Construction and Analysis of a Mobile Game for Measuring Cognitive Flexibility Skill

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***Abstract*—This paper aims to report the construction and analysis of a mobile game to measure cognitive flexibility in children in the school cycle. This paper presents an analysis of the items that include the indicator of cognitive flexibility calibrated in terms of the information they provide about the specific psychological construct evaluated. Statistical results show strong evidence of validity regarding the internal consistency of the instrument and the psychometric properties of the items.**

***Index Terms*—game, measurement, cognitive flexibility**

I. Introduction

The school cycle is the child's main phase. At this stage, the child practices sports, martial arts, dances, and mainly recreational activities. Recreational games are of great importance, as they enable the development of the child's ability to solve problems [1]. It is also at this stage that the child must stimulate executive functions [2].

Executive functions are cognitive skills responsible for the control, integration, and maintenance of cognitive and metacognitive processes that are directly linked to the power and direction of the individual's behaviour, as well as in the orientation and generation of cognitive behaviours and emotional functions [3] [4] [5] [6].

Executive functions postulate the existence of three essential executive functions: inhibitory control, cognitive flexibility, and memory [7]. However, in this paper, we only address cognitive flexibility that refers to conscious changes in perspectives or approaches to solving a problem, adapting flexibly to new requirements, rules, and priorities [8].

This skill allows an individual to have different angles about the decisions to be made when realizing an error and being able to correct it before the action. Working memory and inhibitory control are related to the development of this skill. It is necessary to inhibit the reasoning method used previously and to put in working memory a new aspect of seeing the problem [8]. With the absence of cognitive flexibility, individuals were unable to solve problems using other methods, recognize errors, adjust to changing priorities, and take advantage of unusual new opportunities [2].

At the same time, the development of Information and Communication Technologies (ICTs) in the different areas that are part of the human domain is undeniable. Not so different in the field of psychology, technological advances include the use of computerized instruments for the use of virtual reality in the rehabilitation and therapy of patients. The lack of consent and the printed limits make it difficult to conclude the various instruments and measures proposed for the assessment of cognitive flexibility because it is a complex construct with multiple directions. Therefore, a broader and more detailed study of its functioning is necessary [9].

Due to the scarcity of valid and accurate computerized instruments to assess the ability of cognitive flexibility in the school cycle cite b9, we developed the game "O Mundo de Phie", in partnership with the Laboratory of Cognitive Neuropsychology and Technological Innovation at the Federal University of Campina Grande (UFCG) and Paraíba State University (UEPB). This game should be used in school interventions for children, in the school phase, in activities that involve cognitive flexibility.

We propose an instrument as a way to overcome these limitations in the scientific and academic field to instrumentalize these practices to provide significant support, taking into account a series of requirements that contemplate this study. We analyzed the instrument's internal consistency and the psychometric properties of the items based on the Classical Test Theory (CTT) and the Item Response Theory (IRT) to demonstrate the reliability of the game.

We organized the paper as follows: In Section II, we present the background; In Section III, we present the construction of the game through its structure and elaboration of items; In Section IV, we explore the method used in this study; We present the results and discussions in Section V; and, Finally, in Section VI, we present the final considerations and suggestions for future work.

II. Background

This section describes the stimulating process of cognitive flexibility in children in primary education [8], CTT and IRT [10].

A. Cognitive Flexibility Process

In the literacy phase, children face new challenges. Children must solve these challenges individually or in groups, with one or more teacher instructors who guide them in this new phase. For that, teachers need tools that go beyond the blackboard and the book; such resources should assist in children's learning, making it more dynamic and interactive. It is up to the teacher to create an environment that integrates motivational elements in which the child will be happy to perform tasks [11].

Several children have a unique opportunity in the school environment to receive scientifically-based stimuli, which helps in the development of some linguistic, socio-emotional, behavioural and academic skills. Many studies show the highlight of interventions in the school environment. Projects created for children in this age range are very concerned with offering language skills, executive functions and self-regulation, as well as socio-emotional skills [12]. Providing the development of cognitive flexibility in children would be able to reduce later difficulties, in addition to those related to maladaptive and antisocial behaviours [13].

The connection between Neuroscience and Education is widely studied. It shows that in this field of interaction, executive functions play a significant role, since they are responsible for structuring the neural orchestra in most of the activities of daily life, assuming, thus, a fundamental role in school learning.

The practice of universal interventions in the school environment is very valid in reaching everyone and providing an environment of stimulation and prevention. In the school environment, teachers encourage academic and socioemotional skills in children. Attitudes of support to educators are still minimal to develop skills of emotional self-control, pro-social practices, control of aggression and impulsivity. Also, several executive skills, such as problem-solving, inhibitory control, planning and organization, have stood out among the authors so that they can be guided and instructed through methods peculiar to this end [14] [6].

The lack of consent and the printed limits make it difficult to conclude the various instruments and measures proposed for the evaluation of executive functions, as it is a complex construct with multiple directions, a broader and more detailed study of its functioning is necessary [15].

Most conventional tests provide accurate and transparent guidelines. These tests reduce the probability of the investor perceiving deficits of executives who are subject to appear in uncertain or ambiguous circumstances [16].

The attitude of the investor and the environment with the absence of distractions mask the deficits. In this way, the cognitive performance obtained in the test performed in an office equaling real situations involves the same skills. However, the tests can differ significantly between them. Different moments and different situations can lead to different performance paradigms. However, tests can provide more information about the child's functioning. A school environment with highly elaborated classrooms and with immediate help from the teacher ends up adjusting itself as a circumstance in which executive skills are little explored [15].

In Psychology, technological advances can be observed from the use of computerized tests to the use of virtual reality in the rehabilitation and therapy of patients. Psychologists, even with the expansion of the use of computers, have had a slow engagement with the use of new technologies, coming to use them for personal use and not as reinforcement to the treatment of their patients [15]. In a study by Soto-Péres et al. [17], it showed that a small number of professionals see the use of computers in the neuropsychological analysis as being unreliable, worthless and that users would not well accept it.

With this in mind, many questions arise regarding the development of technological solutions for the field of Psychology. Changing the tests done with paper and pencil to computerized tests is not so simple. Both have their limits and advantages, and it is up to the researcher to adopt the method according to the precision of the individual evaluated, especially in the literacy phase.

Technologies are available for teachers who are willing to have one more ally in their teaching practice. For this to occur, an absolute change will be required, which requires observation and organization so that it does not become a to-do, but something significant.

One way to contribute to children's learning in the classroom is the use of digital games. With digital games, teachers help students to overcome their difficulties presented in the classroom, stimulating the student's symbolic capacity, providing their learning. It is necessary to understand that within the learning process with digital games there are two points of view: the daily moment when an independent investigation by the child occurs and the formal moment when the teacher, with appropriate techniques and procedures, uses his knowledge to lead and challenge the student to develop new skills and competences [18]. Interaction with games tends to test hypotheses, play naturally and explore creative skills [19].

Playful activities, such as digital games, involve a series of cognitive skills, such as decision making, actions that are limited by rules, challenges and objectives to be fulfilled and graphic representation [18]. We emphasize that with the support of digital games in the classroom, the teacher should not discontinue his teaching and evaluation methodology, as the validity of a didactic resource is not only due to its playfulness [20].

B. Classical Test Theory

The Classical Test Theory (CTT) which uses as a reference the total number of correct answers of an instrument to assess the individual's performance, in the same way, that it makes it simple and direct in its application.

However, CTT has some limitations in its evaluation area, among them: i) sample of individuals who respond to the

instrument for the first time can influence the validation of the instrument if applied in another group of individuals and they should have characteristics similar to those of the first application; ii) individualization of the response of individuals can influence the question of variance in measurement errors because it does not take into account individual particularity, as each subject submitted may or may not respond consistently to a particular item [10].

As a way to complement the limitations in CCT, the Item Response Theory (IRT) emerged intending to overlap standardized educational assessments on a large scale. Many countries, including Brazil, use IRT in the elaboration of items in multiple-choice assessment instruments to assess skills, such as the 'Exame Nacional do Ensino Médio'.

The IRT considers the item as a basic unit of analysis, since different people or the same person, in different situations, can have their skills compared from the everyday items in the instrument, due to the use of parameters that are statistically measured regardless of the sample used [10]. In them, the same item bank is applied to all individuals, allowing greater precision, speed, ease of updating, in addition to the fact that the instruments based on IRT are less subject to errors in the dissemination of their results.

In CCT, the correlation coefficient of the biserial point and Cronbach's alpha coefficient determine the quality of the items and the instrument. The coefficient of the biserial point estimates which items have the most significant impact on the estimated skill; that is, if the assessed individual gets this item right, he has a good chance of passing the exam. Cronbach's alpha coefficient verifies the internal reliability/consistency of the instrument, that is, examining the homogeneity of the items that make up the instrument.

C. Item Response Theory

In IRT, a set of factors can predict the individual's behaviour in an item. The dependence between behaviour and skill may be related to a growing monotonous mathematical function, whose graph is called the Item Characteristic Curve (ICC). The ICC provides information on the probability of each getting the item right. Different mathematical models may be used depending on the number of parameters involved, dimensionality, or type of items present in the Instrument. In this paper, we considered the 3-Parameter Logistic (3PL): slope (a), threshold (b), and guess (c).

The threshold or parameter 'b' refers to the skill required for an individual with a given probability of hitting the item, calculated from the probability of hitting the item by chance, ranging from -3 (easy items) to +3 (difficult items), passing the value 0 (median items). In turn, the slope or parameter 'a' refers to the slope of the item's characteristic curve. It describes how many individuals of different skills are distinguished as to the probability of hitting the item, that is, the power to specify subjects with close magnitudes in the latent trait to which it refers, ranging from 0 (not discriminatory) to 4 (extremely discriminative). The guess or parameter 'c' refers to the probability of a subject of low ability to give a correct answer to a difficult item, that is, the chance of an individual to hit the item with the kick, ranging between 0 and 0.5 [10].

The 3PL produces a scale called a latent trait or skill. The generated scale is standardized (mean = 0 and standard deviation = 1) and, as observed to the measurement of parameter b, in theory, this scale can vary from -3 to +3. Thus, the scores are highlighted by the IRT, using an estimation method. In this work, we use Expected a Posteriori (EAP), is attributed to each person the score that best identifies their ability on the scale, estimating the capacity of an exam. It is an average of the posterior distribution and the standard error after application of the instrument and depends on the Item Information Function (IIF) and its parameters.

In cases where the amount of information on the item is large, it means that that item is the most appropriate/accurate to estimate the acting ability of the examiner. Having a small amount of information means that capacity cannot be estimated accurately, and estimates will be widely spread over actual skill.

III. Game Building

In this section, we present the steps taken in the construction of the game "O Mundo de Phie". It is a game that will help school-aged children in the development, maturation, and cognitive flexibility in a fun and practical way.

A. Game Design

The game "O Mundo de Phie" available at http://projectaweb.com.br/mundodephie/, has a target audience, children from 6 to 12 years old, of both sexes. Children must have a medium or low experience level to handle a mobile device. Also, children must retain a high level of attention to perform activities as it requires concentration.

The game recounts the adventures of a little fox that sees his world-dominating by the wolf Avalon. The adventure begins when Phie joins his friend, the player, to perform tasks in order to liberate his world.

The game's initial screen (Fig. 1) consists of an email and password field, in which the user/applicator can access the game's functions after their authentication. If the user/applicator does not have a register, he can do it through the 'register' button.

Fig. 1. Game Home Screen

Once authenticated, the user/applicator is faced with a screen (Fig. 2) containing three buttons: i)'my students' access to register, edit and choose a student to apply the game; ii) 'edit data' access to all user data, which can be changed; and, iii) 'report' access to the list of all students who have played, the user/applicator being able to view the performance report individually.

Fig. 2. Post authentication menu

We divided the structure of the game into three steps. In step 1 (Fig. 3), it is possible to explore the child's perception and attention skills in finding a specific object among other distractors. In step 2 (Fig. 4), it is possible to explore the child's ability to adjust his behaviour and attention in the solution of new activities even if distracting objects are in the game plan and have a similarity between them. In step 3 (Fig. 5), it is possible to explore the child's ability to adapt and pay attention to associating objects with their even elements.

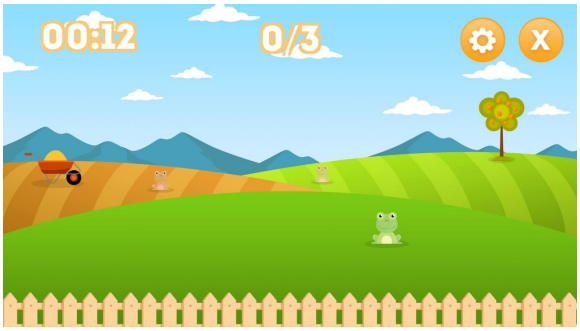

Fig. 3. Item example - Step 1

Every orientation of the game is at the beginning of each stage that contains a descriptive text and audio for general orientations. Step 1 contains eight items, the first being called the training item, which is similar to the later ones, steps 2 and 3 contain seven items each.

To achieve the objective of this investigation, we used IRT in the process of elaborating and calibrating the item bank to verify its psychometric properties and analyze whether the scale is minimally adequate for the study to continue [10].

B. Game Items Bank

An item consists of a set of graphic images and an audio file. Figure 3 shows an example of a game item. In this item

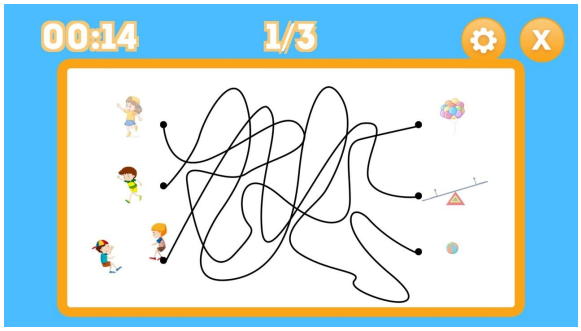

Fig. 4. Item example – Step 2

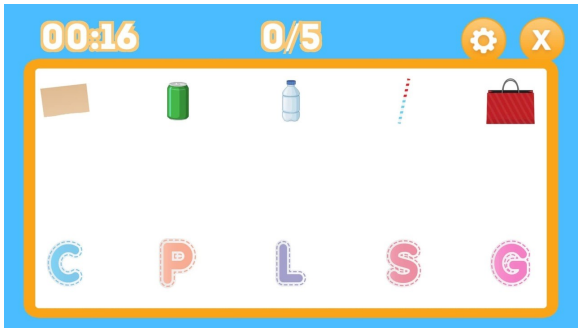

Fig. 5. Item example – Step 3

have the following sets of images symbolizing a farm setting: a landscape containing mountains, a green field, a fence and land for planting, and the following objects: a cart with earth inside and a tree considered distracting objects; and three frogs considered target objects. The audio associated with this item says: "Find the frogs that are among other objects".

For the construction of the game items, we requested the elaboration of the drawings by a designer, and we requested the vectorization by a designer who used the Adobe Photoshop CC 2017 tool. We downloaded other images used in the game, with free use rights, from the freepik library (https://br.freepik.com/), being modified using the graphic editing tool Adobe Photoshop CC 2017. To make the drawings effective, we consider the children's age and the target audience of the game. Altogether, 110 drawings were selected/modified to compose the items. Then, we request the elaboration of the audios that were used according to the game outline and recorded by a female person, using a semi-professional microphone and edited in the Audacity tool.

C. Game Requirements

We collected the functional and non-functional requirements of the game through an expert in order to define an outline that met the requirements raised. We obtained this information through an interview with open questions.

Soon after, we perform a synthesis of the primary information and organize it in an analysis table by component. This information guided the development of a project through a set of requirements that allowed us to understand its complexity.

We separate the requirements between functional and non-functional.

Functional requirements include:

- Providing the following public access screens: information about the game, tutorial, and registration request submission;
- Provide the following post-authentication access pages view/update the registration of the applicator, register/edit student data, list of available tests, and report of individual student performance;
- Make the following functions available to the child: viewing game instructions and interacting with the game activities present;
- Establish the following rules of the game: the items must incorporate text (stimulus word), synchronized images and audios, each item must be calibrated and present its level of discrimination, difficulty and the probability of success by the kick and, mandatory, register response time and hit/miss.

Non-functional requirements define system properties and restrictions, such as excellent portability properties, ethical requirements, legal requirements, usability, security, confidentiality, integrity, and interface.

D. Game Engine

Support technology describes the game engine for solving the problem. The game engine is software that offers developers a set of resources to create games quickly, safely, and efficiently.

Regarding the existing engines for game development, we opted for Unity 3D, in its 2017 version. Unity is a multiplatform 2D/3D game engine that has an Integrated Development Environment (IDE). It has several versions, and the free version provides tools that met the needs of the development of this project.

Previously, this game engine had support for three programming languages, C#, Boo, and JavaScript. However, in 2018, Unity discontinued the Boo and JavaScript programming languages, focusing only on C#, where it has a very active developer support community about its use with tutorials, courses, and implementation examples and codes in that language that is maintained by Microsoft Corporation. With that, we adopted C# as a programming language for the development of the project.

Created by Microsoft Corporation, C# is a strongly typed object-oriented programming (OO) language that allows developers to create a variety of robust and secure applications running on the .NET Frameworks.

Therefore, Unity meets the application requirements aiming at low cost and agility in the development of the application, as this development engine is multiplatform reduces the cost of the project.

We chose the Hypertext Preprocessor (PHP) programming language to be the bridge between the game, created on Unity, and the MySql database hosted on the web. PHP is a web-oriented programming language, oriented towards objects that run on the server-side. With it, we can host a system on the internet and access it from anywhere in the world.

E. Game Architecture

In applications aimed at the web uses the client-server architecture model, where the client-side requests an action using a browser or other internet access program, for example, registration on a website, where this information is saved in another computer that can be anywhere in the world, that would be the server. There are programs on the server that verify the request made by the client to the database. We have adopted this structure to maintain the security, homogeneity and integrity of data when accessing the system in any location.

In software programming, depending on the programming language used, it is essential to have acceptable practices following the paradigms of each language. Programming paradigms are a model of problem-solving that correlates to a particular genre of programs and languages. We adopted the Object-Oriented (OO) paradigm due to the languages adopted: C # and PHP that makes the code organized and readable for those who created it and for the entire project team.

All well-structured object-oriented architectures are full of patterns. In the construction of the game ”O Mundo de Phie”, we use the model pattern View-Controller (MVC), Model/View/Controller because to separate each class and its responsibilities, giving more control over each one of them. MVC consists of three types of objects. The model is the application object, we present the view on the screen, and the controller is the one that defines the way the user interface reacts to its inputs. Figure 6 shows how this design pattern, MVC, works.

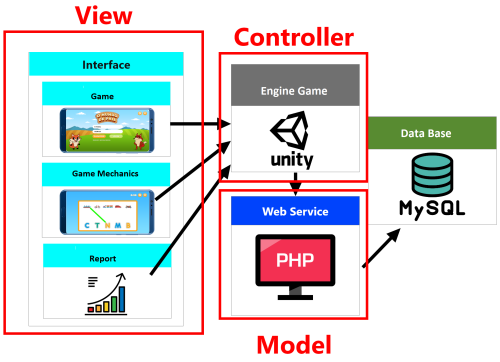

Fig. 6. In-game MVC design pattern

The project (Fig. 7) has five blocks, namely: users, interface, game engine, web service, and database.

There are two types of authenticated users in the game - the applicator and the student. The applicator is an educator, psychopedagogue, manager or guardian who wishes to analyze the child's cognitive flexibility capacity through activities presented in the game. The user/applicator authenticates the student to have access to the game, freeing access to the

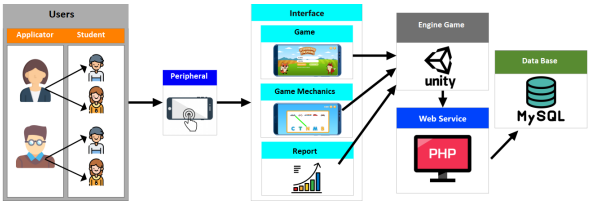

Fig. 7. Game Architecture

environment to interact through the answers provided in the application.

The interface, view of the MVC design pattern, is responsible for interacting with the user, showing the game scenes as menu screens, buttons, reports, and other graphical parts.

The game engine is where all the mechanics of the system and the game itself are. The game engine is responsible for organizing the information that is requested by the user and maintaining its control with the data that is received and sent to the Web Service.

We host the web service on the internet contains all model classes that are responsible for the communication between the data received or sent by the Controller and saves or retrieves it from the database. All this data communication between the game engine and the web service is done through the JavaScript Object Notation (JSON) data format, allowing applications to communicate over a network through full REST APIs.

Finally, we built the database using MySQL Relational Database Management System maintained today by Oracle. With it, it was possible to control data access to ensure that multiple users can work with data at the same time.

IV. Method

In this section, we present the planning of the case study carried out in the 2019 academic year.

A. Participants

Thirty-two children participated in this case study. Nineteen (59%) girls and Thirteen (41%) boys, aged between 11 and 13 years (mean age = 11 years and seven months), public school students in the city of Patos, Paraíba State, Brazil. We consider the inclusion criterion to be enrolled in school in the final years of elementary school II and consented by parents or guardians. We exclude all children who did not want to participate.

It is worth noting that, we defined the sample selection process as 'accessible', we admit only children who, when the game was applied, were present in the classroom.

B. Execution Procedures

The case study took place at the CIEP III Firmino Ayres Leite and Otto de Souza Quinho School located in the municipality of Patos, Paraíba, Brazil. Such children were consented by responsible who signed the consent form, allowing the lowest to participate as a volunteer in the study.

The consenting children performed the activity in the school's computer lab in groups of four children. Upon arriving at the lab, we instructed the child about the study and collected some information, such as name, age, date of birth, and education. Then, the child used the smartphone to start assessing his skills. As the instrument was self-administered, the child performed the instructions corresponding to the item and selected the answer that he believed was correct. The average time each child took to finish the game was 10 minutes.

C. Data analysis

We collect information about hits/errors and the response time of each child. We tabulated the results and transformed the items into dichotomous, assigning 0 when making error and 1 when making a hit.

We analyzed the data collected in this phase of the study by IRT with the aid of the MS Excel tool for the analysis and adjustment of the 3-Parameter Logistic Model (3PL) by the Expected a Posteriori (EAP), in order to verify the internal consistency of the instrument and the estimate of item parameters.

The 3PL estimates the individual's ability more accurately, describing the expectation of hitting an item through the following psychometric properties of the items: slope (a), threshold (b), and guess (c).

D. Threats to validity

We considered some factors that generated threats and directly influenced the conclusions of this paper:

- Problems related to the incorrect interpretation of the questions. To mitigate errors, all students were assisted by an applicator;
- Participants feel intimidated or uncomfortable when taking the tests. We apply the guidelines of the research ethics committee to minimize this possible constraint. The UFCG Human Research Ethics Committee approved this study, which is part of a more extensive study entitled "Avaliação Computadorizada das Funções Executivas na Infância: A Flexibilidade Cognitiva de Crianças em Idade Pré-escolar". Only children whose parents signed the consent form participated in the study;
- Like all empirical research, this work has threats to validity. The number of subjects participating in the study does not allow generalization of results;
- A large sample that allows the formation of a database that, according to a psychometrist, based on probability, statistics, and axioms of the measure and considering the objective of the Instrument, can have centralized control in the application.

V. Game Analysis

We conducted a study to ascertain the psychometric properties of the items. This step is significant in the design of an instrument, as it allows verifying if the scale built is minimally adequate for the study to continue.

A. Internal Consistency

The purpose of an instrument's internal consistency is to check the reliability of the instrument. It consists of examining the homogeneity of the items that compose it.

This internal consistency is measured using Cronbach's alpha coefficient, which assesses the magnitude with which the items of an instrument are correlated, that is, the average of the correlations between the items that are part of an instrument. Cronbach's alpha coefficient varies from 0 to 1. The closer to 0, the lower the consistency, and the closer to 1, the greater the consistency of the instrument.

We present the results of the internal game consistency in Table 1.

TABLE I
GAME INTERNAL CONSISTENCY

Skill	Subjects	Items	Average	Standard Deviation	Cronbach's Alpha
Cognitive Flexibility	32	22	15.313	3.762	0.797

The homogeneity of the instrument was on average, 0.777. Indicates that there is adequate internal reliability and consistency of the instrument with the measured skill.

The ability of an individual in an item can be measured using a set of properties or hypothetical variables. We will present below.

B. Psychometric Properties of Items

We used the 3PL to clarify the distribution of children's responses to each game item. Also, we considered the proportion of correct answers (c.a.) and the biserial point correlation (b.p.c.) between the correct answers in the item and the total score of the game.

The CCT measures the proportion of correct answers and the biserial point correlation. The proportion of correct answers determines the probability of the individual getting the item right, and the correlation coefficient, the biserial point, is Pearson's correlation between dichotomous variables and the test score.

In traditional instruments, it is possible to calculate the correlation coefficient between two variables, one numerical and the other categorical nominal. In this case, the categorical variable has only two values (hit/error), a variable of this type is called a dichotomous. So, to calculate the correlation between this variable and another (numeric), Pearson's coefficient calculation was adopted in the usual way. This measure aims to establish whether there are any questionnaire criteria, such that the individual assessed when answering this question has high chances of obtaining excellent results on the exam.

In Table 2, we present 22 items with the respective parameters, which we considered in this paper.

We checked if the items met the conditions required by their parameters to the 3PL to avoid or compromise the representatives of the assessed domain. We did not find any critical values for the estimated values. Thus, all items have values higher than 0.30 for the slope, for the threshold between 2.95 and -2.95; and, a guess below 0.40.

TABLE II
CALIBRATION OF ITEMS

Step	Id	a	b	c	c.a.	b.p.c.
Step 1	F0	1.590	-1.868	0.160	0.906	0.481
	F1	2.298	-1.577	0.157	0.906	0.574
	F2	1.829	-1.746	0.158	0.906	0.574
	F3	1.123	-1.951	0.160	0.875	0.385
	F4	0.892	1.404	0.162	0.375	0.227
	F5	0.890	-0.893	0.163	0.719	0.296
	F6	0.867	-1.671	0.163	0.813	0.378
	F7	0.943	0.847	0.156	0.438	0.258
Step 2	L0	1.443	0.370	0.159	0.500	0.333
	L1	1.155	-0.377	0.164	0.656	0.316
	L2	1.241	-1.544	0.160	0.844	0.440
	L3	1.026	-1.231	0.162	0.781	0.373
	L4	0.694	-3.301	0.164	0.906	0.299
	L5	2.631	-2.531	0.160	0.969	0.708
	L6	0.875	-1.146	0.162	0.750	0.269
Step 3	A0	1.001	2.853	0.157	0.219	0.172
	A1	0.777	-1.517	0.164	0.781	0.330
	A2	0.833	-0.736	0.160	0.688	0.324
	A3	1.700	0.223	0.134	0.500	0.426
	A4	2.284	-1.108	0.161	0.844	0.567
	A5	0.690	-2.794	0.164	0.875	0.276
	A6	2.190	2.658	0.086	0.063	0.191
Average		0.589	1.617	0.017	0.696	0.372
Standard Deviation		1.315	-0.802	0.156	0.239	0.134

Regarding the probability of correct answers, we obtained easy items (with indexes above 75%), moderate items (with indexes between 50 and 75%), and difficult items (with indexes below 50%).

The point-biserial correlation revealed a tendency to choose the wrong option for children who obtained higher scores in the game. For example, item A0 is the one that least influences the total score of students who obtained excellent performance in the game.

We present the graphical representations of the Item Characteristic Curves (ICC) and the Item Information Function (IIF) in Figures 8 and 9, respectively, where the extreme values of the discrimination, difficulty and accuracy ratios and how much information each item provides in a particular region of the latent trait.

The ICC's for the cognitive flexibility skill highlights the extreme values of slope, threshold and guess. For example, item L5 is the most discriminative. Already item A5 is the least discriminative, the easiest is item L4, and the item with the least probability of kick is A6. Regarding the IIF's, we can see how much information each item provides in a specific region of the latent trait. For example, item A3 offers more information, when the skill is average (i.e., Theta equal to 0).

VI. FINAL CONSIDERATIONS AND FUTURE WORK

This paper has as scientific relevance the use of game elements associated with computerized adaptive assessment and its current conditions applicability. The purpose of which was to preserve the child's full state of physical and mental well-being. We start from the concept that such fundamentals of the game can stimulate their behaviours and captivate

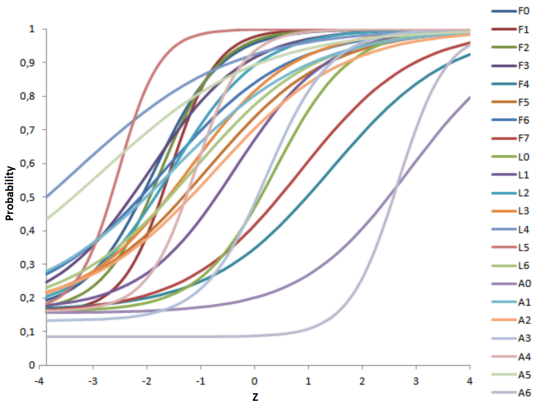

Fig. 8. Game ICC

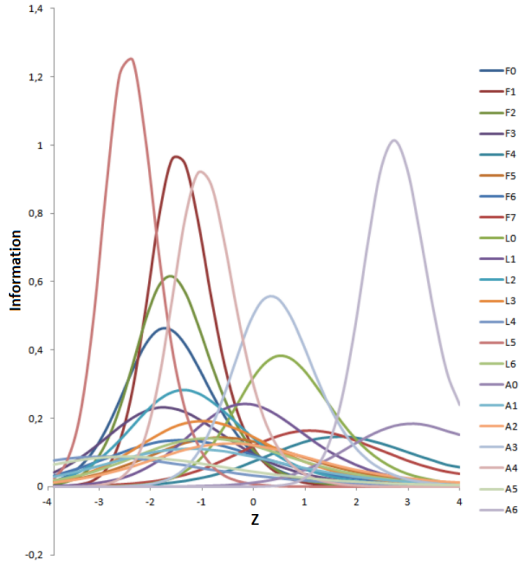

Fig. 9. Game IIF

the participants during the application of the instruments, constituting the application of playful elements in standardized practices to make them more captivating, joyful and efficient.

The game ”O Mundo de Phie” uses multiple-choice items and has fast and comfortable gameplay, which does not provide exhaustion and disinterest to the player. In addition to automating an instrument that measures one of the skills of executive functions, the game obtained reliable statistical results on its consistency.

We emphasize that contributions to subjects who participated in the research and to society, in general, are granted through an assessment of the cognitive flexibility skill, in an organizational context, allowing and guiding the education professionals involved in this scenario to conceive and develop actions to adapt to the individual's possible needs, thus providing more precise and effective interventions.

Through the results obtained, pointing out that the instrument designed can measure the ability of cognitive flexibility in children, it is planned to complement it with new studies since this assessed skill is part of a triad: cognitive flexibility, inhibitory control, and working memory. Among the various possibilities, we highlight: i) improving the current instrument, assigning items of the inhibitory control and working memory skills, making it complete for measuring the triad of executive functions; ii) normalize the game developed to enable an interpretation (statistical analysis) of the data (estimated skills) in order to provide a standardized instrument; iii) expand the intervention, serving a public aged between 6 and 14 years; and, iv) to develop an integrated web system so that the applicator has access to the data at the same time that the game is applied with the child.

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