errors committed can be calculated until the expected result is reached), and the right associations (so that it can be compared with the results obtained before the implementation of the gamified process).

In such a way, at the end of the session, when the user (professional or child) clicks on the ”End” button, the number of errors and successes committed by the child during the session must be stored in a report. Thus, at the end of the implementation of the process, the results of all these reports could be compared in order to find the effectiveness of the process.

D. Results

As described before, the project was built and with the aim of facilitating the teaching process of children with ASD through the association of images with words.

For the implementation of the proposed process, as planned, before starting the session, the professionals responsible for this defined what the child’s prize would be when making all the associations. It was defined that the child should carry out eight associations in total, regardless of whether he needs help or not.

When starting the session, all sixteen cards were placed on a table (eight with pictures and eight with words). The word letters were placed side by side next to the child. Initially, the cards containing the figures were placed two feet away from the child, however, as soon as the mobile device was delivered to the child with the open AssociAR application, the professionals who accompanied this session report that he was distracted by the projections and momentarily lost focus.

Starting from this moment, it was defined that the cards that contain the words would be presented in the same way, however the cards that project the images of the animals on the cell phone screen were presented to the child one at a time. The sequence being defined by the attendants while the session was taking place.

Fig. 6. Moment of Utilization

Among the eight desired associations, the child managed to make five of them without any help from the professional in his first attempt. In such a way, considering only the

first attempt, the child obtained 62.5 percent of success (32.5 percent more hits than in the measurement performed before the implementation of the process described in this work). One of the associations made by the child can be seen in Figure 6.

In a second attempt, after the child received hints of the animals' names (the first letters or the first syllables of the name of the animal in question) present in the remaining cards and after being reminded of their prize, two more associations were made successfully. Thus obtaining, in this second moment, a percentage of correct answers of 87.5 (17.5 percent more correct than in the measurement performed before the implementation of the process presented here).

In a last attempt, the name of the animal referring to the association not made was said to the child and, only in this case, the child was able to carry out the association. It is noteworthy, however, that at no time was the association literally shown to the child. In this case, 100 percent of the correct associations were obtained.

The second treatment session with the child took place exactly one week after the first. In this, the letters were presented again all at once, with the letters containing the words were placed on the right of the child and those containing the images of the animals on the left.

In order to avoid that, as in the first session, the child is distracted by the projections, before handing the smartphone to the child, the child was instructed to first choose a letter from among those containing the words and, only after that, she took the mobile device to project the images of the animals and carry out the association (when choosing between the animal letters which corresponds to the previously chosen word card).

In this section, seven of the eight associations were completed by the child on the first attempt (without any assistance), thus having 87.5 percent correct answers. The last association, however, as in the first session, was only concluded after the professional said the word corresponding to that animal.

In addition to these numbers, according to the domain experts who accompany this work, the child's engagement in association activity (using the Augmented Reality mobile app) was higher than expected, even if it was already imagined that it would grow.

Figure 7 shows a graph of the children's evolution. In the measurement related to pre-implantation, the children had 30 percent correct answers. Eight weeks later, at the end of the process development, the first session was held with the use of AssociAR where, in the first attempt, the children had 62.5 percent success. In the following week (nine weeks after the measurement) the second session was carried out using the AssociAR and in this, 87.5% of success was obtained in the first attempt. In such a way, the improvement of the child's performance in this period between a stage and another was 32.5 percent (between pre-implantation and the first session of the implantation) and 25 percent (between the first and the second session). Between the measurement performed in the pre-implantation and the measurement performed in the second session, the improvement in the ability of association

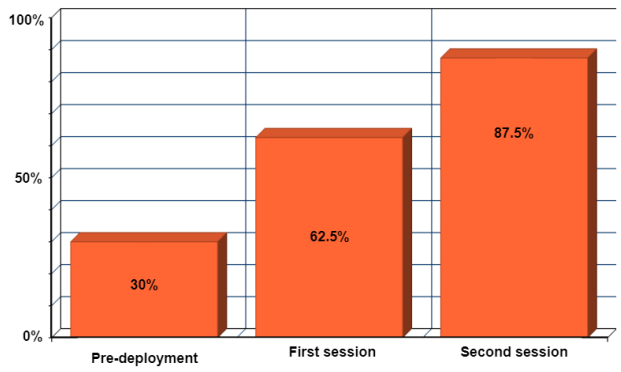

Fig. 7. Children's Evolution

in this context was 57.5 percent. It is noteworthy that among the three described measurements, no similar and/or similar processes were carried out with the child and that all these measurements took about 10 minutes (each).

E. Threats to Validity

Although the tests performed have shown satisfactory results, the number of children who participated can be considered small (only two), so the data may not prove the effectiveness of using the described process.

The application of the process with more children is essential because, in this case, it would be possible to divide them into groups according to their characteristics and identify the differences in results for each group. In addition, segmentation would also allow us to define better how each group will work with the application, such as: which groups will use AssociAR; what is the frequency of use; what is the difference in the evolution of groups that use and groups that do not use; and other nuances. In this way, more data can be collected and this can be studied in order to allow a more consistent result.

Besides that, another threat to validity is that all the domain experts helping this work are from the same child development center, from the same city and have similar experiences. The results could be richer if feedbacks from different experts with different experiences and contexts was taken into account.

V. Conclusion

Considering that this work aims to gamify an activity already used in the treatment of children with Autism Spectrum Disorder (ASD), its objective has been achieved.

Regarding the effectiveness of the process, it is noted that, despite the positive result previously presented, this does not prove that the process is effective in all contexts. One of the reasons for this statement is that, as shown throughout the work, the process presented here was carried out according to the mapping of the users profile. The other reason is that, as also described earlier, the process was tested with only two children.

Thus, it is proposed as future work to carry out tests on children with different levels of autism, as well as to carry out

a test process with two groups of children at the same level of autism, where, in a group, it would be applied the traditional process and in the other group the gamified process would be applied.

As stated by Shackel [33], usability is as important as functionality. With that in mind, we propose as a future work a process of evaluation of the usability of the app. Given the complex context, however, the evaluation will have to happen with the help of domain specialists (and not directly with the children with ASD).

Furthermore, considering the good results and positive feedback from domain experts, it is worth proposing as a future work the development of different Collection Sets (in addition to animals) so that this gamified process can be used in more related contexts, associating images to words. Finally, we propose internationalization (other languages) as a future resource for the application, as it is currently available in Portuguese only.

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