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Designing augmented reality cards as an educational resource to teach Portuguese Sign Language

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***Abstract*— This paper presents an educational resource to support the teaching of Portuguese sign language. This educational resource emerges in response to the significant needs for the development of adequate digital tools to support deaf people in different tasks, especially in the language learning process. This work is motivated by the results and conclusions from previous studies that identify augmented reality as one of the promising solutions to improve the learning and teaching processes, and benefits from the advances already accomplished in the development and application of augmented reality solutions in several domains of the educational environment. The educational resource presented in this work is an augmented reality solution that enables associating hand gestures, representative of Portuguese sign language, to different cards, which represent different letters of the alphabet. In this way, it is possible to associate the alphabet letters with the respective gestures in a visual and straightforward way, facilitating the learning process.**

Keywords*— *Augmented Reality; Virtual Environment; Sign Language; Education; Human-Computer Interaction; Multimedia; Interaction Design; UX Design.

I. INTRODUCTION

Innovative digital solutions are increasingly important to provide support in different aspects of people's daily lives. The relevance of such technology is especially pertinent when considering the care of people with disabilities, such as deaf people. Tools that are able to contribute to a safer and more efficient way of life are essential and can contribute to improve crucial aspects in deaf people's lives, such as the communication capabilities, especially through the improved learning of sign language [1].

Portuguese sign language is one of the three official languages of Portugal, recognized since 1997 in the Constitution [2], which states that it is up to the Portuguese State to "protect and value the Portuguese sign language, as a cultural expression and instrument of access to education and equal opportunities".

In fact, sign language is used all around the world, presenting significant variations from country to country [3]. It is, however, important to take into account that deaf people have different communication needs, different communication skills and different communication preferences. Some individuals communicate using oral language and/or writing and lip-reading, some use sign language and some are bilingual individuals that use both forms of communication [4][5].

These forms of communication are intrinsically connected to the life experience related to hearing loss that deaf people go through in addition to the type of deafness and the psychological affectations that may result from that disability. Aspects such as the family support and way of raising the deaf individual during the childhood, the age from which the contact with sign language starts, the overall social environment, and the country or region-specific education inclusion policies, are all critical aspects that influence the communication capabilities [6].

Although sign language provides a means for expressing and communicating, it needs to be complemented by other sources of information, such as facial expressions interpretation. Moreover, since sign languages are different in different countries and even regions within countries, they use distinct symbols, grammar, and syntax [5][7][8], which makes the translation and interpretation even more difficult. This makes it a very challenging task to develop effective technological solutions to support sign language translation, interpretation and learning.

Contributing to surpassing this gap, this paper presents an educational resource directed to the improvement of the learning process of sign language. The educational resource is an augmented reality solution that enables associating hand gestures, representative of Portuguese sign language, to different playing cards, which represent different letters of the alphabet. 3D models of the hands are used to create models of the different gestures that represent distinct letters. Through augmented reality technology, these gestures are presented visually on top of the card holding the respective letter, through a mobile device such as a cell phone, tablet or smart glasses. The Braille system is also incorporated in the cards, so that people with vision difficulties can also use them.

After this introductory section, Section II presents an overview of related work, highlighting works associated to

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sign language learning and to augmented reality solutions applied in education problems, and identifying the literature gaps. Section III describes the proposed educational resource, namely the description of the card set, including the incorporation of the Braille system and the card design; and the description of the augmented reality implementation, which includes the presentation of the process used to build the 3D hand and bones models, and the computer vision approach that has been implemented. Finally, section IV presents and discusses the main conclusions of this work and identifies some relevant paths for future research.

II. Background

Deafness was traditionally associated to cognitive developmental difficulties. Therefore, when included in the education process, it was assumed that deaf people had a cognitive problem. However, in fact, the difficulties of cognitive development are related to the lack of stimuli and the communication barriers between deaf and hearing people which lead to an increased difficulty in knowledge transfer [9].

On the other hand, cognitive development is known to be associated with language learning. Consequently, deaf disability is usually classified directly based on speech and language ability, namely [10]: (i) mild hearing loss (no significant effect on development, as there is usually no need to use a hearing aid); (ii) moderate hearing loss (may affect speech and language development, but not enough to prevent a person from speaking); (iii) severe hearing loss: (interferes with speech and language development, but with the use of a hearing aid, it is possible to receive information using hearing for speech and language development); and (iv) profound hearing loss (speech and language understanding are not possible without advanced aid).

Sign language is used to enable deaf people communication. Although there have already been some advances is this direction, there is still no universal language, rather a collection of sign languages, implemented in different countries. In Portugal, in specific, and according to the National Survey of Disabilities, Disabilities and Disadvantages, published in 1996 by the Portuguese Institute for Rehabilitation, there were over 115 thousand people in Portugal who did not speak Portuguese Sign Language, but had a hearing deficit [11] and, out of those, 19 172 were considered deaf. Moreover, the study showed that around 80% of the Portuguese deaf community had insufficient education or literacy problems, causing only 2.5% of these people to have age-appropriate reading skills.

After more than 10 years later, the same study was even less clear in the field of disability, and in particular on deaf people, since it only distinguished the population with difficulties in carrying out some daily activities such as "hearing", which can be caused by health or age reasons.

This highlights the importance of creating new tools to support people with hearing deficiencies in communicating and expressing themselves, not only with the objective of increasing inclusiveness, but also to improve their cognitive development process.

The complexity of sign languages is significant. Besides the gestures that are used, the language is complemented by other expressions, e.g. facial, which enlarges the grammatical possibilities of the language [3]. Additionally, the language differences from different countries, bring an added difficulty, especially in distinguishing among similar gestures. This is further aggravated when considering not only the gestures themselves but also the movements and sequences of gestures [12]. Another significant issue is the reading and writing difficulties of deaf people due to the reasons discussed before.

All of these act as barriers for the effective digitalization of deaf-directed digital support solutions. It is critical that new, advanced solutions are developed, to enable surpassing such barriers, especially in the deaf-education domain. One of the most promising approaches to address these problems is augmented reality, which enables adding new digital features to the existing contents. A relevant review on augmented reality solutions and their application in education is presented in [13]. This study concludes that the research in this area is mostly student-centred and proposes a shift away from research focused solely on learning outcomes and towards research which also considers how augmented reality integrates into the teaching environment. The work presented in [14] explores a similar topic, although from the perspective of a developing country. The reached conclusions are similar, pointing out that augmented reality can be an effective tool for learning, but its widespread adoption is still not a priority and not being fostered well enough.

In fact, several works can be found in the literature, addressing augmented reality technology for education, e.g.: [15] addresses school physical education, [16] presents a pilot study of augmented reality in nursing education, and [17] proposes the application of augmented reality to promote collaborative and autonomous learning in higher education. Secondary education is the application focus of the work presented in [18], which implements a mobile augmented reality solution using a service oriented architecture. Results from an initial usability testing of the proposed augmented reality system showed a user satisfaction of 97%. Actually, mobile solutions for augmented reality are increasing in terms of research and application potential, as shown by [19], which presents a study on the advantages and possibilities for such solutions in education. Some of the main advantages, as identified also in [20] in another study directed to learning experience using mobile augmented reality in engineering education, are the increased opportunities for students to improve their creativity, and the inclusion of an additional element of motivation and collaboration.

Given the identified potential and the advantages of augmented reality, especially when integrated in mobile solutions, and considering the significant needs for digital support to deaf people, this work presents an educational resource with the purpose of providing an enriched augmented reality experience to deaf people and to trainees who are learning the Portuguese sign language.

III. The Educational Resource

The name adopted for the Educational Resource was GPT – *Gestos Para Todos* (in English, Gestures For All), and a Card Set with the complete Portuguese Alphabet was created, along with a brand identity, as a way to define its graphic line and bring value to the project.

Our concept for the Logotype, depicted by Fig. 1, was to bring life to the Acronym “GPT”. For this, we intended to incorporate a hand representation in each letter, for it is how we communicate using sign language. Also, as we are dealing with children as our target audience, we embedded a mascot-

like representation for each letter, thus portraying a sense of animation, fun and flow to the Logotype.

Fig. 1. Logotype of the Card Set

A. Card Set

Following the brand guidelines, we created a specific layout for the card set and color coded the alphabet. Hence, the letters are organized by color: yellow represent vowels; blue represents consonants; and orange represents the foreign characters.

Evidently our target audience were deaf people that wanted to learn Sign Language; nevertheless, with our focus on a universal design, our intention was clearly to include everyone, with or without disabilities. As such, in each card there is the intended letter of the alphabet represented, its respective translation to Braille and the card color using the ColorADD international system.

1) Braille system

Braille is a tactile writing system used by blind or low-vision people. It is traditionally written on relief paper [21]. Braille system users can read on computer screens and other electronic media thanks to an upgradeable Braille dial. Braille characters are small rectangular blocks called cells, which contain palpable tiny bulges called raised points. The number and arrangement of these points distinguish each other's characters. Since the various Braille alphabets originated as transcription codes for printed writing systems, mappings (character designation sets) vary from language to language. In this work, we are using Portuguese language, in alignment with the hand gestures for sign language. These are included in the card set, namely placed in the bottom right corner of each card (see Fig. 2).

2) ColorADD system

Color blindness (color vision deficiency) is a decreased ability to see or distinguish several colors and affects a substantial portion of the human population. There are 350 million colorblind worldwide (approximately 4.5% of the world population): 1 in 12 male and 1 in 200 female [22]. As such, and because we used a color code in the cards in order to identify the vowels, consonants and foreign characters, we wanted to make sure all users could be aware of the color, regardless. We chose to implement the ColorADD international system [23], as it is a unique, universal, inclusive and non-discriminative language that enables the colorblind to identify colors. It encompasses a wide spectrum of use on companies/entities whenever color is a factor of identification, orientation or choice.

3) Card design

With the focus on accessibility, we designed the card set for the standard playing cards size, in order to bring an innovative project that could be used by anyone on a daily basis. Fig. 2 shows the card set and the respective case.

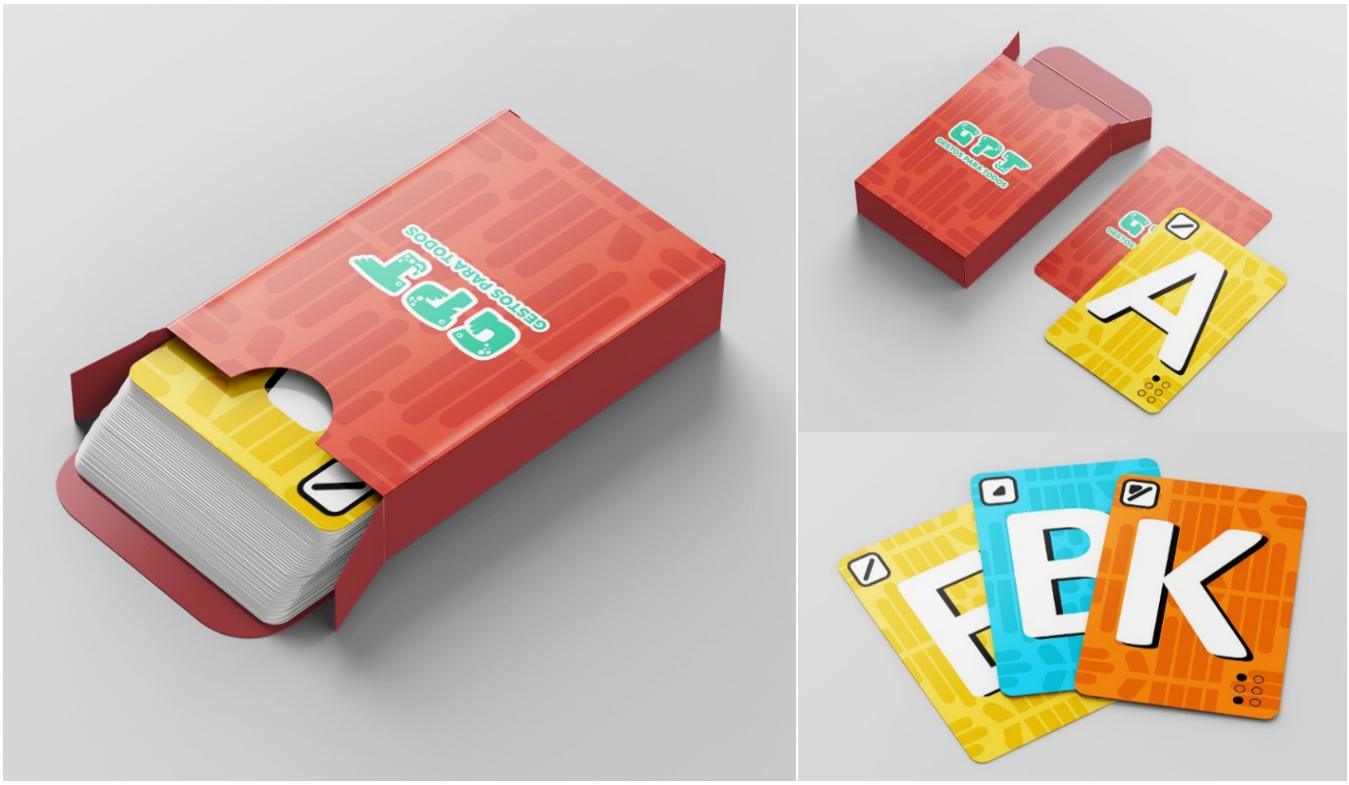

Fig. 2. Card set design

B. Augmented Reality Implementation

An augmented reality application was created, so that the user could access the respective hand position and its different perspectives. Indeed, the user can access the 3D model of the hand gesture by holding a mobile device and pointing the camera towards the intended card. Then, the application recognizes the letter, and shows the 3D model of the respective gesture in Portuguese Sign Language. This is achieved through the scan of each letter of the card set. By using each card, the user will see the correct gesture (Fig. 3).

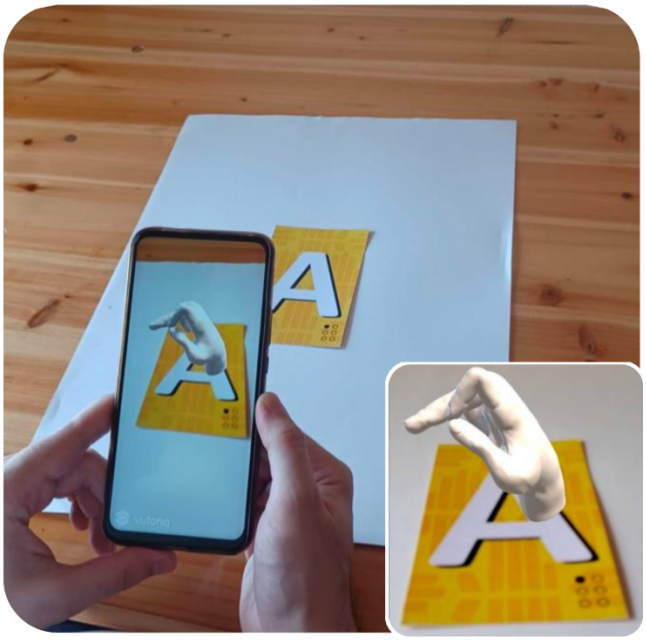

Fig. 3. Hand Gesture for Letter A (in Portuguese Sign Language)

1) 3D hand and bones model

The first step towards implementing the envisaged augmented reality solution has been the creation of 1) 3D hand and bones model. This is accomplished through Blender, which is an open source computer program designed for modeling, animation, texturing, composition, rendering, and video editing. In this work, we initially downloaded a 3D hand model, which, through Blender, has enabled creating and associating bones to the 3D hand, allowing to model it, as shown in Fig. 4. In turn, this process allows creating the necessary gestures of the LGP alphabet.

2) Computer vision

Once the hand models and gestures are defined, it is necessary to identify the target gesture that should be displayed according to the respective card, as well as automatically associating the gesture to the card.

Vuforia is a mobile augmented reality software development kit that allows creating augmented reality applications. It uses computer vision technology to recognize and track planar images and 3D objects in real time. Vuforia detects the relevant targets and creates a database where these points are stored. Fig. 5 shows an example of reference points identified for the card with the letter A.

a)

b)

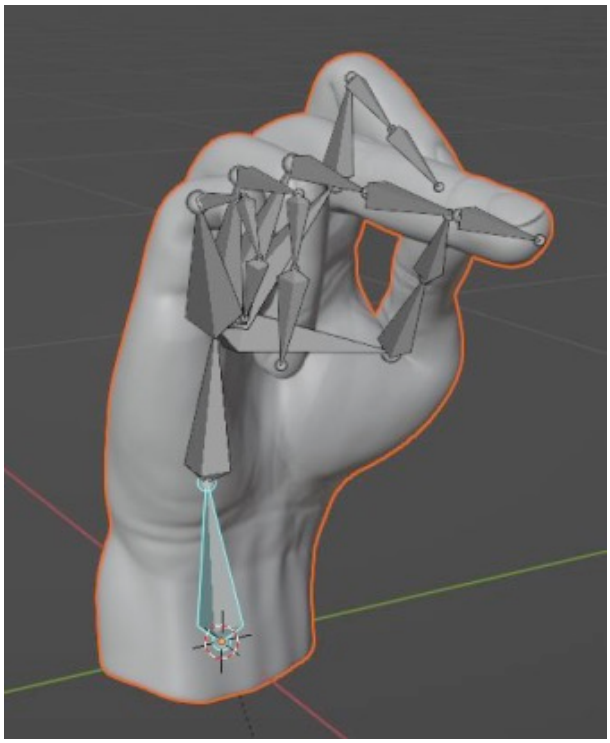

Fig. 4. 3D Hand & Bones Model: a) general model; b) hand gesture for letter A (in Portuguese sign language)

Fig. 5. Reference points in card A.

After having identified the reference points, it is necessary to create the augmented reality models. For this purpose, we have used the Unity Editor, which is a popular and useful authoring platform for creating cutting-edge augmented reality experiences for handheld devices and digital glasses.

Through Unity we were able to associate the modeled hands to the respective cards. Firstly, by assigning the animations made in Blender, with the respective cards that are stored in a database, created by Vuforia. Finally, Unity converts the app to a mobile solution, so that it may be used by a mobile phone, tablet, smart glasses, or any other mobile device.

IV. Conclusions and Future Work

This paper presents an educational resource, namely an augmented reality solution that enables associating hand gestures, representative of Portuguese sign language, to different cards, which represent different letters of the alphabet.

With the creation of this educational resource, our goal was to bring forth a solution that could assist in the teaching of the Portuguese Sign Language, whether in school environments or even by independent users with the will to learn at their own pace. Thus, we believe that we were able to propose a valid solution to bridge the gap that exists in our society and its knowledge of sign language with the presented interactive accessible application for assisting users in the learning process.

This is still a work in progress, as there are still many aspects to improve and to be developed. We are aware that user tests are necessary to assess and understand the validity of the educational resource and efforts will be put into evaluating the usability of the solution. However, we believe that this educational resource could open the door to new possibilities within the study area.

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