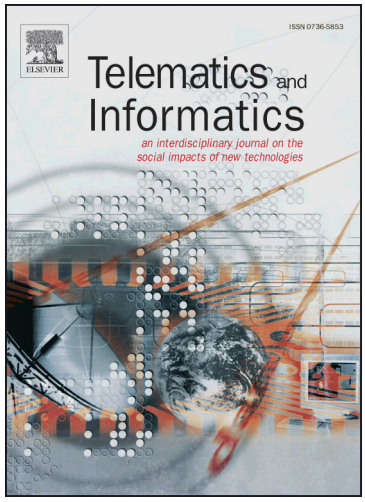

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PII: S0736-5853(17)30302-7
DOI: https://doi.org/10.1016/j.tele.2017.09.011
Reference: TELE 1006

To appear in: *Telematics and Informatics*

Received Date: 11 May 2017
Revised Date: 29 July 2017
Accepted Date: 28 September 2017

Please cite this article as: Cano, S., Collazos, C.A., Flórez Aristizábal, L., Gonzalez, C.S., Moreira, F., Towards a methodology for User Experience Assessment of Serious Games with children with Cochlear Implants, *Telematics and Informatics* (2017), doi: https://doi.org/10.1016/j.tele.2017.09.011

Towards a methodology for User Experience Assessment of Serious Games with children with Cochlear Implants

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Abstract. Information technology is transforming different areas, such as rehabilitation, in such a way that serious games are finding a use as an alternative in hearing therapies for children with cochlear implants, creating a motivating experience in children. As a result, the design of products oriented to children depends on the skills they have to interact, because if they have a better user experience they may have a better learning experience. Most existing methods of assessment are aimed at adults, although some have been adapted for children with special needs, including children with cochlear implants. This article presents a methodology for User Experience Assessment (UXA), that provides support for following the necessary guidelines and choosing techniques adapted to the characteristics of the child with cochlear implant. The methodology has been applied in a case study with 23 children with cochlear implants in the Institute for Blind and Deaf Children in Colombia, where different methods have been used and adapted to assess the user experience.

Keywords. Assessing methods, User Centered Design, Children with Cochlear Implants.

1 Introduction

Information technology is transforming many different areas, even the area of rehabilitation. Serious games are finding a use as an alternative for generating meaningful experiences in different contexts of use. Computer Games have become

an important part of life in child and a youth culture [1]. A serious game can be defined as a balance between the entertainments and pedagogy [2]. Auditory Therapy (AT) is the process whereby the child learns to use his hearing to the fullest. The goal of rehabilitation is to help children learn to extract or take information from the stimuli they perceive via the cochlear implant[1]. The incorporation of serious games in therapy can make a healthy contribution in such a way that they bring together entertainment and education [2-3] and can be integrated into the rehabilitation process.

Currently, games have adapted formal Human-Computer Interaction (HCI) techniques in order to assess interaction and product quality [4-9]. Usability is a quality attribute that determines user satisfaction and consequently the product. This is defined by ISO 9241 as "*a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use*" [10]. According to Nielsen [11] usability comprises five attributes: ease of learning (Learnability), efficiency (Efficiency), ease of memorization (Memorability), low error rate (Errors – Low Rate) and satisfaction (Satisfaction). The HCI approach furthermore involves a design philosophy that aims to create products that meet specific needs of the end users, achieving a better satisfaction and user experience.

User experience (UX) can meanwhile be understood as a set of feelings and emotions that are produced in a user on interacting with an interactive product [12], such as a serious game. Thus, the experience children have with a product depends on the skills they have when interacting with it more easily or with more difficulty [13][14]. Therefore, the evaluation of a product focused on children is a different process compared with adults [15], this is in part, due to the focus of the technology is different [16]. These statements are reinforced if children have a special need, as hearing impairments. Thus, the design and development of a therapeutic game for children is not a simple task, because with children come particular requirements. In turn, to find out these requirements it is necessary to know the views of the children when a product is evaluated. Therefore, it is important to use proper suitable techniques in order to extract information on assessing the product.

A child with a hearing impairment acquires language skills at a slower pace than a hearing child. Thus, the younger the child, the greater they find the challenge of communicating. According to Piaget [17], in his theory of development, children between 5-12 years old can classify objects and are able to make decisions. It is therefore a good age to involve the child in assessing a product and they can be asked to complete specific tasks with the aim of finding out their opinion.

Mader et al. [18] propose a model for analyzing therapeutic games, which describes a relationship between three aspects: therapy, game and player. However, the model does not follow a user-centered analysis, so it does not consider aspects of user experience or usability. Therefore, there is a need to select suitable assessment methods to design products centered in the user (in this case children with cochlear

[1] This consists of a translator that converts acoustic signals into electrical signals that stimulate the auditory nerve.

implants). The assessment of user experience is not an easy task, it requires to follow a set of stages that allow to know aspects of a user and product satisfaction to interact with the serious game. The proposed methodology would help to identify attributes and selecting appropriate assessment methods for children with cochlear implant, and to design serious games according to the needs of the children.

Therefore, UXA refers to a set of methods, skills and tools used to know how a person perceives a system before or during and after interacting with it. The methodology could help to select the most suitable methods, tools and skills to be used with children with cochlear implants and designing systems according to the child perception.

The purpose of the methodology is to be able to provide support for non-experts who require evaluating educational/therapeutic products for children with cochlear implants.

This article is structured as follows. Section 2 begins with a brief description of children with cochlear implants and the challenges that they must overcome. Section 3 discusses different methods for assessing usability that have been applied to children and how these could be adapted to the characteristics of a child with cochlear implant. In Section 4 the methodology for user experience assessment is proposed. In Section 5, a case study is described with a group of children with cochlear implants from the Institute for Blind and Deaf Children in Colombia. In Section 6, a discussion is made taking into account the results obtained. Finally, conclusions and future work are described.

2 Children with Cochlear Implants

Deaf children can benefit from fitting a cochlear implant, an electronic device that picks up sounds from the environment (noise, sounds, words) and transforms them into electrical energy that can directly stimulate the auditory nerve endings, producing auditory sensations in the brain [19]. Children with cochlear implants are beneficiaries of auditory-verbal therapy, where they must learn to listen and identify sounds to learn to speak [19-20].

A child who receives auditory-verbal therapy must extract information from the stimuli picked up by the cochlear implant. Rehabilitation is supported with educational material aimed at stimulating the senses of the patient with the implant. The children meanwhile are not able to develop skills at the same pace as hearing children, which makes it difficult to identify problems in the development of their cognitive skills and can affect their progress in the acquisition of learning [21]. This indicates that they need more attention and, in turn, motivation for learning, as they are easily distracted, especially when they lose interest in the task or when the difficulty level of the task is high in comparison to their ability level.

3 Assessment with Children

When technology is evaluated with children it is important to define the purpose of the evaluation and to understand the data gathered. Existing evaluation methods tend to focus on usability and user experience. ISO 9421-210 defines "*user experience as the perception of a person and responses that result from the use of a product or service*" [12]. UX could be subjective or objective and one way to get information about UX is by observing the emotions of the user when interacting with a product. In children with special needs the subjective approach is more used, because the communication with them is difficult. Therefore, if we measure the use of a tool for children with hearing disabilities, we must evaluate it based on basic skills. This indicates that aspects may vary depending on the user profile and the purpose of the evaluation. This implies the need to establish evaluation methods adapted to the level of difficult; i.e. if a child with a cochlear implant is just starting to acquire skills in speech, the Thinking Aloud method could not be the most appropriate for them. This method is aimed at children who can establish a channel of communication through speech, so it becomes quite complicated for a child with a cochlear implant wherever speech is involved, since a lot of the children are in the process of language acquisition and learning how to listen: some research works [16] do not recommend this method, because the child must carry out two simultaneous actions – complete the task and give verbal information on the activity. Normally, they are distracted very easily and furthermore make very few comments. There are methods based on drawings [23] as an alternative to the verbalization methods, such as Drawing Intervention [24], a method that is used to elicit visual information from the child by means of drawing.

Furthermore, several studies [24-26] have analyzed different methods for the evaluation of interactive products applied with children. Based on these studies, Table 1 shows some of the advantages and disadvantages found in each evaluation method.

Table 1. UXA methods for Children.

Method	Advantages	Disadvantages
Direct observation [16]	Does not require that the child to verbalize as he or she can express their views by simple expressions or body movement.	A shy child who feels s/he is being watched can become uncomfortable. This could also influence the outcome of his actions on interacting with the product.
Thinking aloud [27]	Allows collaborative work by the children. They will thus be more confident when it is their turn to present their views orally.	For a child who does not have the ability to speak or cannot verbalize, the method can be very challenging.
Drawing intervention [24]	Requires the child to draw something about a product to be evaluated. As such it does not require that the child	Knowledge to assess the drawing well is needed, since drawings are open to wide interpretation.

	verbalizes.	
Picture card [28]	Rates usability and UX using the visual communication channel to extract information from the child.	The children can fail to understand the meaning of the pictograms.
Wizard of Oz [29]	It is observational and informative. The child is only required to interact with the product and does not have to comment on their experience.	The assistant must constantly be attending the child to ensure that they do not lose motivation.
Fun toolkit [6]	Can be applied to children with low cognitive skills. It is designed to be used with children whose communication channel is visual.	The opinion of the child is made in a more visual way. When there are more than two options to be selected, it becomes a challenge if the child is not familiar with all the emotions.
Surveys [30]	For children, this technique can be employed in several ways: child-child, teacher-child, and assessor-child.	For young people this method is more convenient. In children older than 11 years it can also be used but how the questions are asked must be considered very carefully.

From the methods that have been analyzed (Table 1), it ought to be noted that capturing the attention of a child is not an easy task. A communication channel must be established that makes it possible to establish greater concentration on the activities to be carried out during the test tasks. In turn, this channel may vary depending on whether a disability is present and the type of disability. Thus, a child with hearing impairment is more visual, and if they have a cochlear implant they can learn to speak, so that their objective is to further strengthen channels of communication through listening without leaving aside the visual channel.

Meanwhile, there are measurement instruments of qualitative (subjective) and quantitative (objective), which correspond to non-verbal and verbal instruments [16] [32]. These instruments are used with the evaluation methods to capture the emotional, physical and aesthetic experiences of the user [33]. The majority of the methods are especially adapted to the experience of the user, for example: Fun Toolkit [6], identification of images on cards (Picture Cards) [28], simple observation, thinking in a loud voice (Thinking Aloud) [27], and Laddering [34], among others. Many of the methods are not applied to all contexts of use and need to be well understood to know when to apply them and when not to [35]. Since of those methods are not adapted to children with special needs and do not consider if children have some type of disability, it indicates that many of these methods are designed for children without disabilities.

Direct observation and verbalization methods such as Thinking Aloud, Usability Testing are responsible for gathering information about the experience of the user as they interact with the system. However, the Picture Card method does not requires verbalization, but may prove difficult at times, because the children may feel that they are being watched and change their attitude in the moment of the test and may at times be considered intrusive [36]. The child's cognitive skills can affect how easily

they understand each of the methods presented to them. The attention span of a child, in most cases, is limited and they are able to focus for about 30 minutes, so that activities are limited by time [7]. As a result, the method called Fun Toolkit [6] is designed for children who have a reduced cognitive skill level, since to be able to respond, the child must fill in or select one of the options presented to them. Smileyometer [37] is a visual scale tool (Visual Analogue Scale, VAS) based on the Likert scale with ratings from 1 to 5, where each level on the scale is represented by facial expressions, i.e. a disappointed face corresponds to (1) and a very happy face to (5). Smileyometer is used to obtain opinion of the children on a game or another activity. Therefore, children use smileyometer to answer a question associated to an emotional scale.

Smileyometer is an instrument subjective has been developed for children, therefore it has been used in previous studies to measure satisfaction [8] and fun. However, if a child is unfamiliar with some of the emotions that are presented on the scale, the selection of the child will perhaps not be correct. One possible alternative is EMODIANA [38], a visual tool based on 10 graphic representations of different emotions of a character and the intensity of the emotions by means of a target, by which evaluation of emotions for 7-12 years was conducted.

The objective of Picture Card [36], is to find usability problems and images are used to verbalize sentences. It is used for children who have language problems, as a way of establishing a communication between the child and the evaluator.

The channel of communication of children with cochlear implants in the early stages of learning how to listen is primarily visual. Teachers therefore base their teaching of concepts on pictograms accompanied by sounds. In the therapeutic context, children with cochlear implants must develop auditory qualities, for which they need to follow a process that involves a number of stages, such as: detection, discrimination, identification, and understanding. Many children have trouble pronouncing certain specific phonemes in the middle of words. Therefore, audiologists perform therapies individually, which takes more time.

Suitable evaluation methods are sought for this reason, that make it possible to identify the needs of children with cochlear implants, in such a way that, according to the level and characteristics of the learning, some techniques can be adapted to involve the child in the design of the serious game.

There are a number of different methods of evaluation which in turn must be adapted to suit the profile of the child, since not all methods are adapted in the same way for them to use. Evaluation methods provide support for measuring usability, user experience, or both. These methods applied will be either subjective or objective, depending on the type of activity to be conducted with each child. The evaluation methods that have been used with children with cochlear implants, are: Direct observation [16], fun toolkit [6], test of usability, video analysis, interviews [30], drawing intervention [24] and picture card [28].

4. UXA Methodology

The purpose of this methodology is to be able to provide support for non-experts who require evaluating educational/therapeutic products for children with cochlear implants. In their turn, no methodologies or set of techniques and methods currently exist for evaluating user experience with hearing impaired children. The present methodology involves the participation of therapists, teachers, and experts in HCI, in order to be able to understand the child in each of their facets and select the appropriate methods and based on this, design experiments and successfully capture information from the child.

The methodology includes a multidisciplinary team of several disciplines that are the relationship between therapy, player and game, where each is identified by a color. Each discipline includes a set of elements that form the methodology (Fig. 1). Relationships between each of the elements can either be of dependence represented by a broken line, or association, represented by a solid line.

Fig. 1 shows the process of the methodology, which comprises 3 phases: analysis, evaluation and post-evaluation. The first phase is called **analysis**, in which the objectives to be achieved are defined and suitable assessment methods are selected. In the second phase, called **evaluation** aspects of the child are evaluated, objective and subjective metrics are identified based on user experience and usability. Depending on these, appropriate instruments are selected. In the last phase, called **post-evaluation**, qualitative and quantitative data are collected. Using the data, the results obtained are analyzed, wherein useful information to make constructive criticisms and improvements in the design and interaction of the serious game is interpreted.

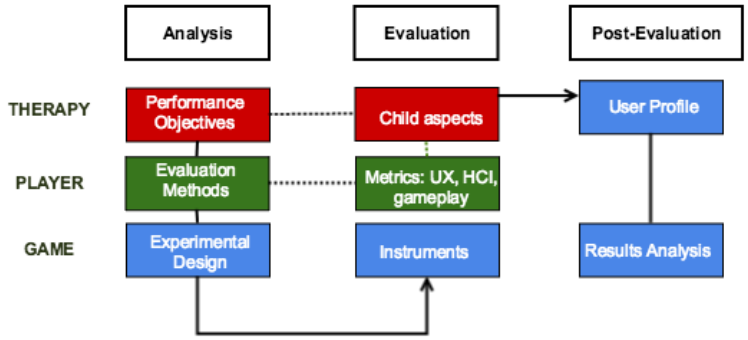

Fig. 1. UXA Methodology in serious games to children with cochlear implants.

To support the methodology, a web tool is being developed with the aim of establishing a framework for evaluating products for children with hearing problems. Each element of the methodology is described in the following:

A. Performance objectives

The objectives are focused on identifying aspects of both the game and the user to be able to evaluate a serious game aimed for children with cochlear implants.

B. Child Aspects

The participation of the child in the process of design, development and evaluation of a product requires a number of aspects to be taken into account. These may affect the type of communication that is established between the system and the child by means of the design and interaction of the interface.

It is thus important to analyze the behavior of the child and identify variables that can affect the quality of the results. As such, direct observation methods were applied, including simple observation, and interviews with teachers, psychologists and speech therapists. Variables that were considered are based in areas like psychology, cognition, experience, behavioral science, among others, in order to be able to analyze the child's experience. The variables that may affect how the child with a cochlear implant interacts with the system were based on a study carried out in [40]. These variables are: Personal information (age, gender and academic level), skills/abilities, disability (physical/cognitive), learning style, emotions and motivation.

C. Methods of UXA for children

There are a number of different methods of evaluation which in turn must be adapted to suit the profile of the child, since not all methods are adapted in the same way for them to use. Evaluation methods provide support for measuring usability, user experience, or both.

The number of methods suitable for use with children is small compared with those for adults, because the great majority of games are designed for adults. The evaluation methods applied will be either subjective or objective, depending on the type of activity to be conducted with each child.

In Table 2, the evaluation methods that have been used for children with cochlear implant are shown and how these can be classified into subjective (verbal, qualitative) or objective (nonverbal, quantitative).

Table 2. Methods of UXA applied with children with cochlear implants

Method	Description	Type
Direct observation	Observation of the children while they interact with the game along with annotations made at the time.	Subjective / Objective
Fun Toolkit	It is designed to be used with children whose communication channel is visual.	Subjective / Objective
Usability Testing	A method based on the observation of users when real tasks are performed.	Objective.
Interviews	Interviews conducted by experts to gather information more quickly.	Subjective
Drawing Intervention	A method that sets the child to draw. Depending on their drawings, simple questions are asked related to the elements of user experience of interest.	Subjective.
Picture Card	The aim is to find problems of usability and user experience. The child places different cards grouped depending on the type of problem they face in their experience of the game. This is a way for children to verbalize with images instead of words.	Subjective.

D. Metrics

A metric is a measure assigned to characteristics or attributes of set of observable data, which can be either objective or subjective. In measuring these variables for usability, a set of questions were selected that involve a set of usability metrics recommended by ISO/IEC 9126-6 [41] - effectiveness, efficiency, and satisfaction. Other metrics to measure UX –emotions, learning – were also selected.

Considering that the products to be evaluated are serious games, many principles used to evaluate usability have been applied to software tools, but not exclusively to serious games. It is thus important to consider metrics for evaluating the mechanical aspects of the game. The metrics taken into account are: feedback, control, objectives, difficulty, and variability.

E. Experimental Design

Once the method to be used has been selected, measuring instruments that could provide support in evaluating usability in serious games are defined, as well as the experience of interacting with the product. Thus, a set of tools is proposed that can assist in evaluating quantitatively and qualitatively a range of aspects such as interface design, game flow, emotions, content, and learning.

F. User Profile

Once the most meaningful aspects for children with cochlear implants have been identified, the information is analyzed to identify guidelines that could be taken into account in the design and interaction of serious games. The aspects identified were described in the work made by Cano et al.[40].

G. Results Analysis

When the data is captured and stored in a database, they can be analyzed to identify important aspects related to learning, user experience and usability.

5. Case Study

The case study is applied to 23 children with cochlear implants between the ages of 5 -11 years with cochlear implants, in the Institute for Blind and Deaf Children in Colombia (INCSVC) working in two use contexts as, auditory-verbal therapy and literacy. Therefore, we divided into two groups to work both contexts; 11 children with auditory-verbal therapy, which is currently carried out with the support of the speech therapist by means of a number of different activities that involve very little technology, and 12 children in literacy working with methods of UXA, such as: drawing intervention, picture cards and fun toolkit. Also, it is important to mention that children are in scholar grades as: prekindergarten, transition and primary.

The purpose of this evaluation is to identify different aspects of user experience following the work proposal by Cano et al. [40][42], with the aim of designing an interface that is useful to the audiologist or teachers to be integrated into therapies or classrooms using the technology. Among the activities for evaluating the inclusion of technology in user experience, three games oriented to voice and speech therapy were selected, e.g. Talking to TEO [43] Pre-lingua [44] and Vivoso [45]. The three games are used in PCs, where Talking to TEO supports speech therapy, while Pre-lingua and Vivoso are aimed at voice work skills such as pitch, timbre, intensity, breath, and vowel articulation. The **Talking to TEO** game meanwhile consisted in using a microphone to capture the phonemes "da-de-di-do-du" with a number of configurable

repetitions for each phoneme pronounced correctly, and the child receives a star as a score. The **Pre-lingua** tool helps the child to acquire some sound characteristics such as pitch, timbre, and breath. Pre-lingua uses a set of mini-games to evaluate sound characteristics. The activity consisted in the child pronouncing a certain vowel and through play they detect the presence of sound with a suitable voice timbre and a car moves along until it reaches its target destination. **Vivoso** works acoustic aspects, like: voice timbre, pitch, among others.

The different activities carried out with the children lasted 20-36 minutes. The objective is to evaluate usability and identify needs and improvements in a game oriented to children with cochlear implants.

A. Analysis

a. Performance Objetives

The objective is to evaluate and identify user experience for each child in order to find needs and improvements in a game oriented to children with cochlear implant.

b. UX Evaluation Methods for Children

In the evaluation methods, the use of technology was incorporated into the evaluations along with activities on paper, as a means to identify factors related to entertainment, use and learning and characteristics of the child with cochlear implant that may affect the assessment methods used. Such methods may be affected by the children's level of experience, their level of use of technology [39], by culture, or by demographic characteristics [31] [16]. Therefore, the evaluation methods that were selected have two approaches: objective (quantitative) and subjective (qualitative), used to obtain information in relation to the performance objectives.

To determine the aspects that are most relevant to the child, methods of inquiry are used, such as interviews and questionnaires to teachers, psychologists and speech therapists in the interest of extracting information about the child such as learning styles, behaviors, interests, and others. In turn, the technique of direct observation was applied, to observe the interaction between teacher-child and speech therapist-child.

A questionnaire with 13 questions was made for teachers and speech therapist, where most of the questions were open questions, such as: What are the teaching strategies that teachers are using with the children that are learning to listen?. Are you using a teaching method for literacy? What types of difficulties do children with cochlear implants frequently face when they interact in a general environment?. What needs do you have related to tools or materials to support the teaching methodology and to help in the learning of children?. Are you using technological tools in the teaching process with children?.

The answers obtained from teachers show that they use pictograms as pedagogical material, so the children can rely on images to represent

certain vocabulary in their first learning stages. In the teaching process of literacy, they are working with a method called **Invariant Method** [51] which is used with the children of prekindergarten, kinder and transition. This method begins teaching children to identify sounds that make up a word, consonants and vowels, and finally they learn the writing of consonants and vowels. Some activities that children work in the classroom, are: to complete words with missing letters, to create categories lists (names, animals, foods) that begin with the same letter, to create a dictionary with images and words, among others. Also, teachers have indicated that the child must work in-group and individually, on the one hand, when they work individually, teachers can identify needs and support them. On the other hand, not all activities are suitable to be worked in-group because sometimes there is too much noise and children with cochlear implant cannot listen clearly, and this is counterproductive when they are in the process of auditory discrimination, where they must focus in listening. Also, when the children learn a new word, for instance a noun, they are taught to identify things such as: what the word (object) is useful for, where and when it is used, always trying to support the oral language with the support of the real object; thus, children can feel it, see it or touch it.

Children with cochlear implants tend to communicate visually; so appropriate methods of verbalization were selected. Fun Toolkit was used in the beginning, adapting nonverbal expressions to formulate question and answer combinations. Only two rating scales are used - This or That. The questions are related to the experience they feel on interacting with the game. As a result, use was made of an instrument called Smileyometer or VAS (Visual Analogue Scale). In the early stages of the evaluation, all five faces represented in the Likert Scale were used, but on being shown these different expressions some of the children became confused either because some of the expressions were unknown to them or they were too similar to each other. When teachers introduced them to a different evaluation framework, they were filled with doubts and became confused, so this also influenced the decision to continue using just the two faces for the rating scale. The scale is modified to include just two faces and this changes according to the gender of the child. The faces show either a happy face to indicate a positive response or a sad face for a negative response (Fig. 2). In the faces design, the gender was taken into account because it was wanted to evaluate if it influenced in their answer.

This method is helpful for use as a form of communication response, where children express their opinions by identifying themselves with the feelings. This method was applied with the group of 11 children in the therapy auditory-verbal to evaluate activities related with the inclusion of technology with the three games proposed. The idea was that they should

assign an emotion by each game, and to know their opinion if they liked or not.

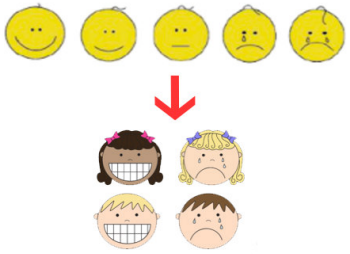

Fig. 2. Proposal for improving the Smileyometer tool, adapted to include just two emotional states, depending on the gender of the child.

Each of these interactions was recorded on video. To evaluate the user experience using the proposed tools, two videos were recorded: one in front of the children, in order to observe their facial expressions and one behind to observe the interaction of the child with the game. Two assessors took notes, where one interacts with the child during the activities, while the other observes and records his observations. The children answered with happy face the three games, but when they interacted with the mouse, they had difficulties and they were not very expressive with the three games. Furthermore, Vivoso was the game that they had less difficulty, because it is a game that is used in the first stages after acquiring the cochlear implant and they begin working the sounds detection.

Another method called drawing intervention [24] communicates the user experience through drawings and the children are not required to speak or comment. This method is based on the observation about what the children draw and has been used to understand children's thinking. A modification was made to this method so that the objective for each child was to construct an animated character in order to be more involved in the game (Fig. 3). Therefore, using a set of body parts supplied to each child, two characters were built using all the pieces as they pleased. Another activity applying the drawing intervention method was that the children should draw themselves.

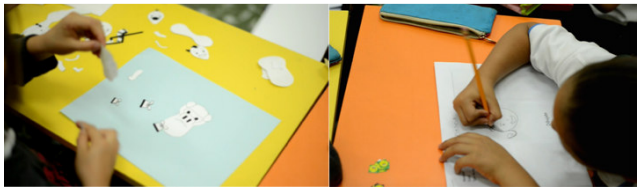

Fig. 3 Applying the Drawing Intervention method to 12 children courses of kindergander and transition in INCSVC.

Selection of the methods depended on the level of schooling of the children. For example, for children in prekindergarten whose ages range from 5-9 years, the only method that could be applied was Drawing Intervention, because they don't yet know how to write, so that mainly the visual channel was mainly used. Some of them vocalize, but lack oral clarity and are not easily understood. Moreover, many of them have been using the implant for less than a year. They also have a very poor vocabulary and don't manage to write their name well, which is why the interaction with them was only visual.

Therefore, is important to take in account that each assessment, questions or indications made to the child must be adapted according the age. Also, when it is made an evaluation with children not mandatory to answer, because they could answer influenced.

c. Experiment design

One experiment consisted of selecting a set of interactive tools for speech and voice therapy. These tools interact with the child through the microphone, into which they pronounce a given phoneme and voice aspects such as intensity, pitch, and timbre are evaluated. Tools such as QUIS [37] that relates to technology, USE [46], to user experience, GEQ [47], and UEQ [48] are used in order to evaluate the established metrics, as shown in Fig. 4, so as to assess usability.

Fig. 4. Applying the direct observation method for children group aged 7 to 11 years.

Other kinds of activities are also done on paper, such as the children drawing themselves, or putting together a character from pieces handed out to them, where

they are required to choose parts of the body and face, and go on to piece them together.

B. Evaluation

a. Metrics

To select the evaluation metrics, a number of evaluation criteria were considered. These are: effectiveness, efficiency, satisfaction, emotions and learning.

b. Aspects of the Child

In order to identify aspects of children with cochlear implants, several different inquiry activities were carried out, such as interviews with the teachers and speech therapists, in order to capture information about the child. Observations of the therapies with the children and the various activities involving the children were also made. These may vary depending on the support they require.

c. Instruments

A set of instruments are proposed for assessing user experience with children with special needs like auditory impairment. The methods used helped to obtain qualitative data and these can change according to the needs of the child. Therefore, we used some instruments as usability test evaluating aspects like: effectiveness, efficiency, satisfaction, emotions and learning. Also, some evaluations that allow knowing cognitive aspects in the child are proposed, such as: perception, visual memory, and auditory memory, among others.

C. Post-Evaluation

a. User Profile

To gather information about the children with cochlear implants, interviews were carried out as well as questionnaires with experts such as teachers, psychologists, speech therapists, designers and experts in HCI. Direct observation was carried out for each child in order to obtain information that is relevant and able to assist in identifying behaviors, difficulties and reactions in the children. The user profile seeks to be able to adapt appropriate evaluation methods according to the characteristics of children with cochlear implants.

b. Results Analysis

The results obtained had two approaches, qualitative and quantitative. The quantitative results were obtained with a group of 11 children from 7 to 11 years of age with cochlear implants, where a set of games oriented to auditory therapy was evaluated. The qualitative results were obtained with a group of 12 children from 5 to 11 years old, applying assessment

methods, such as: direct observation, drawing intervention and picture card. Also, interviews were made with a group of teachers, audiologist and psychologist.

In the quantitative results, there are children with an average age of 8.5 and standard deviation of 1.4. The success of the pronunciation of a child with a cochlear implant can be achieved by the quality of the stimulation and the age of the implant. For example, one of the boys with a cochlear implant evaluated in the study was 11 years old in Transition level at school, the stage before primary education, which means his learning process was delayed due to the late acquisition of his cochlear implant. He suffers from pronunciation problems, but the kind of games that he was presented with, have a content that is not much fun for a child of 11; whereas an eight year-old girl who had benefited from stimulation throughout her early years performed the exercises with excitement.

A usability test was applied with the three games, where the test was used as an instrument to determine the degree of acceptance of the game by the child, as well as its success as a learning tool. The test consists of a total of 50 questions, structured based on the QUIS [37], USE [46], GEQ [47] and UEQ [48] questionnaires, taking into account the effectiveness, efficiency, satisfaction, emotions and learning attributes. In the use of technologies taking into account the research made in [49], where were basic open questions were also asked to every child from INCSVC, such as:

- ¿Do you have a tablet, smartphone or PC at home?
- ¿Do you use the tablet/smartphone/PC alone?
- ¿Do you use the tablet/smartphone/PC with your parents?
- How many times a day do you use the tablet/smartphone/PC at home?

Fig. 5 shows the results obtained on assessing the children using the Pre-lingua tool. The usability aspects evaluated were effectiveness, efficiency, emotions and learning. In the efficiency aspect, it was seen that the results are almost identical. This is because most of the tasks performed with the children were not matched well to their level of learning, so that they were easy tasks for them. As a consequence, when they performed the task successfully their facial expressions were not of great significance.

This also had an influence on the learning aspect, where 48% where found to have succeeded without much difficulty. As a result, 47% was obtained for the emotions aspect, where the children did not reflect a high degree of intensity in their emotions. This is because the game turned out to be easy for them and they did the task more as a mandatory activity, rather than as enjoying themselves.

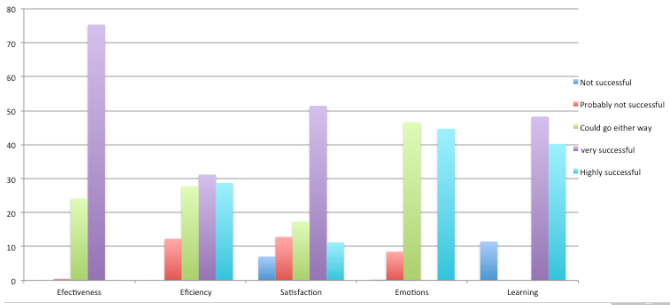

Fig. 5. Results obtained with the Pre-lingua tool.

The effectiveness aspect, meanwhile, registered 27% in which the child succeeded regularly, because the children were often unaware of the challenges presented in the game and played it mechanically, always with the help of the evaluator. It was sometimes necessary to explain to the child that they needed to pronounce with more intensity in their voice so that the animation could work, but the game offered no constant feedback, so that the assessor at times acted as informant in all the interactions the child carried out with the game. The evaluated metrics show that *effectiveness* obtained better results compared with *efficiency*. The *effectiveness* metric is related to aspects in interface appearance and exploration of the game, for instance: appropriate colors, readable letters, comprehension of the activity and the challenges, among others. Meanwhile, efficiency relates to aspects with content of the game and interaction. Satisfaction and Learning metrics have related aspects of user experience and learning. Learning relates to the difficulty level, ease of use and satisfaction relates with feels. The results obtained help to indicate that challenges presented to the child must have a well-balanced difficulty level, because if it is very easy the child tends to get bored and if it is too difficult s/he tends to get frustrated and it is possible that s/he will not continue with the game.

The results obtained with Talking to TEO (Fig.6) and VIVOSO were similar. However, children liked more the game Talking to TEO, because every time that they did the activity correctly, they obtained a punctuation or start and it motivated them to continue doing the activity and to advance in the difficulty level.

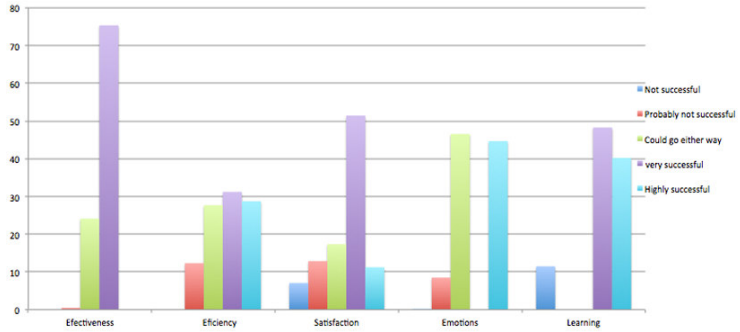

Fig. 6. Results obtained with the Talking to TEO tool.

Games do cover a kind of necessity for children who are only just starting out on the hearing therapy process, but for children whose learning level is more advanced, this type of game can get boring since the challenges on offer fall short of the skills they have acquired.

On the other hand, the interaction with technology was also evaluated. Tests were conducted on handling the tablet, where it was observed that the children had greater positive reactions on interacting with the mobile device than with the PC. In addition, there was no need to explain to them the activity to be performed; they did it independently without any support from the evaluator. Also, a set of questions were made about the use of technology, where most of the children answered that they have Tablets and use them with their parents, but only to play.

Meanwhile, results obtained with the qualitative approach, where the children built characters, linking different parts of the body, helped to identify the imagination level, behaviors and interests. We observed that children use the symbolic representation; therefore they have difficulty to build imaginary characters, so they tend more to represent their real environment. Furthermore, they are used to receive orders from the teachers and to trust in the criteria of older people. In the activity "drawing themselves", it was observed that the only part of their bodies they did not draw was their ears, and when they did, they did not draw their implants. However they drew physical aspects that they feel identify them, like eyes size, haircut or accessories. Also, this activity was made in group, so they were not shy in their answers and interactions.

On the other hand, observation of verbal and non-verbal behavior in the child helped to provide information about their receptivity to the testing instruments, mood, orientation and attitude with the test and evaluator. Children with auditory impairment present some expected difficulties during the tests, for instance, they did not understand questions so these had to be asked more than once.

6. Discussion

In the assessment carried out with the children it was observed that they usually tend to be more visual. In addition, communicating with them was no easy task, especially when the objective was to extract information or find out their opinion about some product or other.

It is important to involve not only the expert evaluators, but teachers and speech therapists because these can assist in the acquired knowledge bases of the children and the way of interacting with them. With the teachers, we find that they can help in giving support in terms of the vocabulary that the different children know and how best to communicate with each one. This factor was very important, since it was adapted for working with the Drawing Intervention technique, where an activity was undertaken in which they had to draw themselves. The results found were that the only part of the face that they neglected to draw was the ear, or the cochlear implants. However, they did draw physical aspects that they more strongly identified themselves with, such as hairstyle, accessories, and behavior.

Moreover, when they are with a person that they don't know, they tend to be shy, making it difficult to extract enough information. They were very restrained in their responses and answered hesitantly. Also, when working with children using the Smileyometer tool, therefore we changed the test to only two types of response, but the problem was that it still did not give up a lot of information on the test, since in practice they did it without thinking, because they felt they were being evaluated and tended to give answer (1), corresponding to a happy face.

When children have little acquisition of the language, other methods that allow to obtain information about them must be used. Furthermore, when they are evaluated individually, they tend to be shy. Also, it was observed that they restrain in their answers but when they make group activities, their expressions are more real and they can express easily without help, and they can support with other peers.

It was also observed that digital games produce positive effects on children, especially when they work with tablet devices, showing acceptance to do activities with a pedagogical or rehabilitation approach. Researchers reported in [50] that deaf children have problems related to focusing their attention. Therefore, it is important to understand, why design guidelines cannot be applied to the children in the same way that are applied with an adult or hearing children due to their different needs and skills. Furthermore, children with cochlear implants are in their language development process and the age of the child must be taken into account as well as their auditory impairment or if they have any additional cognitive disability, since it can affect the way of communication, input methods, tasks and appearance to be involved in the game.

7. Conclusions and Future Work

The purpose of this article is to identify elements of entertainment that can be incorporated into games for rehabilitation. It is therefore important to include the

children in the design process, to find out their opinions. Moreover, not all children have the same abilities, so a means of communicating with them ought to be established. Existing methods of evaluation were adapted, in such a way that the motivation of the children could be captured and thus their points of views.

The methodology provides support for following required guidelines and choosing techniques adapted to the characteristics of the child. In addition, the methodology follows user-centered design philosophy, in such a way that takes into account human and demographic factors of the children.

It is also important to involve specialists like teacher and therapists into the design process because they can provide additional information not just about the children but also about the teaching and learning processes that designers and developers lack.

The use of technological tools engages children into learning and thus it can support the development of new skills in different areas of knowledge like language or math and with an adequate platform, it could also give teachers or therapists statistical information about the progress of the children.

As future work, it is intended to incorporate evaluation methods that make it possible to abstract cognitive skills of the children and thus automatically adapt these evaluation methods according to the characteristics of each child.

Acknowledgements

Institute for Blind and Deaf Children from Cauca Valley department of Colombia

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Highlights

Computer Games have become an important part in life part in child and a youth culture

A serious game can be defined as a balance between the entertainments and pedagogical

The evaluation of a product focused on children is a different process compared with adults

A child with a hearing impairment acquires language skills at a slower pace than a hearing child