Software *mTEA*: from Computer Design to Application by Professionals with Students with Autism[1]

Software mTEA: do Desenho Computacional à Aplicação por Profissionais com Estudantes com Autismo

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ABSTRACT: A viable way to systematize and customize the intervention in Applied Behavior Analysis (ABA) with students with Autistic Spectrum Disorder (ASD) may be through computational resources. Thus, the objective of this study was to prepare a digital environment called *mTEA* for application of behavioral teaching programs by discrete trial, based on the behavioral perspective, as well as to evaluate the use of *mTEA*, in relation to the elaboration and application of the activities conducted by two professionals with students with ASD. The participants were two professionals and five students with ASD. The procedure was organized as follows: development of the system; then, the two professionals elaborated and applied the activities with five students with ASD and answered a questionnaire about the use of *mTEA*. The results were analyzed in relation to the performance of students with ASD in the activities and to the use of the system by the professionals. The results identified that *mTEA* reached the objective to customize the activities in each student's teaching curriculum, although it still lacks improvements to be implemented in the future.

KEYWORDS: Autism. Applied behavior analysis. Interdisciplinary team.

RESUMO: Uma forma viável de sistematização e personalização da intervenção delineada em Análise do Comportamento Aplicada (ABA), com estudantes com Transtorno do Espectro Autista (TEA), pode ser por meio de recursos computacionais. Assim sendo, este estudo teve como objetivo elaborar um ambiente digital denominado como *mTEA* para aplicação de programas de ensino por tentativas discretas, fundamentados na perspectiva comportamental, assim como avaliar o uso do *mTEA*, em relação à elaboração e à aplicação das atividades por duas profissionais com estudantes com TEA. Participaram duas profissionais e cinco crianças com TEA. O procedimento foi organizado da seguinte forma: desenvolvimento do sistema; na sequência, as duas profissionais elaboraram e aplicaram as atividades com cinco estudantes com TEA e responderam a um questionário sobre o uso do *mTEA*. Os resultados foram agrupados em relação ao desempenho dos estudantes com TEA nas atividades e ao uso do sistema pelas profissionais. Os resultados identificaram que o *mTEA* atingiu o objetivo proposto para personalizar as atividades propostas em cada currículo de ensino de cada estudante, apesar de ainda carecer de melhorias a serem implantadas futuramente.

PALAVRAS-CHAVE: Autismo. Análise do comportamento aplicada. Equipe profissional interdisciplinar.

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1 Introduction

Autistic Spectrum Disorder (ASD) is characterized by qualitative language deficit and social interaction, stereotyped and repetitive behavioral pattern, and restricted interests (American Psychiatric Association [APA], 2013). It is a neurodevelopmental disorder that affects different areas of development, especially in the social, communicative and behavioral areas (APA, 2013). ASD involves early childhood developmental conditions that may appear in the behavioral repertoire of a child with ASD prior to entry into school.

In developed countries with medium and low income, the prevalence of ASD ranges from 0.67% to 1.13%. According to the Centers for Disease Control and Prevention (CDCP, 2014), in 2014, one in 59 children had ASD. Based on these figures, the World Health Organization (WHO) estimates that about 70 million people worldwide are on the autistic spectrum. In Brazil, they are estimated to be similar to WHO (Oliveira, 2015). A single Brazilian pilot study conducted in the São Paulo region found that 0.3% of the Brazilian population must have ASD, meaning that around 40,000 children or adolescents (up to 20 years old) may have the disorder (Bagaiolo et al., 2017).

Symptoms can range from mild, moderate to severe, resulting in different support levels for each behavior affected by the disorder (APA, 2013; Pimentel, 2013). All the peculiarities arising from TEA can make the process of knowledge acquisition difficult. ASD is characterized by deficits that affect personal, social, academic or professional functioning. Such conditions range from global limitations, such as those related to intellectual disabilities, to specific conditions, such as specific learning disorders (APA, 2013). In addition, ASD is a condition that can compromise the ability to communicate with others, to perceive shared events, to express feelings in a variety of situations. Other known behaviors refer to stereotypes, repetitive postures or acts, rituals and restrictive interests (APA, 2013). ASD signs can be identified before 36 months of age (Mitchell, Cardy, & Zwaigenbaum, 2011), enabling early intervention (Koegel, Koegel, Ashbaugh, & Bradshaw, 2014).

From an inclusive educational process, it is possible to provide quality teaching that values individual differences (Farias, Silva, & Cunha, 2014) and respects the individual learning pace of each student (de Rose, 2005). "The perspective of Behavioral Analysis leads us to consider that, in principle, any individual is capable of learning, even those with limitations or disabilities. No diagnosis or label adequately describes a person's abilities or difficulties" (de Rose, 2005, p. 31).

The Applied Behavior Analysis (ABA) refers to behavioral science that uses scientific principles for behavioral change. ABA has shown solid results in treating people with ASD (Andalécio et al., 2019; Bagaiolo et al., 2017; Cooper, Heron, & Heward, 2007; Gomes, de Souza, Silveira, & Oliveira, 2017; Higbee et al., 2016; Lovaas, 1987, 2002), involving the teaching and learning of new behaviors (social, academic etc.), since Lovaas's (1987) first publication. The teaching curriculum is programmed from a sequence of teaching programs (or sets of activities). Through this continuous, small-step teaching, it is possible an accelerated work pace with fast, manageable results (Lovaas, 2002). In general, one of the teaching

procedures used in ABA refers to the discrete trial (Higbee et al., 2016; McEachin, Smith, & Lovaas, 1993).

Discrete trial teaching involves a structured format through the application of an antecedent stimulus, a response and a consequence. This means that the application of the activity begins with a short and objective instruction given by the professional, which has a discriminative stimulus function for the student's response with ASD and, immediately after the answer, a differential consequence is provided immediately, which may be different for situations involving hit and miss, depending on the teaching schedule outlined by the behavior analyst. The teaching consists of small units that are presented one at a time in a set of trials (Ferreira, Silva, & Barros, 2016)

The study conducted by Higbee et al. (2016) evaluated the effectiveness of a training through computerized activities translated into Portuguese for the application of an ABA teaching procedure, through the application of discrete trials, with four undergraduate students, through role-play and four Special Education teachers who worked with students with ASD, in teacher-student with ASD interaction, from a multiple baseline design. Participants were exposed to computerized training and then applied the content discussed in such training. During practical application, five of the eight participants required some kind of feedback to meet the learning criteria. However, all participants learned to apply a discrete trial after training, which evidenced the effectiveness of the proposed teaching.

In order to develop an intervention based on behavior-analytic principles (Cooper, Heron, & Heward, 2007), it is necessary to apply certain items, such as: a) assessing the repertoire of the student with ASD; 2) elaborate customized activities for each one of them, based on the data analyzed in each evaluation; 3) apply the activities and record the performance of each student with ASD in each activity; 4) analyze the student's performance and the applicator's behavior; 5) propose new activities based on data analysis of each student.

ABA interventions can be applied by a variety of professionals, involving an interdisciplinary team, such as; for example, psychologists, speech therapists, educators, occupational therapists, special educators. Technological tools, in this context, can play a fundamental role in the involvement of such professionals, in order to create conditions for everyone to know the applied activities, as well as to have the opportunity to apply each one of them, to analyze the student's performance with ASD and reschedule a new activity for future sessions. As ASD can affect different areas of development, the need to involve different professionals in the same intervention is justified, as well as to comply with the norms described in the National Policy for the Protection of the Rights of Persons with ASD, promulgated by Law no. 12.764 of December 27th, 2012, in its article 2, paragraph 3, when referring to the right of students with ASD to multiprofessional care.

The joint work between different professionals favors the comprehension of different knowledge produced in the different areas of child development. Such attendance, when conducted in an interdisciplinary perspective, favors intensive collaborative work (Curtis et al., 2006), especially when the work involves the target public students of Special Education (such as the TEA) and is built up in the social, political and cultural sciences, with emphasis

on Education, Health and Psychology, due to the contribution they can make in meeting the multiple demands that involve the disorder or disability (D'Antino et al., 2010).

In this scenario, there are some challenges to be overcome: a) the number of people with ASD, in terms of national population (Bagaiolo et al., 2017; Oliveira, 2015); b) a work involving a multidisciplinary team with interdisciplinary work in ABA (Law no. 12.764/2012; Curtis et al., 2006; D'Antino et al., 2010); d) personalized teaching for each person with ASD, considering the variability of symptoms; e) planning an alternative teaching proposal, using a digital environment, with emphasis on the individual repertoire of each student with ASD, in order to value the individual learning pace (de Rose, 2005).

Digital environments, in this context, seem to serve as a way of integrating the team, in order to favor an interdisciplinary performance, besides creating conditions for the systematization of the application of the activities outlined in each curriculum of each student with ASD. The use of computational solutions in teaching tasks with students with ASD has been used with satisfactory results in relation to the learning process (Aresti-Bartolome & Garcia-Zapirain, 2014; Britto, 2016).

Among the software developed for desktop use are: *Mestre* (Britto, 2016), ProgLeit (Rosa Filho, de Rose, de Souza, Hanna, & Fonseca, 1998), GEIC (Capobianco et al., 2009), PELPS (Haydu, 2014), EQUIVIUM (Pimentel, Baldani, Piccolo, & Hubner, 2009) and ABCD SW (Buzzi, Buzzi, Gazzé, Senette, & Tesconi, 2012). Among the software aimed at tablet use are: iCAN (Chien et al., 2015), Go-Go-Games (Hiniker, Daniel, & Williamson, 2013), MOSOCO (Escobedo et al., 2012), DISSERO (Hani & Abu-Wandi, 2015), SCALA (Passerino, Avila, & Bez, 2010) and *ABC AUTISMO* (Farias, Silva, & Cunha, 2014). One way to ensure large-scale application can be through the use of mobile devices such as tablets and smartphones.

Among the computational solutions mentioned, iCAN (Chien et al., 2015) refers to a tablet application based on the visual communication board by the Picture Exchange Communication System (PECS). Go-Go-Games (Hiniker, Daniel, & Williamson, 2013) features a tablet game used as therapy to support the education of students with ASD. MOSOCO (Escobedo et al., 2012) teaches students with ASD to practice social skills in real situations. DISSERO refers to an application that uses the teaching of cognitive tasks and social skills. SCALA (Passerino, Avila, & Bez, 2010) is a tablet application that assists the student with ASD in alternative communication based on the PECS visual communication board. *ABC AUTISMO* is a tablet application that has activities (at different levels) that help the literacy process of students with ASD.

In this scenario, it was found that the related works gathered did not present in the same solution the following characteristics: a) preparation of activities by the professional according to the curriculum and the need of each student with ASD, without requiring advanced knowledge in computing; b) conducting activities using a tablet and exploitation of the functionality of the touch screen; c) monitoring the evolution of the performance of each student with ASD. Through the proposed arguments, it is suggested the elaboration of a digital environment that is able to gather such resources in the same solution, through the application

on mobile devices, to teach specific behaviors, through behavior-analytic principles, with people with ASD, applied by professionals of an interdisciplinary team.

1.1 Objectives

Based on the questions presented, this work aimed to elaborate a digital environment called *mTEA* for the application of discrete attempt teaching programs, based on the perspective of behavioral teaching, as well as to evaluate the use of *mTEA*, in relation to the elaboration and application of activities by two professionals with students with ASD.

2 Method

This is a research with quantitative profile to analyze the performance data of students with ASD and qualitative to analyze the reports of professionals.

2.1 The construction of m-TEA

The *mTEA* consists of three pieces of software: 1. server that stores data in the cloud (*mTEA*-Server); 2. WEB software (*mTEA*-WEB), used to elaborate customized activities; and 3. Tablet/smartphone App used to apply teaching activities to students with ASD (*mTEA*-App). Figure 1 illustrates such software organization.

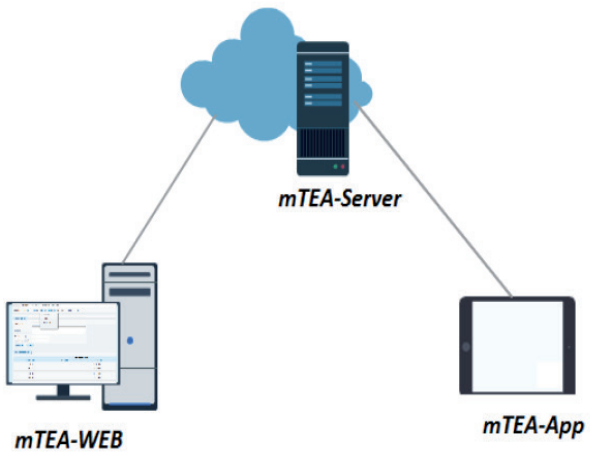

Figure 1. Overview of *mTEA*.
Source: Elaborated by the authors.

The *mTEA*-WEB was developed with Java (Java 8) programming language and can be accessed via any web browser. The *mTEA*-Server is composed of an application service, Wildfly, a Postgres database. The *mTEA*-App was developed for the Android platform. With the tablet, the child uses the *mTEA*-App that acts as a player of activities designed by the professional. The

mTEA-App is available for installation at the link: https://goo.gl/xoLL2u. Access to *mTEA*-WEB is available at: http://bit.ly/2t76rs0. Username: cbie, and password: cbie1.

The *mTEA* was outlined by a set of templates that served as the basis for programming custom activities. Template refers to the structure that defines the type of teaching activity, specifying which parameters can be changed by the professional. The template was designed based on the possibility of developing customizable activities, according to the repertoire of the child with ASD. In addition, the principles mentioned above and the principles of Behavior Analysis were considered (Simpson, 2001). In this context, to enable the elaboration of personalized activities by the professional, the concept of template was used.

The scope of the template is defined by the professional team. This template is passed on to programmers who develop the template for the tool. The developers prepared the templates following the behavioral teaching recommendations listed earlier. Thus, the template will be available in *mTEA* so that professionals can use them. With templates, professionals can create tasks for students with ASD, according to their behavioral repertoire.

Figure 2 illustrates the use of the template "form the word" for *mTEA* activities. On the left side is the list of templates available for this study, previously developed by the software developers. On the right side is illustrated the use of these templates by the professional. For example, when using the template "form the word", the professional uses *mTEA*-WEB to create ACTIVITY 1, forming the word BALL. In addition, for the same ACTIVITY 1, the educator defines a representative image of the word chosen by the educator. The trader can also add a favorite video (which has reinforcing value) that will be presented at the end of the activity, according to the trader's schedule. For example, if the child responds correctly to the activity, he/she may have access to the favorite video, or if the child responds incorrectly, he/she will return to the activity and will be instructed again along with a tip.

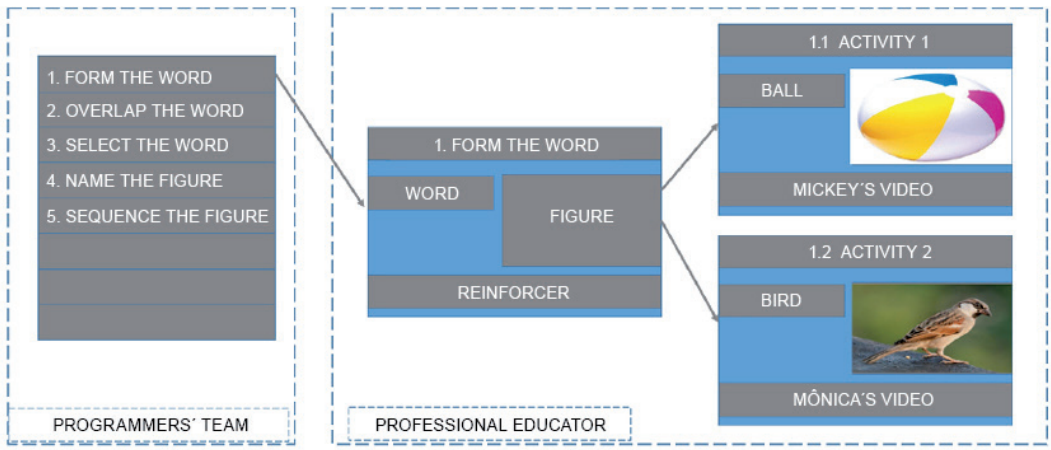

Figure 2. Example of the template "form words: ball and bird" in *mTEA*.
Source: Elaborated by the authors.

Table 1 below shows the description of the five current *mTEA* templates for conducting this study.

Template	Description
Form the words	Form the corresponding word by dragging each letter to the blank space.
Overlay words	Drag each letter over the correct letter in the word above.
Select pictures	Select identical pictures (with memory game function).
Name pictures	Name the pictures that appear on the tablet screen.
Sequence pictures	Select pictures by following the pattern sequence that appears on the screen for the child.
Dictation by composition	The child will be instructed to write the name of the picture that will be displayed on the screen through the composition of the word.
Copy by composition	The child will be instructed to copy the word using the letters available on the screen.

Table 1. Description of the five existing *mTEA* templates.
Source: Elaborated by the authors.

It is noteworthy that these templates were suggested by the team of professionals, taking into consideration the conceptual principles cited, in order to fulfill the findings described in participatory design, in which the Applied Computing scientist dialogues directly with the professional who will use the resource in his/her daily life. In addition, programmers develop templates taking into consideration the concepts of Requirement Engineering (Pressman, 2011). In this scenario, it is possible to see that new templates can be designed in a simple way. This taking into account the recommendations of the principles addressed and the attributes listed by the team professional.

Finally, the purpose of this conceptual model or architecture is to enable and facilitate the development of new components for *mTEA*. In this sense, any new participant who is interested in participating in the project can simply create new templates. Thus, the project is available for other developers to contribute to the evolution of *mTEA*.

2.2 Ethical considerations

This research was approved by the Human Research Ethics Committee of the Federal University of São Carlos, São Carlos, Brazil (CAAE 60273816.4.0000.5504).

2.3 Participants

For this study, two professionals and five students with ASD were selected. The criteria for the selection of professionals were: a) to be developing professional work with students with ASD; b) have basic computer skills; c) compose an interdisciplinary team with theoretical approach in ABA. For the students, the criteria were: a) to be attended by the professional participant of the study; b) to have a medical diagnosis of ASD.

Professional A from the study was trained in Psychology and Pedagogy and had been working for 10 years in the Special Education area, with interventions involving students with ASD and ABA. Professional B was trained in Occupational Therapy and had been working in Special Education for four years. Students with ASD, named E1, E2, E3, E4 and E5, were four, five, eight, six and nine years old, respectively, and had been attended by the professional for more than one year each. E1, E3, E4 and E5 were boys and E2 was a girl. Professional A applied *mTEA* with E1, E2 and E3, while Professional B applied *mTEA* with E4 and E5.

2.4 Situation and materials

The elaboration and application of the activities by the professionals took place in a specialized service center, which has an interdisciplinary team, with professionals in the area of Psychology, Pedagogy, Psychopedagogy, Speech Therapy, Occupational Therapy and Special Education. All professionals apply the same ABA-based teaching curriculum. As a material, it was used a Samsung Galaxy Tab A 16GB memory tablet, 8 inches with internet via 4G or Wi-Fi, Android platform and Quad Core Processor and Desktop type microcomputer to elaborate the activities in *mTEA*-WEB by the participating professionals.

2.5 Variables

The independent variable of the study involved the necessary conditions for the elaboration of the *mTEA*, while the dependent variables were responsible for measuring the effect of the treatments used in the experiment, such as the performance of the professionals in the elaboration and application of the activities in the *mTEA* and the performance of the students with ASD.

2.6 Procedure

The procedures performed in this research were divided into three steps, described below.

a) Development of *mTEA* by researchers as described in the previous section.

b) Preparation and application of the activities by the professional participant of the study.

The study professionals performed several applications in different environments, each one in a different context. The professionals had access to *mTEA*-WEB to register the students (E1, E2, E3, E4 and E5). Then, the professionals elaborated the activities for each one of them, according to the individual needs that they presented in their respective personalized curricula. To register the activities, we used the base of templates available in m-TEA. Figure 3 relates the visualization of the educator (*mTEA*-WEB) in the elaboration of the activity "form the word BALL" and the visualization of the student (*mTEA*-App) in the accomplishment of the respective activity. Then, the professionals applied the activities with the students using the m-TEA-App on the tablet.

Figure 3. The *mTEA* screens. On the left, the example of the *mTEA*-WEB used by the participating professional to elaborate the activities. On the right, the *mTEA*-App screen is viewed by students with TEA.
Source: Elaborated by the authors.

c) Application of the questionnaire with the participating professionals.

Finally, the professionals answered the questionnaire, which consisted of seven open-ended questions about *mTEA* evaluation, namely: Is the proposed digital environment, considering the applied activities, equivalent to traditional methods? Why?; What are the negative points of the digital environment compared to the traditional method?; What are the positive points of the digital environment compared to the traditional method ?; Are students more or less motivated to perform the activities ?; How focused are the children when using the digital environment? Is it possible to compare the level of attention of children in relation to the traditional method? In your opinion, is the environment useful for performing tasks in the children's home with parental support? Does the data in the reports and graphs of the web environment make it possible to monitor the child's performance?

In general, we sought to compare, from the perspective of each professional, the *mTEA* to traditional methods. The term "traditional method" was used to refer to the conventional, in this case, the use of pencil and paper to apply the intervention. The questionnaire also allowed investigation into the negative and positive points of the environment, as well as the motivation and concentration of students to perform the activities. In addition, the objective was also to evaluate the viability for the use of *mTEA* at home, applied by parents and the quality of data analysis proposed by *mTEA*.

2.7 Data analysis

The questionnaires were answered in writing by the professionals and the answers were analyzed by thematic categories, as well as by the performance of the five students with ASD, in the different activities proposed by them. In general, proposals for future improvements and referrals for further improvement of *mTEA* were reviewed.

3 Results

The results were grouped into two categories that refer to student performance in *mTEA* activities and professional responses to *mTEA*. These activities were elaborated by professionals A and B. Then, an evaluation was performed by these professionals in *mTEA*.

Figure 4 shows the performances of students E1, E2 and E3 in the activities prepared and applied by Professional A. E1 performed four activities according to their personalized curriculum: word overlap, word formation - DADDY, identification of similar figures and number sequence. E2 performed five activities, except for the numerical sequence. E3 performed five activities, except for naming figures.

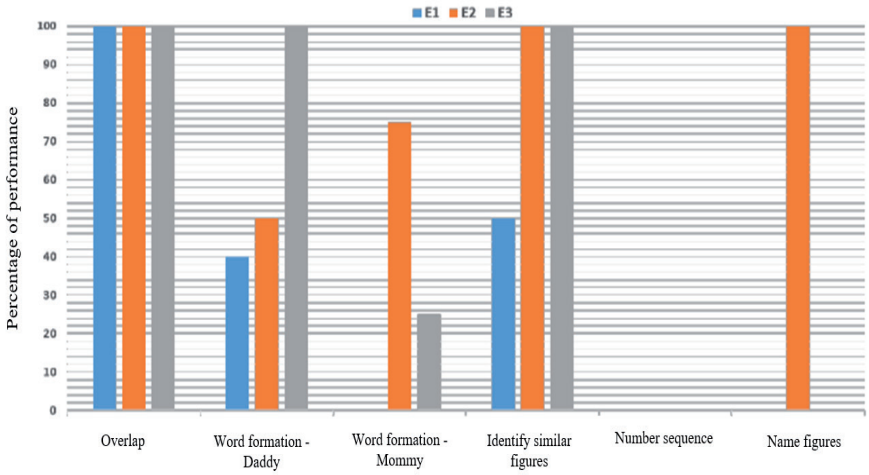

Figure 4. Performance of E1, E2 and E3 in the activities elaborated and applied by professional A in the *mTEA*.
Source: Elaborated by the authors.

The blue column refers to the performance of E1, the yellow column refers to the performance of E2 and the gray one to the performance of E3. Figure 5 shows the performance of students E4 and E5 in the activities elaborated and applied by Professional B.

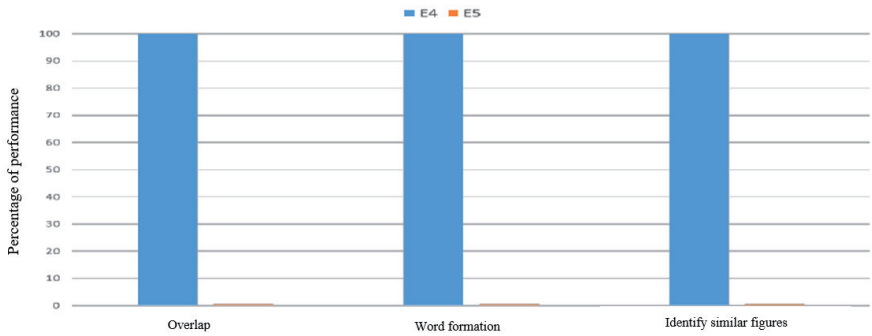

Figure 5. Performance of the two students with ASD in the *mTEA* assessed activities, applied by professional B. The blue column refers to the performance of E4, the red column to E5.
Source: Elaborated by the authors.

Table 2 shows the answers from professional A. One point to consider was the instructions the professionals received to interact with the system. The professionals were instructed to contact the development team whenever necessary.

Answer of Professional A	Answer of Professional B
Category 1: Evaluation of the digital environment compared to manually applied activities (Q 1, 2 and 3)	
"The environment makes it easier for students with ASD to apply activities because of the resources that can be used with technology, as well as favoring faster data analysis over manual work. The environment features a user-friendly and intuitive interface, without prior knowledge in the field of computing, as well as ease of application on tablet or even smartphone. Another point refers to the possibility of elaborating activities, according to the student's performance and adapting them, as needed. The automatic register of performances by the environment saves the professional application time. As with any program, improvements can be made, such as modifying the reinforcing consequence according to the student's interests, for example, at the end of the activity, automatic access to a YouTube video; provide oral instructions to be given directly by the environment, according to each activity and specify the figures/words in the report of each activity ."	"The APP idea is really cool, but it's not attractive enough, for example, like other APPs, which are colorful, speak, have music and bright colors, and have similar activities. However, when compared to manual activities, the application is much more effective, especially for data analysis."
Category 2: Performance of students with ASD in activities (Q4 and 5)	
When viewing activities on the tablet, they would smile and ask to do them, which means they were motivated to perform such activities. Importantly, such behavior did not occur with activities on paper. The students established permanent eye contact with the stimuli present in the activities, which favored greater number of hits in each one, which means they were more concentrated."	"I found the application simple to use, but I think it could have customization options, for example, increase the font size and images for children who have more motor difficulties, as was the case of E5, who did not respond to any activity due to motor difficulty to perform the activity."
Category 3: Use of the environment by the parents (Q 6)	
"The application of the activities is very easy and can be used by any population, including parents. Due to the automation of the activities, the professional can program a sequence and make it available for parents to perform with their children, in order to extend the intervention time in their homes."	"I believe the application is valid for use in various environments. In general, the idea is very good and I think it will help a lot with the children's learning."
Category 4: Data analysis provided by the environment (Q 7)	
"The reports issued by the environment optimize data analysis by speeding up the calculation of hits and misses, thus facilitating decision-making on the curriculum of each student with ASD, however they need to be more specific regarding performance for each word and/or figure."	"Another thing is that I found it complex to register children through the site and then open the application (if it was everything in the application, it would be easier to register several children), I think the simpler, the easier to spread the idea and other people use this feature."

Table 2. Categories of analysis of the responses of professional participant A and B, in relation to *mTEA* evaluation.
Source: Elaborated by the authors.

Among the questions recorded by the professionals, the following stand out: a) Particularities of each activity (for example, about the "need to upload the same figure twice for the activity of identifying similar figures" - memory game) (Professional A), "Need to increase the font size and customize the activity for each child even more" (Professional B); b) Technical questions (for example, "the link typed to access the video on YouTube after the activity did

not work"; "when creating an activity, to be able to take advantage of other students' activity so as to save the professional's time to prepare the activities"; "establish activity repetition criteria"; "provide oral instructions through the environment itself" - Professional A; "difficulty in registering children through the site and then opening the application, if it were all in the application, it would be easier to register several children" (Professional B).

4 Discussions and conclusions

The purpose of this work was to elaborate and evaluate a digital environment, *mTEA*, which allows the professional to: a) flexibly elaborate personalized teaching activities in discrete trial format; b) apply computerized tasks during the ABA intervention with students with ASD. The study was conducted from an interdisciplinary perspective, involving areas such as Inclusive Special Education, Behavior Analysis, Occupational Therapy and Computer Science. This means that interdisciplinarity was the common ground that underpinned the entire construction of *mTEA*.

This research proposed the elaboration and evaluation of *mTEA*, a digital environment that allows the professional to flexibly elaborate personalized activities, in the discrete attempt format, according to the behavioral repertoire of each student. The results are discussed, based on the computational design performed for the proposition of the system, as well as its validation, from the application with children with ASD, by professionals who worked with such children.

As a way of promoting teaching, different strategies were proposed, using technological resources, guided by an interdisciplinary team, usually composed of educators, special educators, psychologists, speech therapists and occupational therapists, aiming to assist these professionals in the educational work with students with ASD (Britto, 2016). The use of technologies that support these teaching strategies favored the teaching of the different skills mentioned above, in the various areas of development, as highlighted in the study by Britto (2016) on the importance of computational solutions aimed at teaching different skills.

Thus, the way the *mTEA* was structured enabled the elaboration of activities, in the form of discrete attempt, that integrated a curriculum outlined in the behavior-analytic perspective (Cooper, Heron, & Heward, 2007). The proposed environment was made possible by the integration of a WEB system (*mTEA*-WEB) and the mobile APP (smartphone and tablet). The *mTEA*-WEB enabled the development of personalized activities by the professional who is part of an interdisciplinary team that worked with students with ASD. In addition, it allowed the monitoring of activities and the analysis of individual performance of each of them.

The main innovation with *mTEA* was to allow the team professional to design individualized activities based on each student's personalized curriculum. In addition, it allowed automatic recording of student performance with ASD, in accordance with the assessment of participant A in Category 1 of Table 2. Another important feature of this environment was the possibility for parents to perform activities with their children in their homes, according to the report of the professional participant in Category 3 of Table 2. The children's parents or guardians could control the time of completion of activities and keep track of the children's performance.

Another relevant item referred to the report provided by the environment, which optimized data analysis and application of activities. In manual activities, the professional needs to manually apply and record the performance of the student with ASD in each activity. In *mTEA*, the professional did not need to register the data, as such registrations were automatically made, according to the report of professional A in Category 4 of Table 2. According to reports from professional A, the motivation of students with ASD to perform the activities *mTEA* was considered satisfactory (Category 2 in Table 2). This corroborates the performances presented in Figures 4 and 5 as they performed all the activities proposed in their custom curricula.

Student performances, shown in Figures 4 and 5, show that they performed the activities at *mTEA* and that, for most of them, the activities were consistent with their individual curriculum. From the performance of students with ASD, it is possible to state that *mTEA* involved cognitive web accessibility (Britto, 2016), due to the nature of the proposed teaching tasks. However, it was not possible to make an explicit comparison of the effect of manual activities compared to the performance in the program activities due to the cumulative effect of learning, that is, by doing the activity in the program the student learned what stimuli he/she needs to respond, just as he/she does manually. Thus, it is not possible to assess the extent to which learning came from the program alone, and to what extent it was the product of manual activities. Future studies may consider how to operationalize this measure in more detail.

On the other hand, regarding the performance of E5, professional B identified that the activities were very difficult for the student, due to the motor coordination necessary to perform them. This suggests that in future versions of the program, templates will be programmed that teach motor coordination, such as doodling, drawing the same model, dragging arrows to different sides, among others. In general, both Professional A and B indicated the tool to other professionals and continued to use the tool with other students. Despite these limitations presented by the system, it is essential to emphasize the flexibility of the professional to propose new activities. Such flexibility is fundamental in the proposition of personalized activities, since other systems available in application format have a set of standardized, closed activities, without any possibility of adaptation by professionals.

In addition, suggestions are made for program enhancement in future versions, with regard to the following enhancements: a) after the end of the activity, to have automatic access to the YouTube video, according to the preference of each student with ASD; b) to copy the activity to different students in order to optimize the elaboration; c) to establish criteria for repetition of the activity; d) provide oral instructions by the environment itself; e) in the data report, to present the performance in each activity according to each figure and each word worked and also describe the student's response, instead of just quantifying it; f) to expand the number of templates for other activities.

Some limitations can be identified throughout the study application, such as: a) it was not possible to make an objective comparison between the use of manual tasks compared to tasks in *mTEA*; b) lack of measurement in relation to the time spent and the quality level evaluated by the professional to perform the activities in the program, compared to the manual activities. However, the data from the questionnaires applied to professionals after the use of

mTEA showed the importance of the resource, despite the need for further studies, considering a large-scale application with different students with ASD.

Another suggestion for conducting future studies involves applying *mTEA* to multiple practitioners and comparing practitioner performance when applying the activity on *mTEA* to manual application. In general, it was possible to verify in the report of professionals A and B, the optimization of the application of sessions, from the use of *mTEA*. Nonetheless, it is suggested that systematic analysis of such applications be conducted in the two proposed formats. Thus, the application with only two professionals can also reveal preliminary data on the large-scale application, aiming at a usability evaluation. It is recommended that future studies expand the sample of professionals to be investigated through a more rigorous usability assessment and a larger number of participants.

The data from this study reached the proposed initial objectives regarding the elaboration and evaluation of the *mTEA*, with fundamental data for continuity and improvement of the environment, aiming at the dissemination and use by different educational agents. In addition, it is recommended that the sample be expanded to involve the target audience of Special Education as an auxiliary tool to be used during Specialized Educational Care by Special Education teachers.

The results show that *mTEA* allowed the creation of specific activities for the curricular demand of each student with ASD, elaborated and applied by non-expert professionals in the computational area and had a dialog with recommendations given by Brito (2016), proposing an accessibility guide for people with autism, regarding visual and textual vocabulary and customization. This means that the environment has a flexible user-friendly interface, as well as the teaching of the above-mentioned basic skills and the dissemination of its use by different people to different students with ASD. Thus, the gathering of knowledge produced by the areas of ABA, as well as Special Education and computer science was fundamental for the elaboration of the *mTEA*, aiming at teaching and learning activities for students with ASD, according to their individual needs. Such dialogue corroborated Britto's (2016) findings when he proposed a Web Interface Accessibility Guide focused on aspects of Autism.

Among the main contributions of this study, the following stand out: a) elaboration of activities adaptable to the level of the child with ASD, using computational resources; b) *mTEA* system developed from a set of integrated tools (*mTEA*-Server, *mTEA*-WEB and *mTEA*-App) forming a *mTEA* digital environment, such an environment enabled professional educating users to design activities in a customizable way and apply to children with ASD , by means of tablet; c) evaluation of the proposal, through experimentation with children with ASD to evaluate the viability of the system, from the perspective of professionals working in the demanded area.

The presented proposal integrates professionals from different scientific fields, in favor of the education of a specific audience, which, through resources and learning strategies, respond to educational tasks, according to their individual learning rhythms. Finally, *mTEA*-WEB is available on the servers of the Federal University of Piauí (UFPI), through the link *mTEA*-WEB (user: cbie and password: cbie1), so that other researchers can continue studies

on the proposal, from the respective improvement, to reach a larger number of users, aiming at the scalability of the system, in this area of knowledge.

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