Fun learning in inclusive education: an approach using Beauty Technology, a tangible artefact, and affective states evaluation

Andriele O. Costa
Federal University of Amazon
Institute of Computer Science
Manaus, Brazil
andriele.souza@icomp.ufam.edu.br

Ada S. F. Araújo
Federal University of Amazon
Institute of Computer Science
Manaus, Brazil
asfa@icomp.ufam.edu.br

Thaís Helena C. Castro
Federal University of Amazon
Institute of Computer Science
Manaus, Brazil
thais@icomp.ufam.edu.br

Elaine Harada T. Oliveira
Federal University of Amazon
Institute of Computer Science
Manaus, Brazil
elaine@icomp.ufam.edu.b

Eliana A. Moreira
Federal Institute of Technology and Education of São Paulo
Campinas, Brazil
eliana.moreira@ifsp.edu.br

Katia C. Vega
University of California, Davis
Davis, California
kvega@ucdavis.edu

Bruno F. Gadelha
Federal University of Amazon
Institute of Computer Science
Manaus, Brazil
bruno@icomp.ufam.edu.br

Maria Cecília C. Baranauskas
Campinas State University
Campinas, Brazil
cecilia@ic.unicamp.br

***Abstract*—The difficulty in reading and interpreting the text has been a common problem in several types of intellectual disability, such as autism and dyslexia. Moreover, it triggers numerous damages to students throughout their academic life. However, this work presents an approach to the inclusive learning of reading, using beauty technology, a playful activities box, and an emotional assessment tool. To verify the approach's applicability, we carried out a learning workshop with six students with some literacy difficulty in elementary school. The results showed that the playful experience of nails with the activity box and the tangible evaluation of use could make students feel good when practicing a challenging discipline.**

Keywords—Reading and text interpretation, beauty technology, technological nails, tangible interfaces, evaluation, ludic.

I. INTRODUCTION (*HEADING 1*)

The difficulty of reading and interpreting text is a very common situation in Brazil, being the object of study of this work. In this sense, we explored the potential of technological nails. We created an activity box aiming to train reading and interpretation, giving voice to users' participation in the project through the TangiSam evaluation resource.

Considering that 92% of the Brazilian population is literate from the age of ten and that 14 million drop out of school due to difficulties in interpretation and reading, it is known that the other areas of learning are compromised [1]. In addition, data assessing the quality of literacy in 2020 [2] has positioned Brazil behind several countries such as Spain, Portugal, the USA, and Korea. Almost half of the Brazilian fifteen-year-old students did not reach an acceptable level of reading skills.

Within this scenario, we still have students with learning difficulties, disabilities, and other special conditions such as ADHD, autism, and dyslexia [3] who experience the absence of facilitated content and inclusive teaching due to this challenge's pedagogical complexity. In this context, the use of literacy support apps can promote an integral and dynamic development in the cognitive, affective, linguistic, social, moral, and motor areas and contribute to the construction of autonomy, creativity, and cooperation [4],[5].

II. BACKGROUND

A. Difficulties in reading and interpreting text

The absence of the ability to read and interpret texts reflects internal problems in the individual's linguistic system [6]. Some traditional cognitive stimuli help to learn to write and read [7]. However, some students cannot always focus on literacy activities or figurative or ambiguous language [8], [9].

Thus, artificial intelligence resources and tools can be convenient and interesting as inclusive educational tools [10], mainly because they allow trial and error. Even so, it is necessary to monitor the development of the player [11] and give space for the speech of the players, especially those with disabilities [12],[13], so that they feel on an equal footing with the technological experiences.

In this article, the authors reason about three issues for the development of inclusive games: (i) the end products must be playable and valuable for students with and without disabilities; (ii) the gaming experience should unite children's interaction, regardless of their cognitive ability, and promote collaborative learning through peer guidance; and (iii) the emotional states of users during the use of the artifact are important metrics in evaluating the efficiency of the product.

III. DESIGNING AN APPROACH FOR FUN AND INCLUSIVE READING PRACTICE

In view of all the concepts visited, the playful sequence developed translates into (i) the design of a box of text interpretation and vocabulary acquisition activities, (ii) the use of technological nails, (iii) the use of TangiSAM tangible emotional assessment. This approach is intended for children with or without learning difficulties, from 6 to 11 years old, with previous knowledge of reading and interpretation difficulties; it is based on learning phenomena for Information and Communication Technology (ICT) [16]. Using the elementary tetrad [15] as a design method, four elements are part of this construction: narrative, aesthetics, technology, and mechanics. The assumptions of Donald Norman [17], Ambrose & Harris [18] guide the usability directions of the artifact. Below is a description of the proposal.

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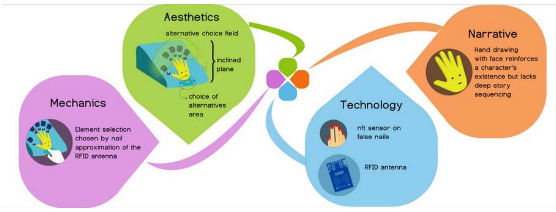

Fig. 01: Elements of the design approach based. Source: own authorship

A. *Narrative*

The drawing of a happy hand reinforces the existence of a character, but there is no deep story sequence; its content is centered on teaching, as it is an initial step in the product design process. In addition, the instructor conducts the game, either awarding points or managing the team's results.

B. *Aesthetics*

For the aesthetics of the activity box, which adopted a format with an inclined horizontal surface, in the center of the box, there is the shape of a hand in which the RFID sensor is contained below, which has a detection area signaled on the artifact. The cardholders with LED below are positioned at the tips of each finger of the hand symbol. This arrangement aims to maintain a comfortable distance from the user's eye and hand movement.

The hand symbol is adopted so that its use is intuitive and direct [17]. The sensors of the technical nails only focus at a short distance on a single location of the artifact. In this way, if each nail can light up an LED, the absence of a simple and playful symbol can cause a blockage or overload to the student.

C. *Technology*

The Arduino is used in the technology layer, with code implemented so that the LED lights turn on when the nails approach the RFID antenna, capturing the radio frequency and can be used with other components (Fig. 02). The sensor identifier is read at runtime, so a 'HIGH' signal is sent to the LED corresponding to the sensor, turning it on.

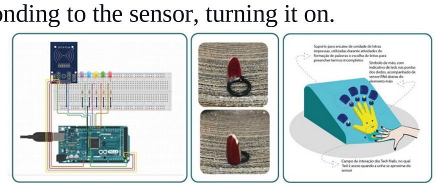

Fig. 02: Left: circuit model; centre: tech nails; right – handbox.

In the beauty technology item of this project, the technological nails [19], micro NFC/RFID transponder sensors, and flexible and small sensors of 15.6 mm x 6 mm were adopted. It contains an NTAG203 chip with an antenna frequency of 13.56MHz and has a capacity of 144 bytes for memory writing and reading. They used them only for recognition of the signal captured by the antenna.

Thus, tests were carried out to verify the ways of recognizing the sensor, either in front of or behind the rod, sometimes with the rod in a horizontal or vertical position and even inclined over the antenna's position [20]. Table 1 describes the data from these tests performed with the antenna positioned in a horizontal plane and the interaction of the rod above the antenna.

Positioning of the tech nails in relation to the RFID antenna	Sensor in front of the tech nail	Sensor behind the tech nail
Horizontal (tech nail upwards)	Non-recognizable	Non-recognizable
Horizontal (tech nail downwards)	Recognizable	Recognizable
Vertical	Non-recognizable	Non-recognizable
Tilted	Non-recognizable	Non-recognizable

Fig. 03: Tests for sensors recognition

This test decided that the ideal position for the technical fingernail for antenna recognition is with the sensor in front of the fingernail horizontally, with the fingernail facing downwards for more comfortable recognition.

D. *Mechanics*

The activities that are part of the playful sequential mechanics and logic were planned in four phases, as described below:

a) Phase 1: memorization of color sequences aiming to familiarize with the type of interaction of the artifact; thus, the sequences were shown on slides and then hidden for users to reproduce the sequence in the artifact.

b) Phase 2: a word must be formed in scrambled letters within a context. Example: “look up a scientific word,” and the word discovered among the randomly arranged letters is “atom.” Stimulating reasoning about the meaning of words and relating two concepts.

c) Phase 3: players must indicate which correct letter completes a given. This activity reinforces the correct spelling of words that present ambiguity and complexity in writing and sound. Example: “__SLE (hint: isle or aisle?)”.

d) Phase 4: After interacting with the activity box, we evaluate the playful moment that occurred previously through TangiSAM, which allows the expression of affective states attractively and understandably [21].

IV. Learning workshop

After a bibliographic survey, ideation, design, and prototyping, we sought to know the users' experiences for validation. The director of our partner school nominated six children to participate in the experiment, aged between 9 and 14 years, accompanied by a responsible teacher. All are students enrolled at the Ana Mota Braga public school located in the south of Manaus. What carried out the set of tests in the laboratory of the Intelligent Systems Group at the Federal University of Amazonas. First, there was a breakfast with the team, and later, the instructor formed two groups to participate in the activities.

A. *Preparation*

The chosen environment was a large air-conditioned meeting room, where the students sat side by side. Two instructors received the children, one presented the artifact and the other performed the tangiSAM assessment. In addition, two other professors and a graduate student were present for support.

B. *Subjects*

Six students with learning difficulties participated. 4 boys and two girls—1 with dyslexia and autism, 1 with difficulty interacting, 1 with advanced age for the grade. Participants attended the workshop during their class hours, corresponding to the morning period, accompanied by a responsible teacher.

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C. *Execution*

Each team used the prototype and the technological nail interaction in game form, chosing a leader to answer the questions at a time, per turn. The time allowed was free and did not exceed five minutes.

D. *Evaluation*

The evaluation with the TangiSAM resource [21] was carried out after the game so that the children could express their emotions and usage impressions about the resources used in the game; the representation of the SAM evaluation through tangible dolls makes this activity more accessible and playful [21]. Thus, the data are presented in the next section.

E. *Results*

For the analysis of the results, a scale from 1 to 5 represents the affective state chosen by the participant, where five means Very Happy (Satisfaction dimension), Very Motivated (Motivation dimension), and Very Easy (Control dimension) regarding participation. in the activity. In addition, it means Very Sad (Satisfaction dimension), Very Unmotivated (Motivation dimension), or Very Difficult (Control dimension). The frequencies of responses with the number of participants are shown in Figure 04.

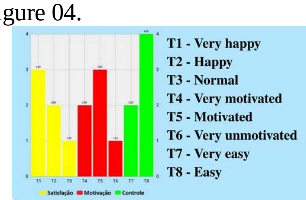

Fig. 04: Total de escolhas para cada estado afetivo. Gráfico gerado pela aplicação de software do TangiSAM.

In general, the children were very happy during the Workshop (n=2 for "Very Happy"; n=2 for "Happy"; n=1 for "Normal"). In the Motivation dimension, most participants were motivated by the activities proposed in the Workshop (n=2 for "Very Motivated"; n=3 for "Motivated"; however, one participant was "Very unmotivated". He commented that he did not find the nail design attractive. In the Control dimension, participants thought they mastered the activities (n=2, for "Very Easy"; n=4, for Easy). Students get involved in the proposed activities, ideally used in a school context.

V. Discussions and Conclusions

This article presents an educational design approach to developing tangible resources, providing learning playfully and attractively. We align ourselves with Jesse Schell's Elements Methodology, where our three elements are part of the same methodological resource: the tangible artifact (handbox), the technical nails, and the TangiSAM. What is observed is that the tangible experiences presented have the potential to stimulate learning with a higher level of satisfaction and motivation.

The experiment found that most children expressed a high level of satisfaction and motivation while reported two negative impressions. However, regarding the difficulty level, most participants considered the activities easy. Thus, even though we observed that the contents of the experiment were in accordance with the users' repertoire, we assume it's important to offer multiple wearable beauty technology options for different personality types. In addition, it is observed that visual elements, together with recreational activities, can be decisive for the user experience.

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