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Design methodology applied to the communication
needs of the deaf community

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Projeto apresentado ao IADE - Faculdade de Design, Tecnologia e Comunicação da Universidade Europeia, para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Design de Produto e Espaço realizada sob a orientação científica do Doutor João Nuno Gago Bernarda, Professor Assistente da Universidade europeia / IADE.

I dedicate this work to the Portuguese deaf community, particularly the people who helped me better understand it.

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Keywords

Design; Social Design; Product design; Communication; Portuguese Sign Language; Deaf Community.

Abstract

The purpose of this research is to create a product that facilitates the acquisition of sign language by hearing parents of deaf children using the product design methodology. The results of the research revealed a need to help hearing parents of deaf children to become more comfortable with learning sign language so they can become an active part of their child's language development. To address this need, a support piece for sign language cards with an interactive system was developed to allow a more flexible use and two-way interaction. Because there are no Portuguese sign language cards in the market, a sample of these was also made. This project revealed that the public is open to learning sign language and introduced a product that can be part of an effort to universalize sign language and equalize it to verbal and written communication.

Palavras-chave

Design; Design Social; Design de produto; Comunicação; Língua Gestual Portuguesa; Comunidade Surda.

Resumo

O propósito desta investigação passou por criar um produto que facilita a aquisição de língua gestual por pais ouvintes de crianças surdas usando a metodologia de design de produto. Os resultados da pesquisa revelaram a necessidade de ajudar os pais de crianças surdas a ficarem mais confortáveis com a aprendizagem da língua gestual para que possam ser parte ativa do desenvolvimento linguístico dos seus filhos. Para responder a esta necessidade, uma peça de suporte de cartas de língua gestual com um sistema interativo foi desenvolvida para facilitar o uso de cartas de língua gestual e uma interação recíproca. Visto que não há cartas de língua gestual portuguesa no mercado, foi também desenvolvida uma amostra das mesmas. Este projeto acabou por revelar que o público está interessado em aprender língua gestual e introduziu um produto que poderá fazer parte de um esforço para universalizar a língua gestual e igualá-la à comunicação verbal e escrita.

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Abbreviations

AAC - Augmentative and alternative communication

ALD - Assistive listening device

ALD - Assistive listening device

ASL – American Sign Language

CAD – Computer-aided design

CODA – Children of deaf adults

FM - Frequency modulated

HOH – Hard of hearing

LGP – Língua Gestual Portuguesa (Portuguese Sign Language)

NIDCD - National Institute on Deafness and Other Communication Disorders

PVC - Polyvinyl chloride plastic

QR – Quick response code

RTT - Real time text during calls

TTY - Teletypewriter

WHO – World Health Organization

Glossary

Alerting devices	Assistive devices that connect to a variety of household devices to let the user know something is happening in a way they can notice by using louder sounds, lights or vibrations (NIDCD, 2019).
Assistive listening devices	Assistive devices that amplify the sounds where there is a lot of background noise and can be used with a hearing aid or a cochlear implant if these contain a telecoil (NIDCD, 2019).
Augmentative and alternative communication devices (AAC)	Assistive devices that help people with communication disorders to express themselves by translating text, speech, symbols, and sign language between hearing and deaf/hard of hearing people (NIDCD, 2019).
Cochlear implant	Medical device that mimics the function of a healthy inner ear (cochlea) by replacing the function of damaged sensory hair cells in the inner hear to help provide sound clearer than hearing aids (Cochlear, n.d.).
Cognitive development	The ability to think and reason.
Critical pedagogy	Theory that claims that humans become dehumanized by oppression, and education can be complicit in this dynamic when it's done in a passive manner, without an exchange of ideas between student and educator (P. Freire, 1974).
Critical theory	Based on the ideal that scientific knowledge must be pursued to understand and help overcome oppressive social structures (Britannica, 2023b).
Culture	A human complex made up of behaviour patterns defined by the perception that the group has of itself and their future perspectives

(Pereira. 2011). It includes language, ideas, beliefs, customs, codes, institutions, tools, techniques, works of art, rituals, and ceremonies, among other elements (White, 1999).

Deaf	Profound hearing loss, which implies very little or no hearing. They often use sign language for communication. (WHO, 2024)
Dialect	‘A form of a language spoken in a particular geographical area or by members of a particular social class or occupational group, distinguished by its vocabulary, grammar, and pronunciation’ (Collins English Dictionary, n.d.)
Disability	‘Results from the interaction between individuals with a health condition (...) including negative attitudes, inaccessible transportation and public buildings, and limited social support.’ (WHO, 2020)
Frequency modulated (FM) system	System where a speaker uses a microphone and a listener wears a receiver (headphones or hearing device) to transmit the sound more clearly and reduce background noise (Burry, 2023).
Global periphery	In world systems theory, it refers to the countries that benefit less from global trade and development (Wikipedia contributors, 2024).
Hard of hearing	People with hearing loss ranging from mild to severe who usually communicate through spoken language and can benefit from hearing aids, cochlear implants, and other assistive devices as well as captioning. (WHO, 2024)
Hearing aid	Small electronic wearable device that makes sounds louder.
Hearing system	loop Sound system that sends a wireless, magnetic signal to an individual’s hearing aid, delivering certain sounds directly to their ears (Slatter, 2024).

Hearing loss	When a person is not able to hear as well as someone with normal hearing, or to sounds below 20dbHL. Hearing loss may be mild, moderate, severe or profound. It can affect one ear or both ears and leads to difficulty in hearing conversational speech or loud sounds. (WHO, 2024)
Holistic	Refers to the concern for the whole rather than the parts.
Homesign	Self-generated linguistic systems created by deaf children (Hill et al., 2018).
Human centred design	Design practice focused on people and their context, understanding and solving the right problems, understanding that everything is a complex system with interconnected parts and making small interventions (Interaction Design Foundation, 2021).
Inclusive design	‘Design that considers the full range of human diversity with respect to ability, language, culture, gender, age and other forms of human difference’ (Inclusive Design Research Centre, n.d.).
Interaction design	Design of the interaction between users and products with the goal of enabling the user to achieve their objective(s) in the best way possible (Siang, 2024).
Intersectionality	Concept that considers the different social and political identities of the individual in the analysis of the systems of power that affect their life (Crenshaw et al., 1995).
Linguistics	The scientific study of language.
Morphology	In linguistics it’s ‘the study of the internal construction of words’ (Britannica, 2024b).

Native language	‘The language of the country that someone is born in or native to’ (Collins English Dictionary, 2024).
Personal amplifiers	Describes any wearable electronic product that amplifies sounds for people who are hard of hearing (Wikipedia contributors, 2023).
Phonetics	‘The study of speech sounds and their physiological production and acoustic qualities’ (Ladefoged, 2024).
Product design	The ‘process designers use to blend user needs with business goals to help brands make consistently successful products’ (IxDF, 2024).
Semantics	‘The philosophical and scientific study of meaning in natural and artificial languages’ (Britannica, 2023b) .
Semiotics	The study of signs and sign using behaviour (Britannica, 2023).
Sign language	‘Any means of communication through bodily movements, especially of the hands and arms, used when spoken communication is impossible or not desirable.’ (Britannica, 2024).
Social design	The use of design to understand social problems and support positive social change by creating ‘opportunities that shift relationships between people and people, and people and institutions’, according to the Centre for Social Design (MICA, n.d.).
Speechreading	‘The act or process of determining the intended meaning of a speaker by utilizing all visual clues accompanying speech attempts, as lip movements, facial expressions, and bodily gestures, used especially by people with impaired hearing’ (Collins English Dictionary, 2005).
Syntax	‘The arrangement of words in sentences, clauses, and phrases, and the study of the formation of sentences and the relationship of their component parts’ (Britannica, 2024a).

Telecoil (t-coil)	Allows a hearing aid or cochlear implant to receive wireless audio transmissions from assistive listening systems (ALS) providing clearer sound and less background noise (Sieber, 2023).
Universal design	‘Is the design and composition of an environment so that it can be accessed, understood and used to the greatest extent possible by all people regardless of their age, size, ability or disability’ (CEUD, n.d.).
Usability	It’s a ‘quality attribute that assesses how easy user interfaces are to use’ and ‘refers to methods for improving ease-of-use during the design process’ (Nielsen, 2024).
User centred design	Design practice that integrates research throughout the creative process, providing valuable insight into the needs, behaviours, and expectations of the target audience (O’Grady & O’Grady, 2017).
User experience	‘Encompasses all aspects of the end-user's interaction with the company, its services, and its products.’ (Nielsen Norman Group, 1998)

Introduction

This research was inspired by a previous project from the Product Design curricular unit of the Masters in Product and Space Design at IADE – Universidade Europeia, in which a digital device was created to improve communication between people of different hearing abilities, based on the given prompts of disabled users in the playground space. From this starting point, the topic of this research became social design with a focus on communication between deaf and hearing people.

Because it is dealing in language, the research was done with Portuguese sign language in mind, since that is the place where the participants are from. However, the dissertation was written in English because the project that preceded it was in that language and by the time sign language became the main focus of the product, a lot was already written and there was no time to translate it all.

The research framework reveals that the experiences of the deaf community are very dependent on the hearing capabilities in the family environment, making it an important distinction whether someone is a hearing child of a deaf adult, the deaf child of a hearing adult or a deaf child of a deaf adult. Each of these situations comes with different challenges for language acquisition and cognitive and emotional development, that require different strategies to be addressed (Singleton & Tittle, 2000; Waked De Brito & Dessen, 1999).

The assistive technologies that can be used are varied, but what stands out is the sign language translations devices because at first, for a hearing person like me, they sound like an all-winning situation, but I found evidence that the deaf community doesn't fully agree with this perspective. Not only do they not think that the technology can accurately capture the complexities of sign language, but they feel that too much burden is put on them to communicate with hearing people, suggesting that more be done from their side (Erard, 2017). This last observation is supported by the idea that Universal Design needs to be expanded and rethought to 'design with disabilities' instead of 'designing for disabilities' (Guffey, 2023)

The research questions are: What communication gaps exist for people with different levels of hearing capability?; Can a device be designed to facilitate communication for the deaf community?; Can design contribute to the development of new mode of communication?. The objectives of the research were the development of a communication device for people with

hearing loss and the evaluation of existing technology. These hypothesize that the integration of design in the area of auditory disabilities can facilitate the development of new communication tools. The research design can be seen below (fig. 1).

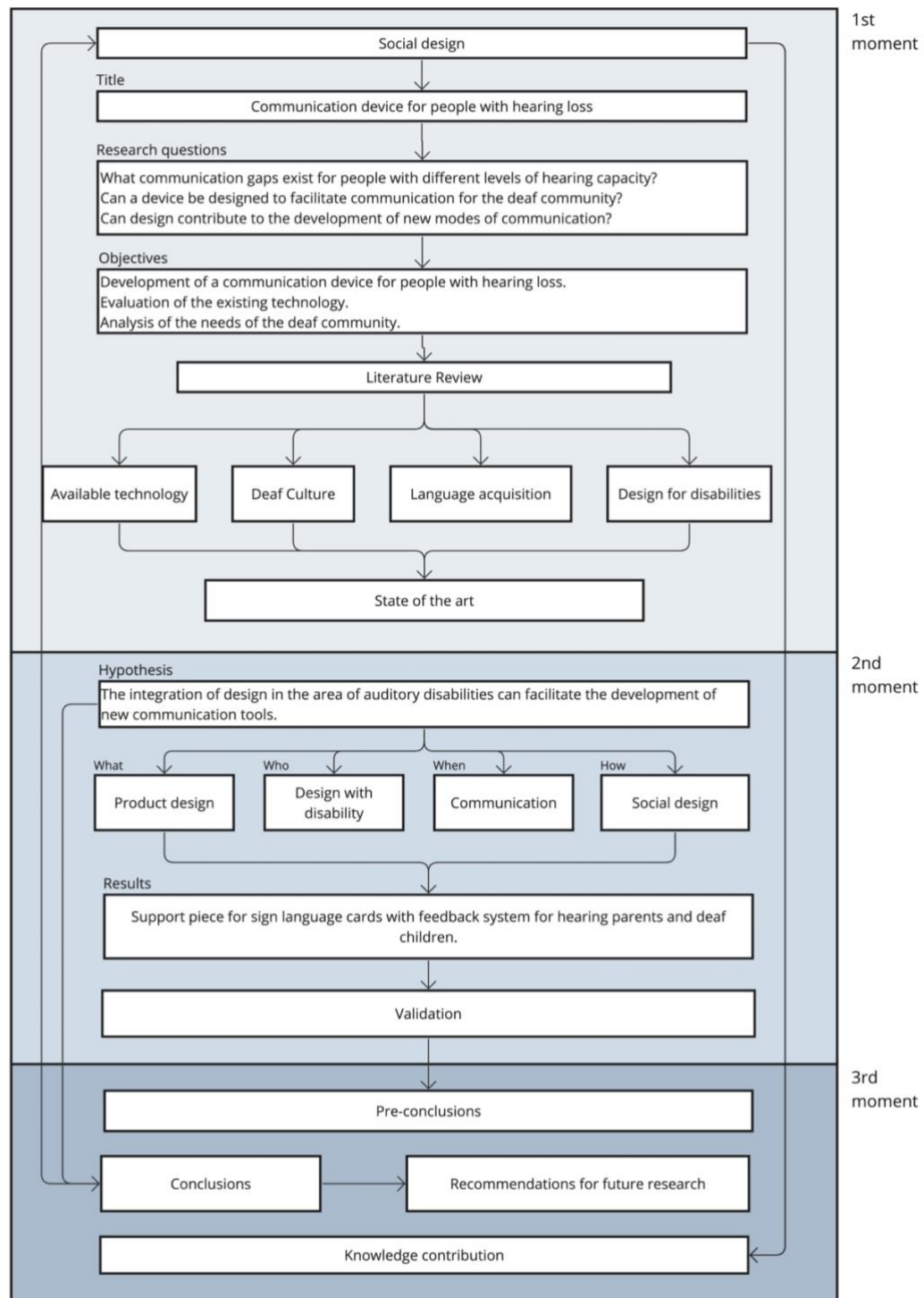


Figure 1. Research design

As the research narrowed its scope, the problem that was chosen as the focus was the communication barriers between hearing parents and deaf children, since this affects the language, emotional, and cognitive development of the latter. With this in mind, the focus of the product became improving the accessibility of sign language to these parents so they can be less intimidated by the idea of learning this new language and learn of its benefits for their children. The result was a support piece with a feedback system to be used with a collection of cards that teach sign language in a simple manner with illustrations and descriptions of signs used in the family environment with the intent of inspiring parents to learn more about the language. The support piece is intended to make the cards more user-friendly and practical for the family environment and the feedback system allows the child to participate in the adult's learning process.

The secondary research is presented in the Research Framework to explore the existing materials and products about the deaf community and accessibility; and in the Theoretical Framework where insight is given into the theories that inform the execution of the project. The first primary research moment is in the Research and Problem definition which helps narrow the problem and move on to the Concept Development, where different solutions for the problem at hand are considered. In the Product Development phase the product is built and tested, to then be evaluated by the end users in the User Testing section, followed by the Finalization which includes the final iteration of the prototype. The Discussion provides reflection of the process and future recommendations.

1 - Research framework

The development of a device that aids the communication of people with hearing limitations requires research into the deaf and hard of hearing populations using literature that explores their experiences of language acquisition, their needs and preoccupations in navigating the deaf and hearing world, their existing adaptations to it and how they see themselves. Since this project does not intend to interfere with the physical body it does not require a medical approach, but instead it requires a focus on interactions, communication, and the relationship between Deaf people and the hearing accessible world. Concepts of universal design and designing for disabilities will be explored to understand how the design profession works with this community.

1.1 Definition of hearing loss

According to the Department for Noncommunicable Diseases (2020) of the World Health Organization, hearing loss is ‘when a person is unable to hear as well as someone with normal hearing’, which can range from mild to profound. The word ‘deaf’ applies to people with severe or profound loss of hearing affecting both ears, while people with less severe hearing loss are described as hard of hearing. It is estimated that there are 460 million people in the world living with hearing loss that can cause difficulties in communication affecting education and work opportunities, as well as social ostracization. In Portugal, the number is around 120 000 people, with about 30 000 of these being native Portuguese sign language speakers (Federação Portuguesa das Associações de Surdos, 2021).

1.2 Deaf culture

When referring to the Deaf community, the word ‘culture’ is often brought up. Pereira (2011) defines culture as a human complex made up of behaviour patterns defined by the perception that the group has of itself and their future perspectives. Because of the language and the relationships that unite the members of the community, being deaf can be said to produce a culture.

A culture tends to evolve in a specific space and context, and for the deaf community those are educational institutions, associations, and family. Educational institutions have played a crucial role in the standardization of sign language when bringing together people from diverse backgrounds who had distinct dialects and signed languages of their own (*homesign*). This

phenomenon is the main contributor for the development of a culture that continues outside of the institution and is referred to as the 'deaf world'. Because the signed language is the main unifier, the community can include people who are hearing and hard of hearing (HOH). It is advised that 'the Deaf community should not be viewed as a disability group with a medical problem, but rather as a distinct cultural and linguistic minority group' (Singleton & Tittle, 2000). However, anthropologists suggest that defining deafness as a culture discounts the diversity between deaf people – different regions and groups have different approaches to deafness and the use of sign languages and gestures - and puts the difference from hearing people at the centre of their identity (Friedner & Kusters, 2020).

The family environment is an important definer of the type of experience the child will have with language since it differs if the dynamic is between deaf parents and hearing children, hearing parents and deaf children (90% to 95% of the Deaf community) or deaf parents and deaf children (5% to 10% of the Deaf community). Singleton & Tittle (2000) acknowledge that interactions between people who are deaf and those who are hearing involve a cultural exchange due to the complexity of each experience.

Children of deaf adults (CODAs) experience life as a bilingual if they are provided with a balanced access to signed language and spoken language. But this family structure comes with risks that need to be intentionally managed by the parents (Singleton & Tittle, 2000):

- The parents can over rely on the children to serve as interpreters.
- The communication between parents and children can be asymmetrical and restricted.
- There can be difficulty accessing information regarding the child's education.
- Certain parenting skills can be hard to implement.
- Other family members can usurp parental authority.
- Professionals bypass the Deaf parents and deal directly with the child or other family members.
- CODAs report feelings of isolation and the need to protect their parents, as well as continuing to provide assistance and advocate for them in adulthood.

These risks can be mitigated with communication and the establishment of boundaries, as well as the parents' awareness that the child has access to a different culture (hearing culture) and that it is to their benefit to connect to that culture as well, which can be done through media and relationships. CODAs, on their end, tend to develop adaptiveness, resourcefulness, and curiosity. It is recommended taking 'full advantage of new technology that can facilitate interactions with the hearing world to reduce the reliance upon the hearing child' (Singleton & Tittle, 2000).

In Curtin et al. (2021) assessment of the behaviour of hearing parents of deaf and hard of hearing children aged 0-3 years, highlight that despite the use of hearing aids and cochlear implants deaf children continue to show delays in 'receptive and expressive language skills', which studies have determined to be predicted by the ability of the parents to effectively communicate with their deaf child. Hearing parents communication with deaf children is reported to be more directive, which leads to more interruptions to the child's attention, and the language is stimulated through requests rather than conversations, which comes with less two-way interactions and less feedback on the child's communicative attempts. Hearing parents need to adapt their communication skills by: 'wait for or gain the child's attention; maintain a shared, mutual focus with their child; follow their child's lead; provide contingent and attuned responses to the child's interests and needs; and use multi-modal methods to interpret, enrich and expand their child's communicative attempts'. The improvement of these parent child interactions can be done through family-centred interventions, but their success depends on 'acceptance of the child's deafness, parental self-efficacy, and the amount of support a family receives'.

It is however important to acknowledge the incapability of understanding the Deaf culture from the outside looking in, due to its complexity. All we can do is listen/read to what the community has to say and hope to empathize as a hearing person.

1.3 Language acquisition

One of the first points Pereira (2011) makes is that language is not exclusively oral and signed language is structured enough to allow for the building of cognitive structures. Singleton & Tittle (2000) take this further by explaining the different ways language acquisition happens for people in the community, depending on whether the individuals have hearing or non-hearing parents and whether they were born deaf or not.

The acquisition of the signed language by deaf children has five stages that parallel phonetic language development (Pratas et al., 2022):

- the pre-linguistic stage happens in the first year and involves babbling, simple gestures like point and reaching the arms, and the child is capable of syllabic sequences.
- The stage of a gesture (12 months – 2 years) includes grammatical elements and gestures with meaning.
- The first combinations stage has the combination of two or more gestures in a specific order, with the sentence structure of subject-verb, verb-object or, later, subject-object-verb.
- The stage of multiple combinations (2 – 3 years) happens with the increase of the gesturing and comprehension of vocabulary.
- The stage of the use of references (5 – 6 years) is when the child is capable of describing simple and complex facts, past and present, with correct use of pronouns, syntactic function and global morphological agreement.

Deaf children who are born to hearing parents can have limitations to their signing proficiency due to delayed acquisition of the language (Singleton & Tittle, 2000). Because the Deaf child doesn't have access to their family's native language, they should be provided with an accessible native language, in this case the signed language of their country; this will allow a gradual learning of their second language, their family's language, with a focus on the importance of reading and writing that can start as soon as the child is 2 years old. This approach is referred to as a bilingual and bicultural education and is currently recognized as the best to provide students with the same level of education and social integration as their hearing peers (Freire, 2013). However, individuals who grow up in this circumstance describe struggling with speech, reading and writing (Singleton & Tittle, 2000).

The only native speakers of sign language are the Deaf children born to Deaf parents. They show better acquisition of their country's spoken language in speech production, speechreading, reading and writing abilities (Singleton & Tittle, 2000).

For the hearing children of deaf adults signed language acquisition happens as naturally and conventionally as it does with spoken language, therefore they are considered bilingual. However, this will be disturbed if the child does not have consistent access to the hearing world and if the

deaf parents choose not to sign with their hearing children, using instead unclear speech with an ‘ungrammatical form’ or are not proficient in sign language themselves (Singleton & Tittle, 2000).

Of the three groups, deaf children of hearing parents are the ones most in need of intervention to limit the impacts of delayed speech acquisition by providing exposure to an accessible native language.

1.4 Benchmarking of assistive technology

People with hearing limitations have several technologies at their disposal to bridge the communication gaps. The National Institute on Deafness and Other Communication Disorders (NIDCD, 2019) puts these assistive devices in three categories: assistive listening devices (ALDs); augmentative and alternative communication (AAC) devices; and alerting devices.

Assistive listening devices (ALDs) amplify the sounds where there is a lot of background noise and can be used with a hearing aid or a cochlear implant if these contain a telecoil. The type of device used depends on whether it is used in a large space – hearing loop systems, frequency modulated (FM) systems, infrared systems - or for personal purposes – personal amplifiers. All but the last of these devices are limited to one source of sound but can connect to multiple receivers and can suffer interferences from other signals.

Augmentative and alternative communication (AAC) devices include anything that helps people with communication disorders to express themselves by translating text, speech, symbols, and sign language between hearing and deaf/hard of hearing people. These include picture boards, touch screens with pictures or symbols, keyboards, text display, spelling and word prediction software, and speech-generating devices.

Alerting devices connect to a variety of household devices to let the user know something is happening in a way they can notice by using louder sounds, lights or vibrations. They work with doorbells, telephones, alarms and include special clocks, wake-up alarm systems and baby monitoring systems.

Sign language translators are not mentioned in the NIDCD article, but they would fall under the AAC category. There are companies offering devices that claim to achieve this like BrightSign and SignAll, as well as projects developing devices with the same objective.

BrightSign (fig. 2) is a glove and wristband that pairs with a smartphone app and allows the user to record gestures that are converted to speech, as well as converting speech to text and translating between different languages. The glove is calibrated to the individual's movement and the sound input and output happens through the phone. It includes a version for children that works with a wristband with a screen and audio output (Knowles, 2018). The fact that it does not have a pre-installed gesture library allows for more flexibility and personalization for the end user even though it increases the start-up effort. A barrier of this product is the price which is over 2000€, as well as the fact that it focuses on hand movements even though sign language involves facial expressions and body movements in general. However, one review (Francis, 2021) expresses positive expectations of the product.



Figure 2. BrightSign glove and application (Limited, n.d.)

SignAll is a company that offers a sign language translation workstation called SignAll Chat (fig. 3) that includes a computer, cameras, a glove, and lights that capture body movements, hand shapes and facial expressions. Working with what they claim is the largest database of American Sign Language (ASL) vocabulary in the world, it produces a translation through text in a chat interface. This system is more restricted since it is exclusive to ASL and it is not portable, so it seems more suited to specific spaces like schools or public areas instead of being for personal use, but it does address the full body language requirements of sign language interpretation. The company also offer a product called SignAll SDK which claims to provide fingerspelling recognition for applications for improved accessibility. However, I could not understand the situations for which this would be necessary since the website didn't provide examples and I could not find reviews online (SignAll, n.d.).



Figure 3. SignAll workstation (Prairie View A&M University, 2020)

While looking for reviews on the two previous devices, there was an article by Michael Erard (2017) that collects the opinions of the Deaf community, including sign-language linguists, about sign-language gloves that have been developed since the 1980s. The main complaints point to the dismissal of the whole-body work that goes into sign communication, the focus on changing the way Deaf people communicate to accommodate the hearing world, the issues of cultural appropriation since the people making these technologies are outside of Deaf culture, the discouragement of hearing people from making an effort to bridge the communication gap with

Deaf people, and the unawareness of the complexities of sign languages and the cultural sensitivities attached to them. These gloves are often developed by engineers who have a method of approaching the problem that's more mathematical than human centred, ignoring politics, social context and 'power implications.' The article mentions calls for cultural awareness in the choice of words (like using the word 'conversion' instead of 'translation') and the impact of the technology (Lipomi, 2017), the inclusion of Deaf users in the projects and the encouragement of hearing people to use sign language in a multimodal and multilingual way. The technologies that are mentioned to be of interest to Deaf people include 'more thorough, higher-quality captioning', 'better interpreting services' and, on a more ambitious perspective, 'glasses that would auto-caption everything that hearing people say'.

Outside of physical devices, assistive technology can be found in mobile applications. Smartphones include accessibility options like connecting with certain hearing aids and headphones/hearing buds to perceive conversations more clearly; mono audio for people with hearing loss in one ear; real time text during calls (RTT) and teletypewriter (TTY) configurations; light and vibration alerts; instant transcription of live conversations; subtitles and instant captions. If some of these functions are missing, they can be supplemented with applications like AVA (fig. 4) for instant transcription of conversations; RogerVoice (fig. 5), which transcribes conversations, synthesizes voice, and has video interpreter assistance; Sound Amplifier for amplified and clearer environmental sound; applications to connect with emergency services, which are region dependent; Subtitle Viewer which synchronizes with the television and movies at the cinema to show live subtitles (Gervais, 2023).



Figure 4. Ava application (Ava, n.d.).

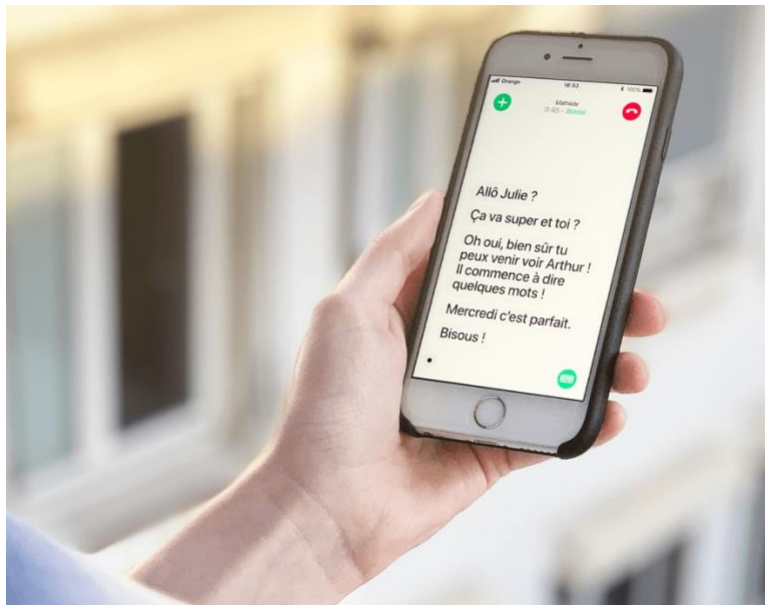


Figure 5. Rogervoice (Rogervoice, n.d.).

The former examples show how the smartphone can make the world more inclusive, but it can also take away from experiences, for example if a person needs to look at their phone to watch a movie, they are missing out on a lot of what makes the cinematic experience. Maybe it would be better if subtitles were put in every movie regardless of language and location, bringing it back to one of the criticisms made in the Erard (2017) article about forcing deaf people to accommodate to the hearing world more than the opposite. It can also be pointed out that the proliferation of smartwatches also increases the possibilities of these applications and configurations, like the light and vibration alerts which, without them, still require the person to always have the phone on them or near them.

These days most people have technology that, as convenient as it may seem, also requires maintenance and sometimes an ecosystem of other products and infrastructures for support. When dealing with a product for communication, we also must think of portability. Deaf people, just like anyone else, want to simplify their lives, and finding a balance between the cost and benefit of adopting a new technology into one's life requires empathy to be part of the product development process.

1.5 Design for disabilities

‘Design for Care’ by Peter Jones (2013) challenges the design profession to learn from empathy in its support of the caring professions in healthcare. The words used to refer to the human subjects are important in the empathy we assign the task, and the author makes the distinction between the frames of user (of a product), patient (client of an institution) and consumer (recipients of services) and sees them as passive and objectified representations. This project is not looking to create a medical product, so the word ‘patient’ doesn’t apply, and the word ‘consumer’ won’t be relevant since this will focus on the human centred research phase. The designations of ‘Deaf person’, ‘person who is hard of hearing’, ‘person with hearing loss’ and ‘user’ will be preferred in this project, because it focuses on this specific public and it is done from a product design perspective.

Jones (2013) defines the values and ideals of the caring design ethic as ‘empathic care, doing no harm, health for the whole person, and helping people live sustainable lives.’ Innovation requires adaptation that people might find intimidating or laborious to engage with, so the design process needs to factor ‘technical and usability concerns’ to increase the potential adoption and acceptance.

The included reference to the four domains defined by Garry VanPatter’s and Elizabeth Pastor’s – first, traditional design (D1.0); second, product/service design (D2.0); third, organizational transformation design (D3.0); fourth, social transformation design (D4.0) –, which represent ‘an evolution of design practice, research, and education to develop new knowledge bases necessary for increasing complexity’, bring us back to the question of whether it should be the Deaf community who makes the effort to adapt more to the hearing world or if the latter should do more to include said community (Jones, 2013). Being that the majority of the population are hearing, this would require a process at the D3.0 or D4.0 level due to the increased scope and complexity of having a bigger population and interfering with a more set status-quo.

In ‘After Universal Design’ Elizabeth Guffey (2023) makes the case for reconceiving ‘disability through design’ by ‘rethinking what is considered normal and clearing space for fuller insight into fundamental human needs.’ The concept of Universal Design tends to focus on the needs of wheelchair users and the author applies the post-Universal Design practice to the extension of the definition of disability that has occurred in the past decades. Disability design accompanies the design theory shift towards ‘equitable approaches, participatory methods’, and reconceptualization of the designer as a facilitator for others by focusing on ‘designing with disabilities’ rather than

‘for disabilities’. These ideas support the needs expressed by the Deaf community regarding sign-language gloves of wanting to be included in the design process.

Chapter 1 summary

This chapter introduces the complexities of the deaf community as a group of people with different abilities who interact with each other in different ways. In it, deaf children of hearing parents are the ones most at need of early intervention for a healthy development of language. Even though the community has access to different assistive resources, there are concerns about being left out of the design process of products made for them and having to make most of the effort to compensate for the communication gap, reminding us to use the empathetic (Jones, 2013) and collaborative (Guffey, 2023) approaches that extend Universal design and offer a better probability of solving the problem at hand.

2 - Theoretical Framework

The research project will be informed by theories of four concepts: product design, design for disability, communication, and social design. The different theories were chosen to inform the macro perspective of designing for the public, the micro perspective of designing for disability and for a community that the researcher is not a part of and, how to best assess and respond to their needs and concerns.

2.1 Product design

The project starts with the definition of the product design process (Bürdek, 2015): 1, Research and problem definition; 2, Concept development and evaluation; 3, Product development; 4, User testing; 5, Finalization. This process is to be informed by Human Centred Design, which puts people first, looks to find the root of the problem, sees everything as a system and, opts for small and simple interventions (Interaction Design Foundation, 2021). Because this project is focused on a niche population, the user centred design philosophy applies since it ‘integrates research throughout the creative process, providing valuable insight into the needs, behaviours, and expectations of the target audience’ (O’Grady & O’Grady, 2017). This will be done by searching for feedback from the target population throughout the process.

2.2 Design with disability

When designing with disability, the first approach is to engage with the principles of Universal Design (CEUD, n.d.): Principle 1: Equitable Use; Principle 2: Flexibility in Use; Principle 3: Simple and Intuitive Use; Principle 4: Perceptible Information; Principle 5: Tolerance for Error; Principle 6: Low Physical Effort; Principle 7: Size and Space for Approach and Use. These principles can be used when evaluating the accessibility of a physical product and can inform the parameters of evaluation with the goal of making it accessible to the greatest number of people.

Just like it was mentioned in the literature review, the book *After Universal Design: The Disability Revolution* (2023) by Elizabeth Guffey offers an extended view of Universal Design by pointing out its limits and suggesting new approaches. The book shares three propositions for designing with disability:

- Agency, by empowering individuals to participate in the design, build and sharing of their own solutions with repair, adaptation, a do-it-yourself approach, and aesthetic customization to reduce shame and stigma. On the side of designers this can be encouraged with a focus on user-initiated disability design, and engaging users as ‘active producers and innovators’.
- Equity, which recognizes the different needs of individuals and required solutions to mitigate design discrimination, and that universality cannot be achieved. To work towards it, opportunities for flexibility, adaptability and innovation should be found in the moments of tension between access needs. It’s also relevant to remember the intersectional nature of disability which can coexist with marginalized race, socio-economic circumstances and other disabilities and identities.
- Speculation, an exercise that moves us beyond problem solving into question-instigation to give voice and authority to the marginalized and highlight the intersectionality of disability. It can also prevent the access loop, where ‘meeting one group’s needs might create barriers for others’. Speculative design (critical design or interrogative design) can be applied to the notions of personhood, independence, autonomy, body mind functions, materials, and practices to make accessibility a ‘creative engagement between body, community, and world’.

The advice made by Guffey (2023) will be used as guidelines to interpret the research results in the concept development and evaluation moments in an attempt to interpret the feedback and research from the perspectives of Agency, Equity and Speculation, and reach a solution that is according to the needs of the Deaf community.

2.3 Communication

In product design, the relationship that is built between the artifact and the user is one that needs careful consideration and, in this project, it requires a focus on the communication aspect of it since the goal is to improve the interactions between hearing people and Deaf people.

Every product concept must concern itself with the user experience, a term which the Nielsen Norman Group (2001) defines as ‘all aspects of the end-user's interaction with the company, its services, and its products’ and requires meeting ‘the exact needs of the user’ and ‘simplicity and

elegance that produce products that are a joy to own [and] to use'. From this concept, the group distinguishes the concept of 'usability' which refers to 'methods for improving ease-of-use during the design process', like learnability, efficiency, memorability, error occurrence, and satisfaction.

The product-user relationship also requires the application of Interaction Design (Siang, 2023), which looks to 'create products that enable the user to achieve their objective(s) in the best way possible'. It is built on five dimensions: words, visual representations, physical objects or space, time, and behaviour.

Because the project works with the Deaf community and their communication needs, the definition and application of semiotics – the study of signs and sign using behaviour (The Editors of Encyclopaedia Britannica, 2023) - should be explored in its application to linguistics. The philosopher Charles Sanders Peirce defined sign as 'something which stands to somebody for something' (Peirce, 1955) and separates it into three parts: the sign (or representamen) as the signifier, like a written word or gesture; the object which is whatever is signified, the subject matter of the sign, like the object which the written word or gesture is referring to; and an interpretant, which is the 'understanding that we have of the sign/object relation', for example the specific language and culture the word or gesture is attached to. The interpretants can be divided into three, each defining a way 'in which we grasp the way a sign stands for an object': the Immediate Interpretant consists in the 'quality of the impression that a sign is fit to produce', in language that would be a recognition of the structure of the language, like grammar, syntax and conventional rules; the Dynamic Interpretant is 'whatever interpretation any mind actually makes of a sign', meaning the first interpretation we have of the sign/object relationship; the final interpretant it's a conditional truth, the understanding of the object after inquiry (Atkin, 2023).

When we focus on linguistic semiotics, we are brought to semantics, 'the philosophical and scientific study of meaning in natural and artificial languages' (The Editors of Encyclopaedia Britannica, 2023b). When dealing with the communication between the deaf and the hearing, the signifiers that can be used – text and sign language – can be analysed to achieve the goal of the research. Sign language is not a direct translation of the spoken and written language of the community it exists in, representing concepts instead of specific words, but it has all the properties of it.

In the case of the Portuguese sign language is made up of five parameters: the shape of the hand, movement, non-manual expression, location, and orientation. The sentences are structured as subject-object-verb or object-subject-verb, and the type (declarative, interrogative and exclamative) is identified with facial expressions or body movements (Pinto, 2017).

These concepts inform the requirements for effective communication with deaf people that the final product should respond to, from the accessibility to the attention to detail in the interpretation of sign language. Factors like the age of the users and the context for which the product will be made will require more research, once determined.

2.4 Social design

Social design is the use of design to understand social problems and support positive social change by creating ‘opportunities that shift relationships between people and people, and people and institutions’, according to the Centre for Social Design (MICA, n.d.). It follows the principles of emphasizing people over projects, humility over hubris, process over product, questions over answers, practice over theory, impact over intent. Designing for social development and innovation is a discussion which intends to counteract the mainstream elitism of the design profession, with different authors analysing the causes and possible solutions since the 1970s. With Victor Papanek’s *Design for the Real World: Human Ecology and Social Change* (1972), the responsibilities of the designer for the impact of their products in the social and environmental spheres is defended and argues that ‘designing for the minority’, meaning the marginalized, is actually designing for the majority, since all together they add up to a large group of people. Papanek suggests solving problems with an ethnographic approach by learning from the local know-how. In a more macroeconomic perspective, Gui Bonsiepe (Penin, 2021) focuses on the economic relationship between countries and how to use design to balance it so the periphery gains autonomy through the development of local industry. This solution involves government intervention for systemic changes in economic and social development to reduce global inequities.

The term ‘social issues’ stands for a broad category of situations each with their own specificities, but the approach to them can be informed by critical theory. Critical theory is based on the ideal that scientific knowledge must be pursued to understand and help overcome oppressive social structures (Britannica, 2023b). It is a basis for theories like critical pedagogy and intersectionality. The first theory claims that humans become dehumanized by oppression, and education can be

complicit in this dynamic when it's done in a passive manner, without an exchange of ideas between student and educator. The solution focuses on dialogue, which allows the individual to experience the world more completely (Freire, 1974), an idea that refers back to the literature review where the importance of giving children the linguistic tools to express themselves from an early age, whether in spoken language or sign language, is a crucial part of their cognitive development. Intersectionality considers the different social and political identities of the individual in the analysis of the systems of power that affect their life (Crenshaw et al., 1995), reminding us of the other identities that the Deaf community can be part of, like race, gender and class, which differentiate the experiences within it and require critical analysis towards an equitable and holistic approach to any problem they may face.

Parallel to these concepts, we can find inclusive design, which the Inclusive Design Research Centre describes as 'design that considers the full range of human diversity with respect to ability, language, culture, gender, age and other forms of human difference' and as working within three dimensions: recognizing diversity and uniqueness, using inclusive processes and tools, and looking to have a broader beneficial impact.

All these concepts demand that the primary research be done with the goal of finding the pain points in the experience of deafness with a focus on social development, inclusion, and intersectionality. The research will help decide if the intervention of the product will be on the deaf community or the hearing community since both are part of the overall effort to reduce any inequities in communication.

2.5 Methodology

The methodology of the project follows the research process for product design (Bürdek, 2015) mentioned in the beginning of the chapter, with more focus on the research, development and evaluation phases.

2.6 Research background

This project was initiated in the Product Design curricular unit of the Masters in Product and Space Design at IADE – Universidade Europeia. We were given a place and a user to create a product for - in this case a playground and disabled people - using the iterative product design process and

a user centred design approach. Because there are so many disabilities, the narrowing down of a specific need to approach was difficult, but ultimately the need for communication was chosen because the playground is a place of socialization. On the advice of the professor and to speed up the process, it was decided that the project would be focused on deaf and hard of hearing people. Once this was decided the focus became how to improve the communication of hearing and deaf people and the interactions between children and adults with different hearing abilities.

From the contents of Research Framework and the Theoretical Framework we can take three main conclusions: that deaf children of hearing adults present the most urgent need for intervention; although there are many technological solutions for deaf people to better interact with the hearing world, there is a case to be made for the disproportionate effort that this group has to make for the world to be more accessible (Erard, 2017); sign language it's a region specific form of communication, with the same properties as spoken and written communication (Pinto, 2017), and can be seen as an extension of these rather than a special ability. This project hopes to find a solution that addresses the reality of deaf-hearing communication from a perspective that involves these elements and creates a valid alternative to reducing the interaction gap between the two groups.

2.7 Research approach

The research problem asks how design methodology can be used to create a product that improves the communication between deaf people and hearing people. For the secondary data, the Research Framework provides with information about the Deaf community and the linguistics of sign language. The primary data will gather opinions and information about communication from deaf people and specialists that work with that community, resulting in qualitative and quantitative descriptive data collected through online questionnaires and interviews. The development and evaluation phases will involve the target users in the collection of data. These methods were chosen because they help integrate the product design methodology with the different design and critical theories mentioned in this chapter through a holistic understanding of the user experience centred on their point of view, particularly the identification of a need of the deaf community and the evaluation of the product.

Chapter 2 Summary

The chapter introduces the theories that inform the research. The product design methodology is to be applied with a consciousness of human centred and user centred design. Universal design will involve a ‘design with disability’ approach with the use of the agency, equity and speculation propositions. The communication aspect will involve user experience, usability, interaction design, semiotics, and semantics. Making a product for social change requires an exploration of social design that focuses on the marginalized, economic inequalities, critical theory and inclusive design.

The research background focused on communication needs in the playground and brought the research to the needs of deaf children of hearing adults, the balancing of the effort made to better the communication between hearing and deaf people, and the perception of sign language as an equal form of communication to speaking and writing. The research problem looks to use the design methodology to better the communication between deaf and hearing people. The approach will involve primary data from questionnaires and interviews, the secondary data gathered in this chapter and the literature review, all to inform the iterative design process.

3 – Research and problem definition

3.1 Defining the problem.

One of the objectives of the research is to identify the needs of the deaf community, so the first step was to do primary research by building a questionnaire informed by the research in the literature review and theoretical framework (deductive approach) but with some open-ended questions (inductive approach) that will allow the participants to offer new insights that haven't been addressed. The answers consist of qualitative, descriptive data. The aim of the questionnaires was to understand the opinions of different participants in the deaf community about communication involving deaf people.

Three questionnaires were made (see Appendix A) – one for specialists, one for Deaf people and another for other people who are part of the Deaf community (like family and friends). In all of them the questions were made to identify the difficulties of different age groups, different common situations, and the preferences in assistive technology from varied perspectives. This was done while keeping the questionnaire short as to make it easier to finish.

The questionnaires were sent to specialists who work with the deaf community (sign language interpreters, speech therapists, teachers, health workers), associations, and social media groups for the deaf community (see Appendix A, table A4). Unfortunately, the response was underwhelming, but the 8 people who responded to the questionnaire still provided useful insights. An interview with a Portuguese sign language teacher was also done to provide more insight into the language.

The answers to open ended questions and the interview questions were analysed using thematic analysis, using themes that will help understand the Deaf community better, it's relationship with the hearing community and locate a problem for the product to address:

- Needs, for references regarding the needs of the general deaf community.
- Children, for references to the needs of deaf children.
- Young adults, for references to the needs of deaf young people.
- Adults, for references to the needs of deaf adults.
- Elderly, for references to the needs of deaf elderly people.
- Hearing people, for references to how they participate in the deaf community.

- Difficulties, for references to situations that deaf people struggle with.
- Assistive technology, for references to assistive technology.
- Assistive services, for references to assistive services.
- Methods of communication, for references to the ways deaf and hearing people communicate.

The graph in figure 6 shows how many participants mentioned each theme in the open-ended questions.

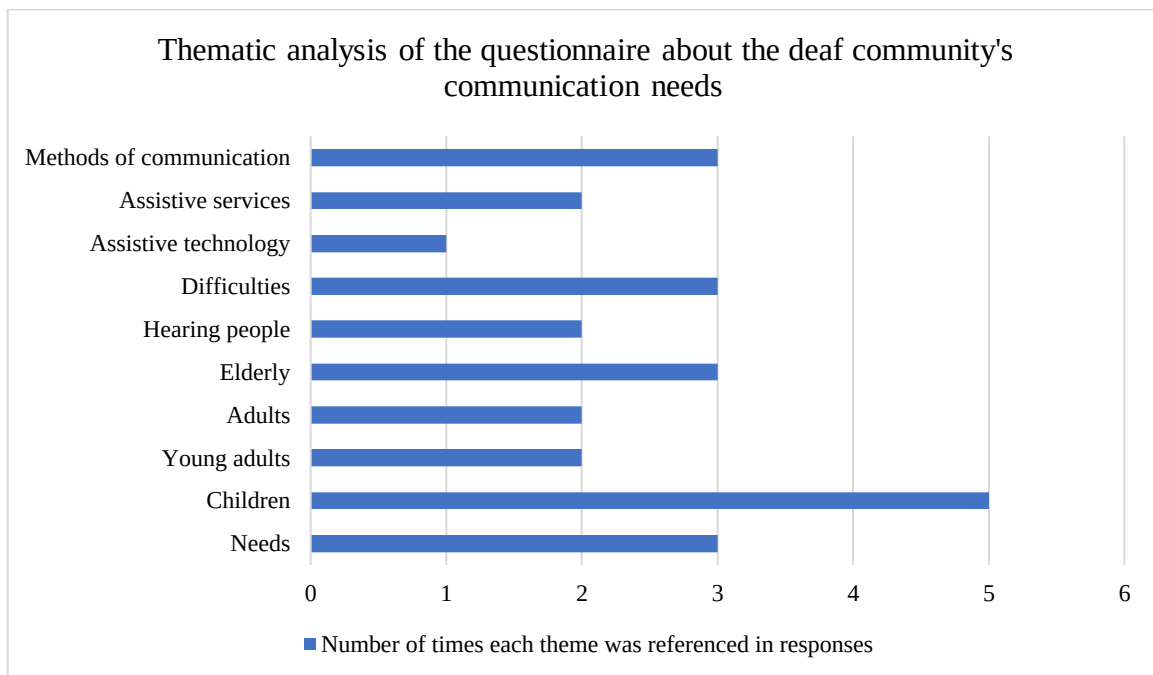


Figure 6. Graph of the thematic analysis

For the close ended questions, the average ranking of the questions was calculated by assigning a weight to each ranking and calculating the average. For example, for a question with 7 choices, the one that ranked first had a weight of seven, the second choice had a weight of 6, and so on to the last place with a weight of 1. Once all the answers were ranked, the average weight was calculated to reveal the answers with the highest ranking (see appendix A).

The results can be interpreted in three main categories: understanding the deaf community, understanding the deaf community's needs, and understanding the deaf community's problems, all listed in the table 6.

Table 1. Summary of results of the questionnaire about the deaf community's communication needs

Categories	Answers
Understanding the deaf community	Children have easier access to technology, support and learn to read lips. Adults are not interested in learning to speak, preferring the use of sign language. Younger people know the schools of reference and navigate the technology better, so they have an easier use of LGP and speech. The elderly are less isolated due to belonging to support groups and other types of community. The elderly are more likely to look for support with social services. Use of applications and online platforms for LGP interpretation. In some settings they need to speak through caregivers. Sign language interpretation, subtitles and audio transcription were the assistive preferred technologies.
Understanding the deaf community's needs	Access to their native language from a young age through a bilingual education. Innate communication needs to be stimulated. The hearing community needs to make more efforts to communicate with deaf people, particularly by having more knowledge of sign language. Easier access to LGP interpreters. Training for health professionals on how to communicate with deaf people.
Understanding the deaf community's problems	Doctors suggest cochlear implants and discourage learning sign language. Not having access to a natural language delays cognitive and emotional development. Older adults might have lost contact with LGP and have a dormant tongue, which causes isolation. The age group 36 – 65+ was ranked as having the biggest communication difficulties.

	Communicating with hearing people and accessing sound alarms were ranked as the biggest difficulties. The interactions that prove to be more difficult are in healthcare and educational settings, and with hearing children. In the day to day, they face challenges accessing information and entertainment.
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Because the experts pointed out that the hearing community needs to do more to be able to communicate with the deaf community and the literature review revealed the effects that the lack of access to a native language has on deaf children, it felt important to learn more about the characteristics of sign language and the people who learn it and use it. An interview was done with the Portuguese sign language teacher Cristiana Ferreira, contacted through an online teaching platform (superprof.pt), who made the following points regarding sign language:

- Sign language is not a substitute for oral language.
- Signs express meaning instead of words.
- A sign can express a sentence.
- In a signed conversation, people observe the face, while the hands are seen through peripheral vision.
- Grammatical information is transmitted by the face.
- Learning sign language is just like learning a spoken language, so the success comes down to practice and exposure.
- People with limited physical capabilities can still learn sign language, they just need to do things differently.

When it comes to the people who learn sign language, the teacher has had students of all age groups, hearing, deaf and hard of hearing. They seek lessons for self-development, because they became deaf or are becoming deaf, and because they have family members who are deaf. It was also revealed that parents, and extended family, of deaf children can be apprehensive when it comes to learning sign language, especially the ones whose children wear implants, even though these do not substitute the need for sign language because the sound they produce is not clear and people don't want to use them all the time.

Access to sign language interpreters and teachers is complicated by the fact that in Portugal there are few courses, and the classes are small but, at the same time, these professionals are not utilized as much as they should be by institutions, leading some to leave the profession. The teacher does believe that teaching all children sign language as part of basic education is viable.

When looking at the problems, the needs, the literature review and the interview with the sign language teacher, it was decided that there would be a focus on hearing people's learning of sign language. The product in development will be made with the goal of sensitizing the hearing community to sign language, with a particular focus on hearing parents of deaf children, because the latter's cognitive and emotional development is at stake when they do not have enough access to the language that is natural to them from early in their lives. The product can show their parents the benefits of sign language for their children's development and make for a more informal introduction that might lead them to take formal classes and learn alongside their children.

Chapter 3 summary

This chapter explains the research made to find a specific problem to address in the communication between deaf and hearing people. Questionnaires and an interview were done to collect primary data that supported the findings of the secondary research and that brought up any other relevant problems. From here, a better idea was built of the characteristics of sign language and the points of view of the deaf community. This led to the choice of hearing parents of deaf children as a target user, with the objective of helping them become accustomed to learning sign language so they can better communicate with their children and give them access to their native language, which will improve their language development..

4 - Concept development

The product is built to facilitate the communication between hearing and deaf people. This is can by promoting the learning and use of sign language in a way that is flexible through the physical ability to use the tools in different settings, with the domestic environment and school being the places where children obtain most of their development. Doing this in the family space, the main challenge will be to find a practical and engaging way to get hearing parents to use sign language with their deaf child and become more comfortable with it. In the school, learning materials could be created but they would be meaningless without support from the educational leadership of schools and/or the educational ministry. For these reasons and being that this project looks to create a physical product, the focus of this work will be in the communication between hearing parents and deaf children because a product can be more readily used in this context compared to the educational system, increasing the probability of positive results.

4.1 Benchmarking

The benchmarking process looks to identify options for the development of a product that is: interactive, by creating a method of allowing the child to express their understanding through an evaluation system that lets the adult be aware of their progress, providing a two-way interaction (Curtin et al., 2021); and promotes communication by giving parents tools that are adapted to their immediate needs in the family environment, particularly physical flexibility.

For the flexibility goal the focus was on support objects and attachments that could be used in different materials, forms and spaces and the different ways the cards could be held in it. Figures 7 and 8 exemplify the possibility of displaying the cards vertically from the bottom on a support resting in a horizontal surface, with the first also including storage for extra cards.

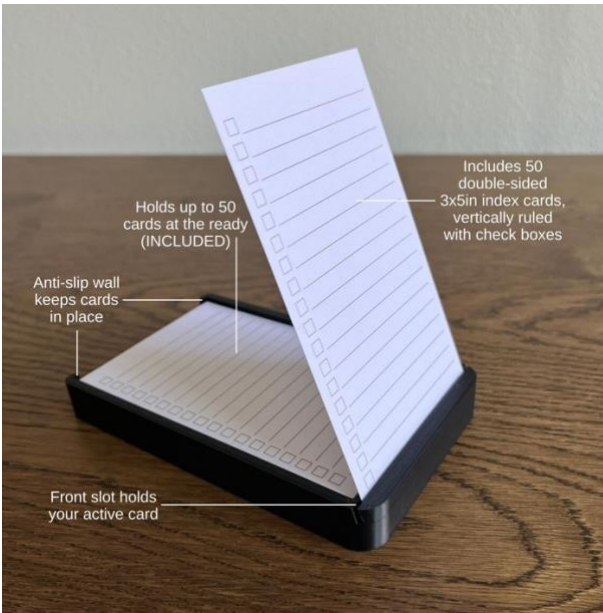


Figure 7. 3D Printed Analog Note Pad Index Cards and Pen Holder (InstaSurfaces, 2023)



Figure 8. Wood card holder (ASSR, 2021)

The product in figure 9 joins clips and magnets but it could only be utilized in a vertical metal surface. Figure 10 displays the product in a similar way, but the cards would have to include a hanging element like a hole, hook or strap, and the suction cups can be used in more than one nonporous material, like glass, tile and metal.



Figure 9. KUNGSFORS magnetic clip, stainless steel (IKEA, n.d.-b).



Figure 10. HULTARP suction cup hangers (IKEA, n.d.-a);

Figures 11 and 12 show the possibility of creating a support element where the cards could be simply placed as needed. Figure 13 works in a similar way but it's a fixed option.



Figure 11. TISKEN hooked supports (IKEA, n.d.-c)



Figure 12. Over-the-Door rack (Yamazaki Home Europe, n.d.);



Figure 13. Waterproof phone case with two-piece Wall support with sticker (Kikkerland B.V, n.d.).

With the goal of guaranteeing that the support object can be used as flexibly as possible, hands-free and in different rooms of the house, the prototype will attempt to join multiple methods of attachment. Table 2 shows a comparison of the different options considered. The prototyping process will explore how many options can be put in the object and will inform the choice of materials based on the shape and construction of the piece.

Table 2. Comparison of different support options

Support options	Positives	Negatives
Bottom opening	Can be used in furniture (doors, drawers, shelving systems)	Needs adjustment system to be stable
Suction cup	Can be used in non-porous materials (glass, metal, tile, painted furniture)	Bulky Doesn't work on painted walls.
Hook	Can be hung in edges.	Limited by the thickness
Strap	Can be used in doorknobs, protruding elements, and around racks if it opens.	Limited by size.
Sticker	Can be used is all surfaces. Fixed position.	Can't be moved.
Clip with magnet		Can only be attached to metal.

It could be argued that the cards themselves could have an attachment system integrated into them, like a strap or a hole to attach the hook. To guarantee the practicality and ease of use, the strap could offer that option without creating more moving parts for the user to keep track of and making the cards bulkier, while still providing the flexibility of using it in different places around the house like doorknobs and furniture. However, because one of the goals of the product is to provide interaction between users, we'll need a separate piece to support this function.

To promote interactivity and positive reinforcement of the learner, the hearing adult, different evaluation/feedback methods were searched. Examples of objects made for evaluation of comprehension by children could not be found but we can analyse different scales of evaluation like colour, numbers (fig. 14), or drawings of facial expressions (fig. 15). The size of the scale of these options leaves a lot of room for ambiguity, so it was reduced to three options. The traffic sign system – red, yellow, green - was chosen as a starting point because it's universally used in a variety of settings, so its comprehension should be intuitive for children. This will be tested in the user testing phase.

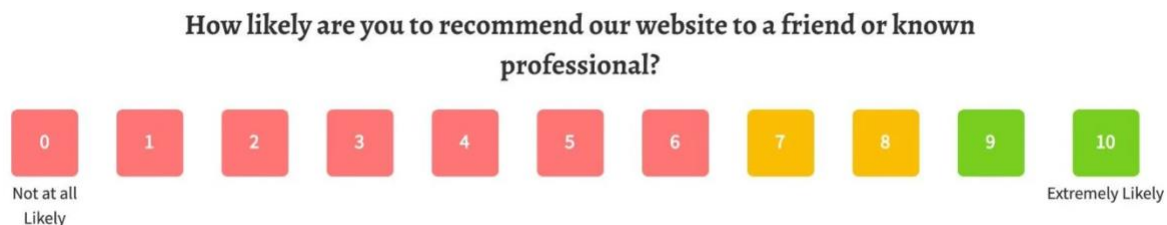


Figure 14. Net Promoter Score Question (Bhawika, 2023).

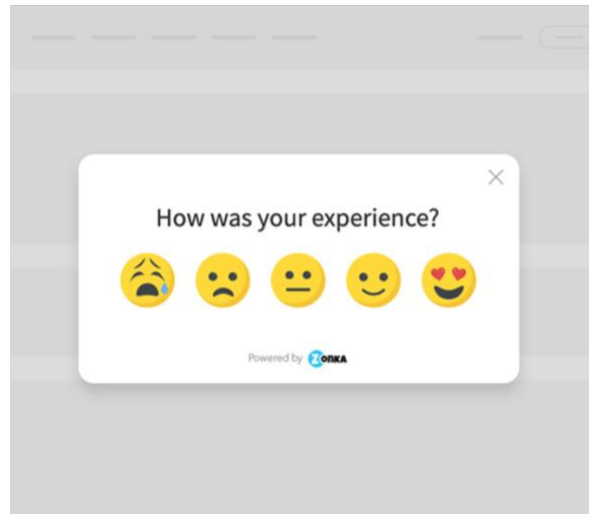


Figure 15. Emoji scale question (Bhawika, 2023).

The learner in this product is the hearing adult, so it felt important to explore educational products for adults. There are ASL cards (fig. 16) as well as language learning games (fig. 17). This product needs to be easy to use and to include in the family's daily routine, so it needs to take a more informative approach like the first example.

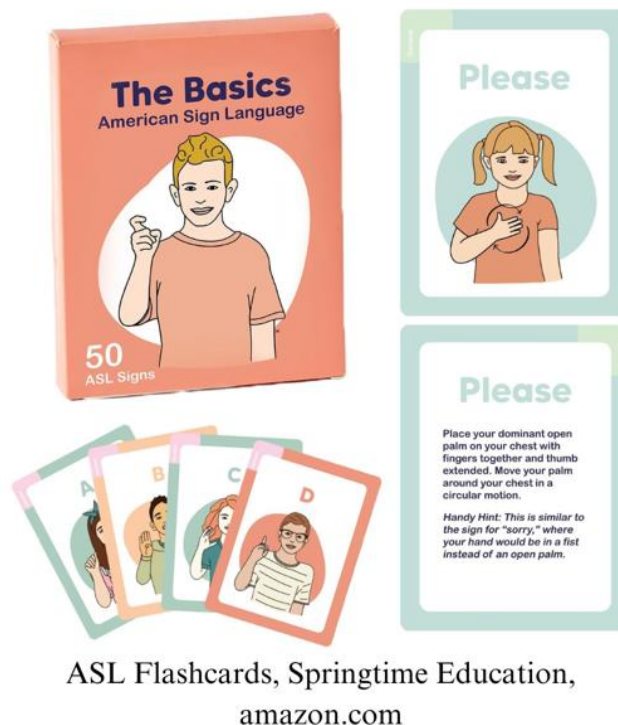


Figure 16. ASL Flash Cards - 50 American Sign Language Flash Cards for Beginners, Kids, Teens and Adults (Amazon.com, Inc., n.d.).



Figure 17. KLOO's Play & Speak English Bundle (KLOO Games, 2023)

The closest equivalent to sign language cards for the Portuguese language on the market are from EKUI (EKUI, n.d.-a), which makes a collection of cards with the alphabet letters and phonetic variations in writing, Braille, LGP, and phonetically. Their goal is to give children the ability to learn different methods of communication faster and more motivating using visual, auditive and synesthetic clues. It also requires training to be used. These cards don't satisfy the goal of this project of making sign language more accessible to parents of deaf children, so a sample of cards that achieve that goal will need to be developed for the Portuguese context.



Figure 18. EKUI alphabet cards (EKUI, n.d.-b).

The ASL examples (fig. 16) can inform the form and graphic language of the cards:

- Colour coding.
- Sans serif, monospaced typefaces.
- Language cards have drawings on one side and the writing on the other side.
- Simple graphics, mostly frames and colour blocking.

Because the card will need to withstand the rough play of children the choice of material was informed by the build of children's books. Paperboard with 350gsm to 400gsm is advised for this use. The edges should be rounded for safety and covering them with a gloss UV varnish will add protection and longevity (Callawind Publications, 2018).

Chapter 4 Summary

This chapter looks to explore the options for the concept of the product by benchmarking products that have characteristics that the product needs, particularly options for physical flexibility of use, evaluation and feedback systems and educational products for adults. For the first requirement, different support options were gathered and compared to be explored in the prototyping phase that

follows; the material options will be chosen after the prototyping to take into account the shape of the object. The evaluations and feedback systems were presented to be later tested with children to see which one is more suitable. The graphic language and materials of the cards was defined in this chapter.

5 - Product development

5.1 Product design development

Starting from sketches (fig. 19, 20) the shape of the object was made to be simple and allow the visualization of different methods of attachment. In CAD software, out of a block, an opening was made for the card to be presented; in front of it there is a space with green, yellow and red buttons for the child to press and express their understanding of the signing; in the back there is a suction cup and magnets that can pop out when needed (fig. 21).

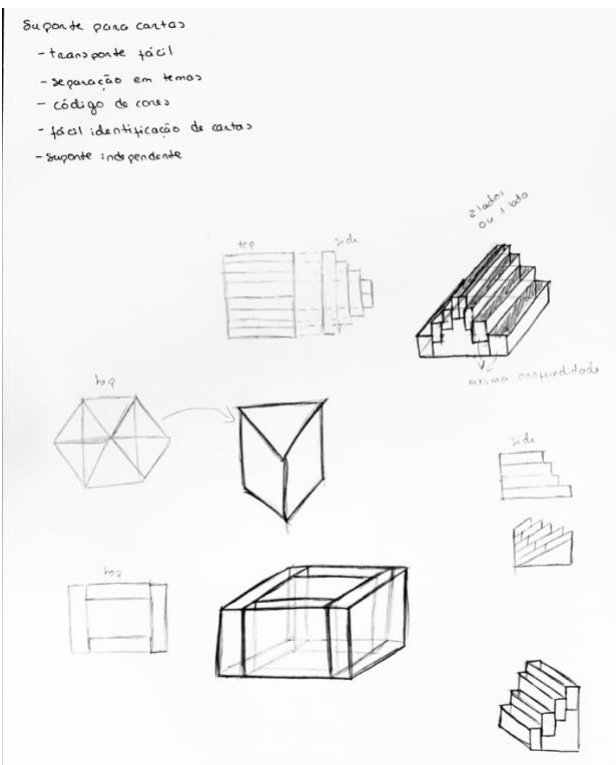


Figure 19. Support piece sketches.

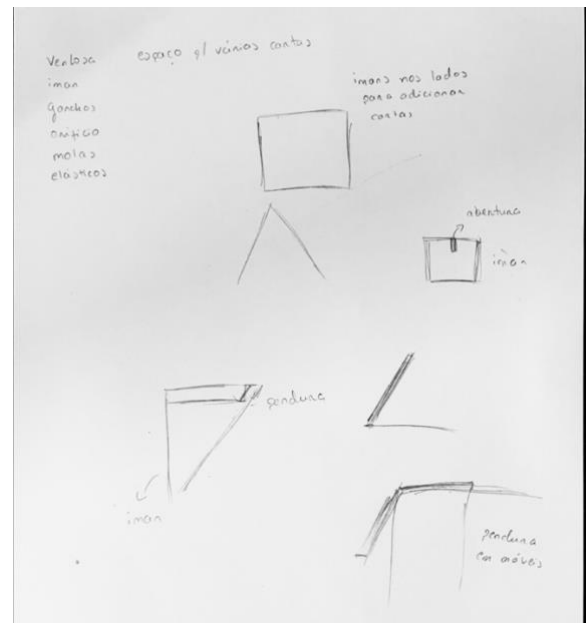


Figure 20. Support piece sketches.

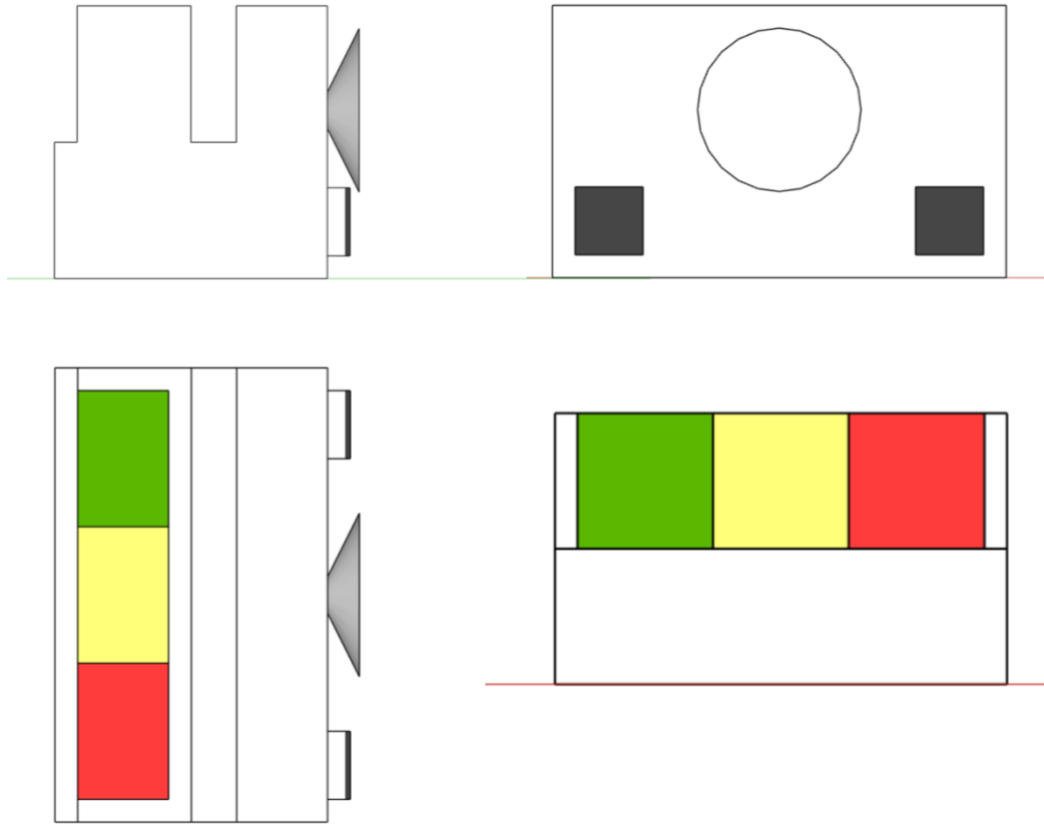


Figure 21. CAD model of the first iteration of the support object. Clockwise from the top left corner: side view; back view; front view; top view.

After this visualization, a first prototype was built out of glued PVC sheets for testing (fig. 22). The back wall in the button opening was lowered for the cards to be more visible and the testing revealed that the suction cup worked well but the position of the magnets made the support tilt forward. To allow for it to be placed on top of doors, the magnet supports had long edges at the ends that would stop them from coming out and would work as an adjustable clip, but this did not work because there was not enough pressure, and it was tilted (fig. 23).

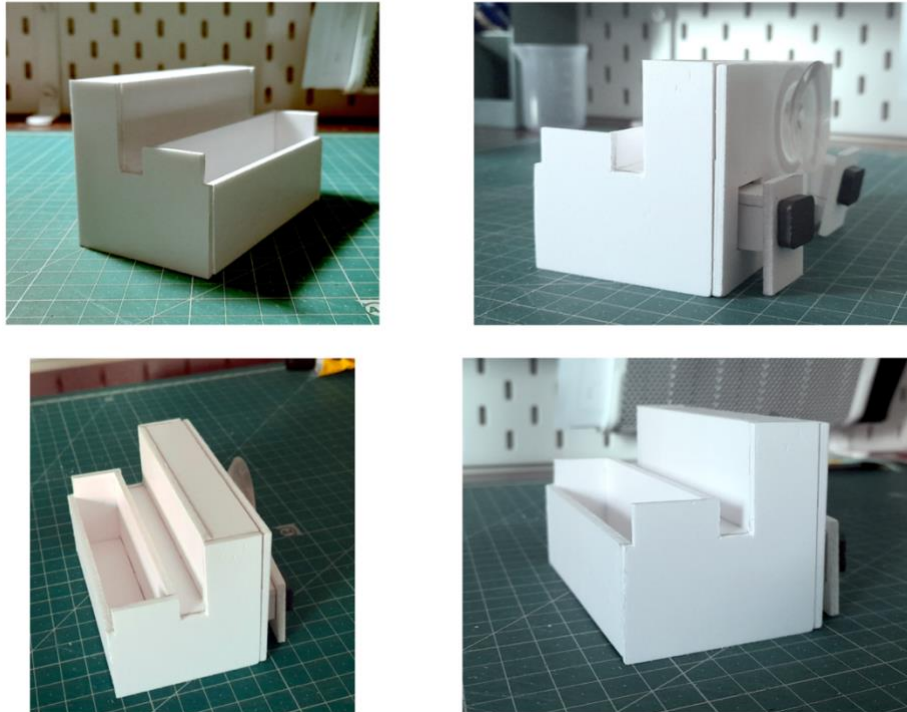


Figure 22. First iteration of the support piece.



Figure 23. Testing of the first iterations

For the second iteration (fig. 24, 25), the magnets were removed because during testing the suction cup could be used in metal which made the magnets an unnecessary addition. To allow for hanging from the bottom, an opening was made on the sides and a screw was added to adjust the piece to different thicknesses. The ends of this screw needed to be long enough to keep it in so it wouldn't be lost; the end that was on the outside needed to be shallow enough to allow for the use of the suction cup without its interference but still thick enough to be used just with fingers.

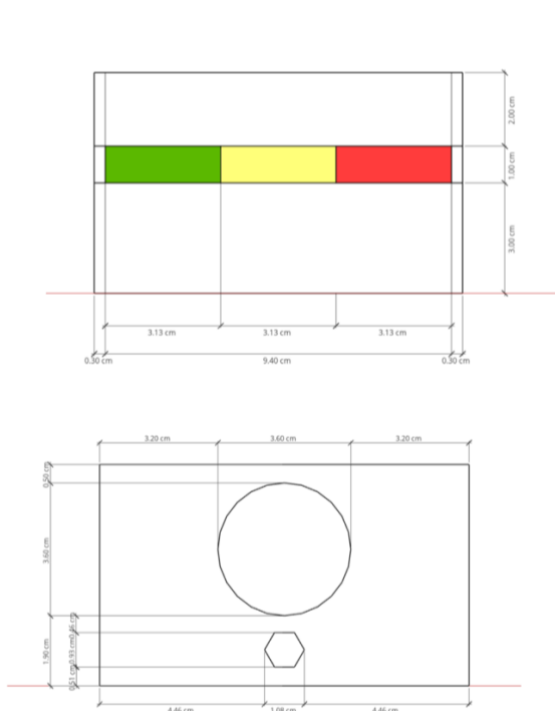


Figure 24. CAD model of the second and final iteration of the support piece. Top: front view. Bottom: back view.

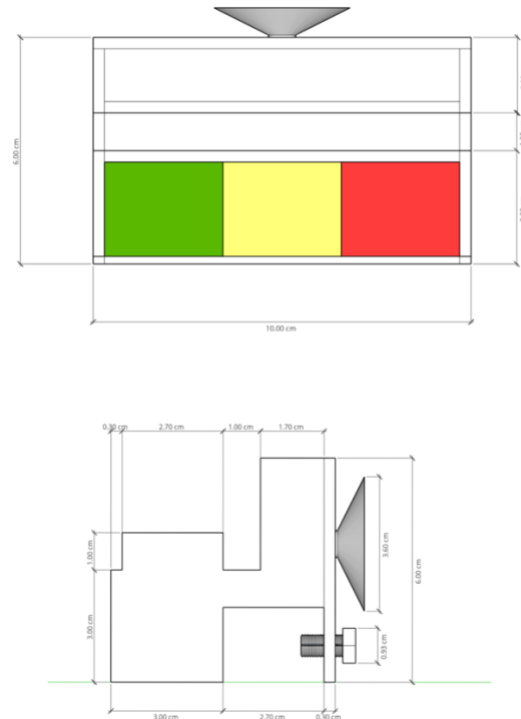


Figure 25. CAD model of the second and final iteration of the support piece. Top: top view. Bottom: side view.

The buttons were also made from glued PVC sheets. Ideally the buttons would be the kind that could be pushed in, stayed in, and would come out with pressure put into it, but I could not understand out how to achieve this in the prototype, so springs were used on the bottom to give a similar effect (fig. 26, 27).



Figure 26. Front and side view of the second iteration of the support piece and card.

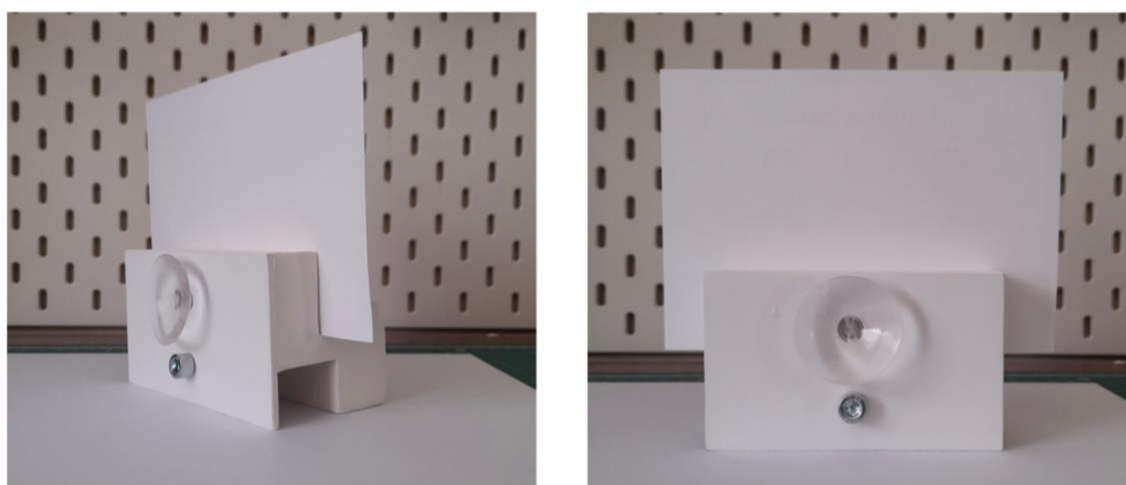


Figure 27. Back and side view of the second iteration of the support piece and card.

The second version was tested in different places to confirm the flexibility of the attachment solutions (fig. 23-25). Once the form was finalized, the buttons were coated with filler to achieve a smooth finish and spray painted.



Figure 28. Support piece and card on fridge and window.



Figure 29. Support piece and card on tile and a cabinet door.



Figure 30. Support piece and card hanging on shelving side and bed frame.

With the form of the support piece established, the options for the materials were explored. Based on the shape and the desire to keep the production low cost and simple, the most pragmatic choice would be ABS plastic in an injection moulding process (Thompson, 2007). This material is difficult to recycle (Empower, 2023) and biodegradable plastics are made for disposable items (Products, 2022), but it answers to the need for resistance and safety that the product requires (Design InSite, 2019).

5.2 Content definition of cards

With the focus on family interactions, research needed to be done to identify which words and sentences would be better suited to achieve the goals of the product. For the parents, a questionnaire was made asking them to rank the words and sentences they use the most in different domestic moments with their children. From the 36 responses, the average ranking of the questions was calculated by assigning a weight to each ranking and calculating the average, just like in the closed ended questions in the first questionnaire. Once all the answers were ranked, the average weight was calculated to reveal the answers with the highest ranking (see appendix B1).

To understand the communication needs of the children, an activity was performed with a group of 22 children – 11 three-year-olds, 5 four-year-olds, 4 five-year-olds, 2 six-year-olds - where a conversation was led to incentivize them to talk about what they express to their parents. The initial plan involved talking to them in small groups to evaluate the frequency of words and sentences

they used, but that wasn't possible, so it was done with all the children at the same time, which did not allow for an individual evaluation. Instead, the conversation was sound recorded, and the strategy became to identify what the children thought of when asked to comment on different domestic activities. During the conversation I tried to lead them to say what specific words and sentences they and their parents used but not much specifically came up. However, there were still insights into the children's perspective on communication, domestic activities, and interactions with their parents. The result of the research was a list of words and sentences to be correlated with the parents' questionnaire (see appendix C1).

When correlating the answers given by the parents and the children, we obtained a group of words and sentences used in domestic interactions (table 2). Each category has a colour assigned to it to help with identification, without special meaning.

Table 3. Words and sentences to be interpreted in the cards

Family (red)	Hygiene (blue)	Rest (green)	Meals (yellow)
Siblings Sister Brother Mother Father	Wash your face Brush your teeth Do you need to go to the bathroom? Bathroom Bath Poop Pee Shower Washing hands Turn off the faucet	It's time to go to bed Sleep Pyjamas Television Stories Bed Bedroom	Eat More Less Setting the table Repeat Lunch Dinner Breakfast Snack Drink
Activities (purple)	Expression (Orange)	Actions (pink)	
Going out Are you ready? Come on Wait Park Walk Library Vacation Put on the shoes Soccer Ball Bicycle Movie theatre	How are you? Good morning Good night Hello Goodbye What do you want? No Yes Please How do you feel? Thank you It's good It's bad	Want Go Say See Play Read	

Movie	Me too		
Tidy up	I like it		
Slowly	I don't like it		
Toys			
Restaurant			
Shop			
Legos			
Pretend			
Books			

For the interpretation I used the website Spread the Sign (fig. 31) provided by the European Sign Language Centre, which works as a sign language dictionary for different languages. The website is constantly being updated, so some sentences and words may be missing. To make the illustrations, I searched for an appropriate interpretation on the website, and took pictures of the different movements in the sign to be traced over. The goal is to make a sample of cards, which will be chosen based on how commonly used they are and whether I can draw them in a trustworthy quality, since this is not my expertise.

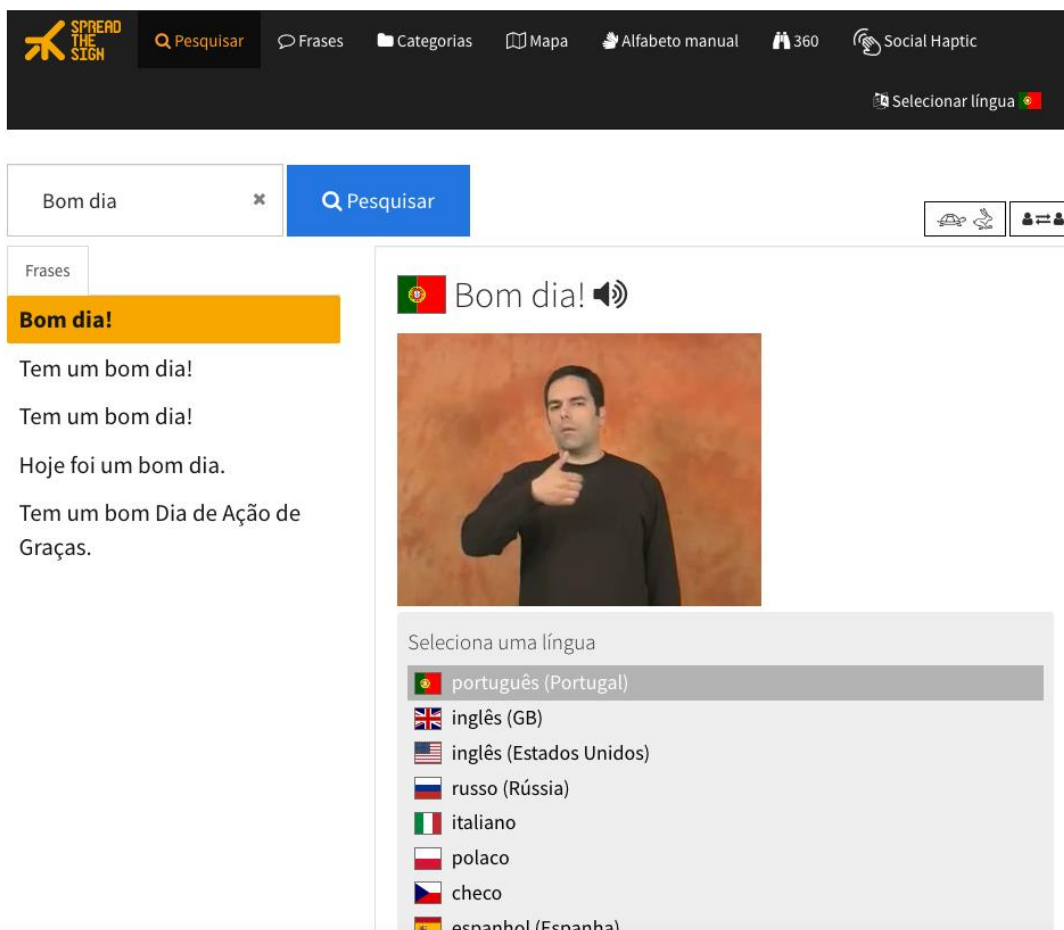


Figure 31. Screenshot of *spreadthesign.com*

The cards (fig. 32, 33) have the following elements:

- A color-coded border to identify the theme, on both sides.
- The name of the theme on the border, on both sides.
- A title describing the sentence or word being signed on both sides.
- One or two illustrations of the sign, each numbered so the order is clear.
- A description of the illustration for each image.
- A QR code linking to the dictionary entry for the sign on *spreadthesign.com*.
- An explanation of the QR code.



Figure 32. Front of Portuguese sign language card for 'Good morning'



Figure 33. Back of Portuguese sign language card for 'Good morning'

When developing the product, the principles of Universal Design, Interaction Design and usability were used as guidelines for its format. It was also considered the diversity aspect by making characters with different genders, skin colours and hair types, with concern for the human centred design and intersectionality of the users. Like it was mentioned in the benchmarking section, the cards will be made of 350gsm – 400gsm paperboard with UV varnish for durability, with a size of 150x105mm, based on similar products.

5.3 Storyboard

The following storyboards (fig. 34 – 36) exemplify how the product can be used in domestic situations with the support allowing a hands free, flexible use around the house to facilitate communication between parent and child.

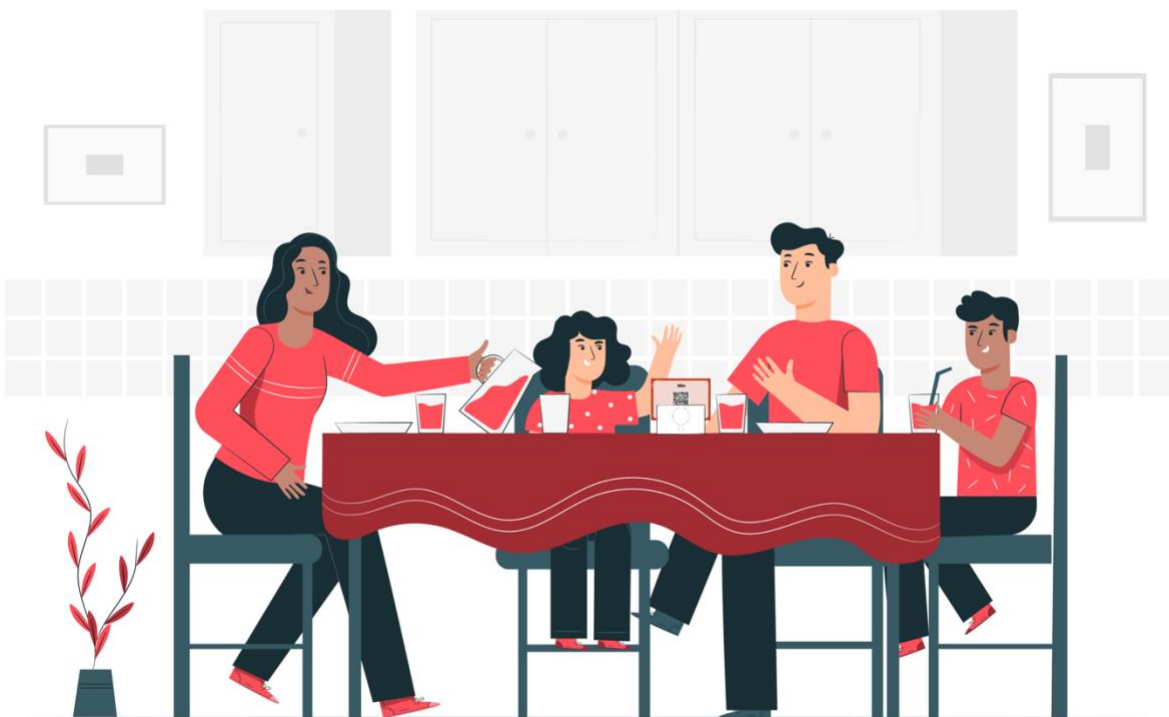


Figure 34. Product being used during mealtime. Adapted from 'Eating together', by storyset, 2019, vector illustration.



Figure 35. Product being used in the bathroom. Adapted from 'Family morning routine flat icons set with kids and adults preparing to work and school', by macrovector, 2022, vector illustration.

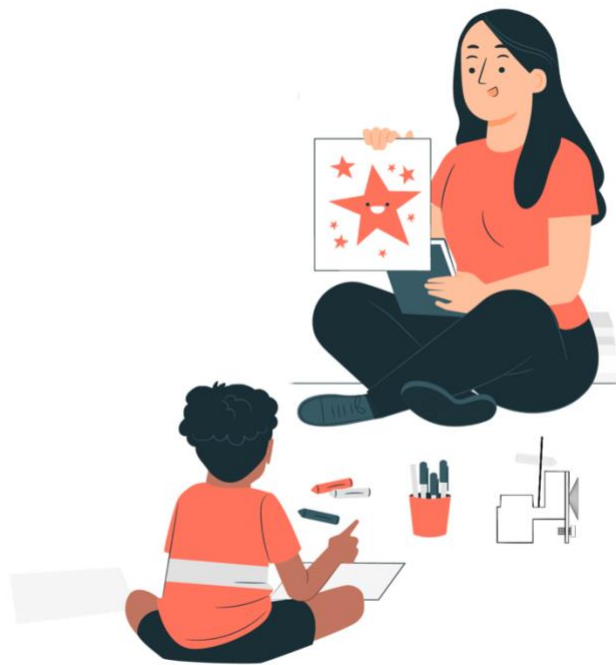


Figure 36. Product being used during playtime. Adapted from 'Kindergarten student concept illustration Free Vector', by storyset, 2022, vector illustration.

Chapter 5 Summary

This chapter presents the prototyping of the product, which involved two iterations. The final iteration became a support object for sign language cards that can be hung from the bottom, attached to vertical surfaces with a suction cup, and simply placed on a horizontal surface. The goal for this piece is to allow the cards to be used hands-free in different places in the house. An interactive system was built into the piece with coloured buttons that for the deaf child to express their understanding and for the hearing adult to be aware of their progress. To define what words and sentences should be included in the collection, questionnaires were made for parents and an activity was done with children to obtain data related to their communication with each other. The form of the cards was defined and storyboards exemplified the expected use of the product.

6 – User testing

6.1 Data collection from user testing - questionnaire

To evaluate the product, two questionnaires were made (see appendix D)– one for specialists and one for the potential users. This method was chosen for the user tests because it was easier for the participants, there wasn't much time left to finish the project, and with it being the end of July it was difficult to have physical access to people. Both questionnaires asked participants to evaluate their comprehension of the illustrations and of the descriptions of a sample of cards (see appendix D), as well as questions to evaluate the concept and their openness to it. When making it, the priority was on brevity and simplicity to avoid participant's loss of interest. It was informed by the User Experience Questionnaire (UEQ Team, 2018), from which some parameters were chosen for evaluation. The questionnaire was sent to people in the general public since it is meant to be used by anyone who needs to communicate with a deaf child, so it needs to be accessible to most people.

6.2 Results

The collected data was analysed by calculating the average rating of the multiple-choice questions, and by adding up both answers of the yes/no questions. There was also an open-ended question for extra commentary. Four specialists – one Portuguese Sign Language interpreter and teacher, two designers and one occupational therapist – and 27 potential users responded to the questionnaire. Figures 37 and 38 present graphics with the feedback of the cards' illustrated and written instructions from both questionnaires side by side for comparison purposes. See appendix D for all answers.

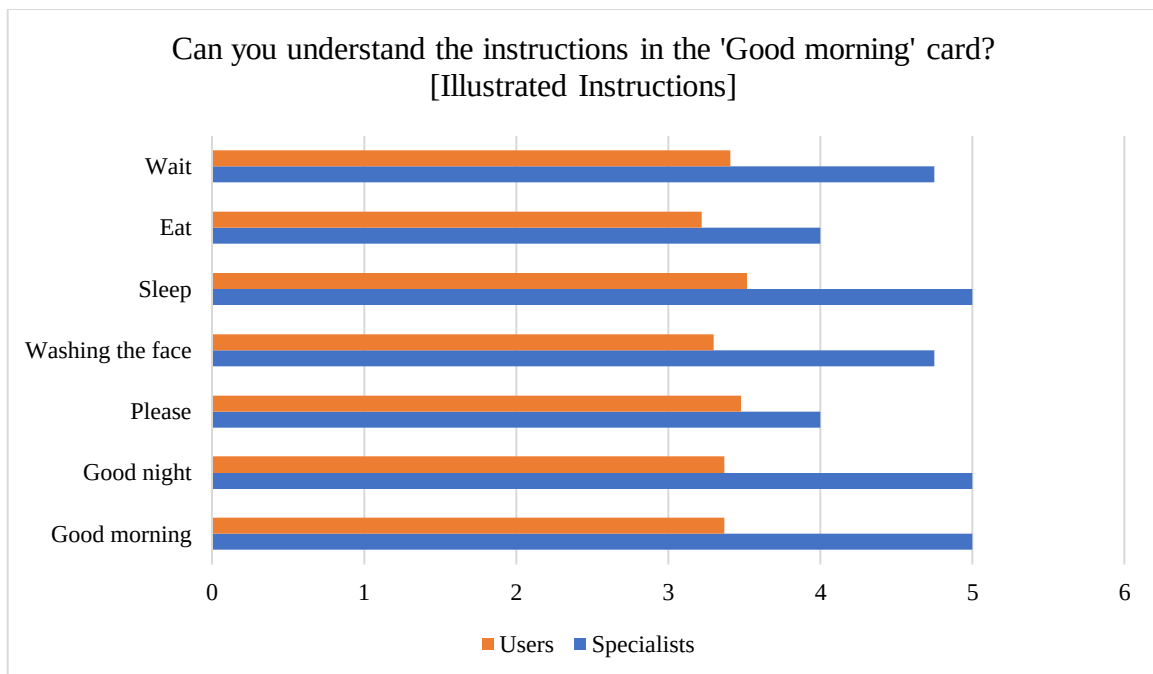


Figure 37. Results of the feedback questionnaires for specialists regarding the illustrated instructions

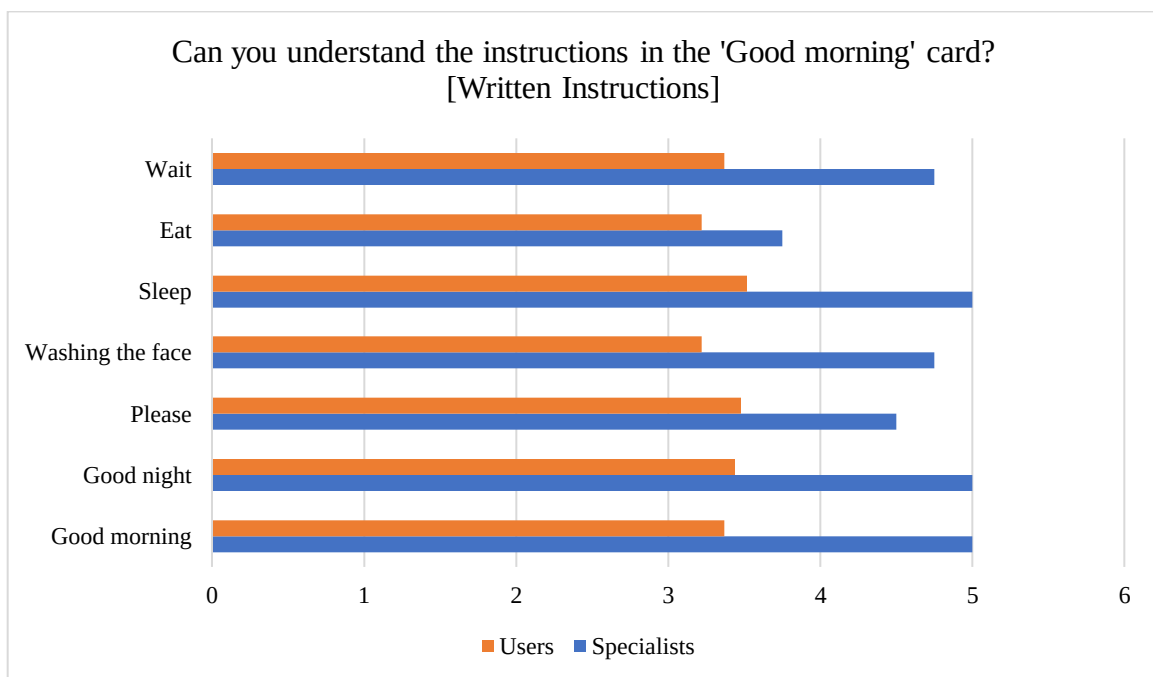


Figure 38. Results of the feedback questionnaires for specialists regarding the written instructions

6.2 Data Analysis – Specialists

In the cards evaluations, the specialists' ratings were between 4-5 in a scale of 6, except for the 'eat' card which had an average rating of 3,75. They all expressed interest in the concept of the product as a tool to promote sign language, rating the concept, the learnability, the graphics and usefulness above 5. One person did not think it could be used in the family environment, but everyone agreed that it could lead people to learn more. It was suggested that it could be used in schools, with autistic children and sign language learners; and that the dark-skinned characters should have lighter clothing for the form to be more perceptible.

Of the specialists, I took particular attention to the feedback of the sign language teacher. She gave a 6 out of 6 rating for the illustration and description of most cards, except for 'please', 'washing the face', 'wait' and the 'eat' description, which were rated with a 5. In the general evaluation of the product, her opinion was overall positive, and it was agreed that the product could familiarize people with sign language in the domestic environment and lead them to learn more about the language.

6.4 Data Analysis – Users

Of the 27 users who responded to the questionnaire, only one had experience with the deaf community. In the card evaluation, the average ranking stayed in the 3,22 – 3,52 range. The overall opinion about the concept of the product was positive with an average rating above 5. One person thought the product could not make people familiar with sign language, but everyone agreed that it could lead people to learn more about it. One participant pointed out they felt that sign language education should be part of basic education to better integrate deaf people into all spheres of society. There was criticism of the 'eat' card regarding the instructions when one of the participants could not understand the written instructions well.

The evaluation of the feedback system showed that the children respond to the faces of the emojis more easily than the colours.

6.5 Data collection from user testing – activity

An activity was performed to test children's reaction to the product; ideally it would have been done with hearing adults and deaf children, but they were not accessible, so it was performed with all hearing participants. The goal was to see if the adults understood the cards, if the children

understood the adult's sign and what visual feedback system (fig. 39) they preferred to express their understanding.

1	
2	
3	
4	

Figure 39. Visual feedback systems used in the activity.

It started with teaching the children three signs, then we met up with the adult and gave them the card so they could perform the sign and see if the children understood it. In the end the child was shown the feedback systems and choose which one better reflected their understanding (fig. 40).



Figure 40. User testing activity.

6.6 Results of the activity

The activity was performed with 7 children and throughout the children quickly learned the sign that was taught to them, and all could identify it when the adult did it. They also chose the emoji feedback system as the one that they would choose to show if they understood it (table 3).

Table 4. Results of user testing activity.

Test number	Understanding of the sign	Chosen feedback system
1	Yes	2
2	Yes	2
3	Yes	2
4	Yes	2
5	Yes	2
6	Yes	2
7	Yes	2

Chapter 6 Summary

The product was evaluated in two ways – a questionnaire and an activity. The questionnaire had two versions – one for specialists and another for potential users, meaning the general public. The feedback on the concept was overall positive but the specialists expressed a better understanding of the instructions compared to the public. The activity involved seeing the product being used by primary school children and adults, all hearing, and also allowed for feedback on the evaluation systems that children prefer to express themselves. The results were also positive.

7 - Finalization

7.1 Iterative process

Once the feedback was gathered, changes were made to the product in response to it:

- The coloured buttons were replaced with buttons with emojis (fig. 35).
- The instructions in the 'eat' card were changed.
- The colours of the clothes of the dark-skinned characters were made lighter to improve the visibility of the form.
- The written instructions were made bolder.

The final prototype is still lacking buttons that can be pressure responsive, but they have springs that show a similar effect. There are probably more details that need work in the illustrations, but it was not possible to obtain such detailed feedback since it would make the questionnaire too long. The changes were applied resulting in the sample in figures 41, 42 and 43, which shows a card of each category (see appendix E for more cards).

The next step in the prototyping of the product would be to create a final version of the support piece in plastic, potentially through 3D printing and the cards would be professionally printed in paperboard.



Figure 41. Final prototype with changed buttons.

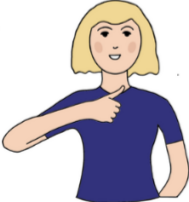
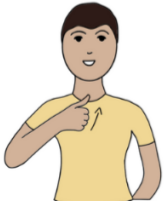
Família Mãe 1  2  Abra a mão em frente à cara. Feche a mão com os dedos esticados.	Família Mãe  Video disponível em spreadthesign.com/pt
Expressão Bom dia 1  2  Levante o polegar ao nível do peito. Abra a mão e suba-a, passando à frente da cara.	Expressão Bom dia  Video disponível em spreadthesign.com/pt
Refeições Comer  Com a boca em forma de beijo, una os dedos e leve-os até ela.	Refeições Comer  Video disponível em spreadthesign.com/pt
Higiene Lavar a cara 1  2  Levante o polegar em direção à boca, baixando um pouco a cabeça. Abra as mãos e imite lavar a cara.	Higiene Lavar a cara  Video disponível em spreadthesign.com/pt

Figure 42. Sample cards.

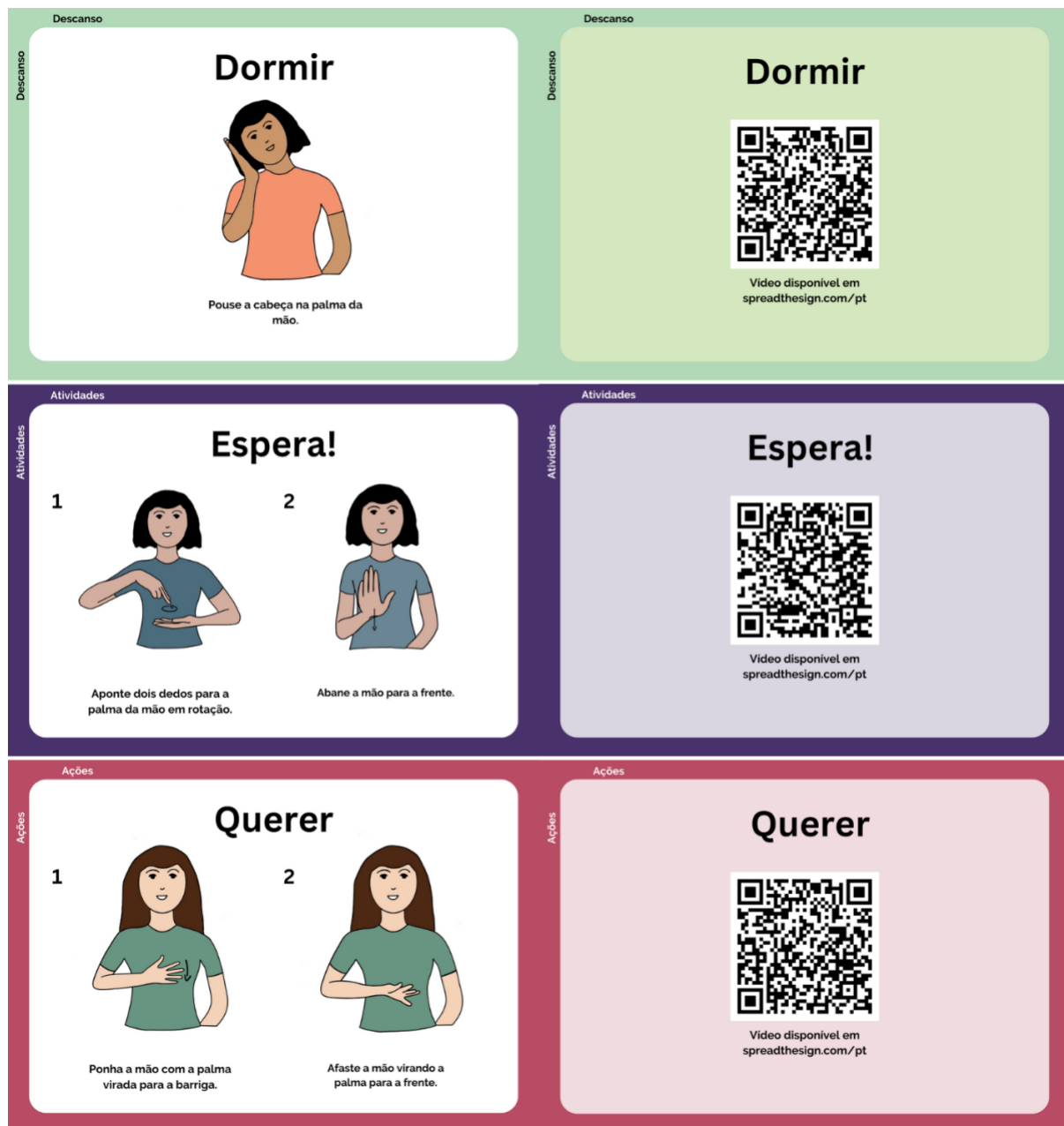


Figure 43. Sample cards.

7.7 Discussion

This research hypothesises that the integration of design in the area of auditory disabilities can facilitate the development of new communication tools. The initial research made through this project revealed that hearing parents are not always comfortable with the idea of learning sign language, and when looking for ways to minimize the language barrier between hearing and deaf

people, more effort needs to be on the side of hearing people. However, the feedback on the product concept was overall positive, suggesting that people are open to becoming more familiar with sign language when it is presented in an accessible and simple format. The design of this product belongs in the second domain (D2.0) defined by VanPatter and Pastor (Jones, 2013), because it involves a very individualistic approach to the problem, but the research opens the possibility of universalizing sign language which can be aided by products that facilitate that process beyond the private sphere, like in schools.

The research and feedback support the ideas defended by Guffey (2023), particularly equity, by levelling the communication playing field between hearing people and sign language; and speculation by moving away from the idea that disability needs to be compensated by the disabled person more than the able-bodied. This product suggests that sign language be treated as any other language, that it be demystified and moved beyond the 'deaf only' box in which it lays in most people's perspectives. It suggests that it should be seen as a natural extension of human communication, like writing, reading and speaking.

In line with the hypothesis, the design methodology allowed for the identification of a problem – deaf children's communication needs are not met when hearing parents are uncomfortable with learning sign language - through primary and secondary research, the development of a concept which looks to facilitate the introduction of sign language in the family environment, an evaluation of the concept through user testing targeted at specialists and the public, and finalization informed by the previous step.

The first primary research moment limits the generalization of the results that contributed to the problem definition because of the low number of respondents, specially from deaf people, but the answers were in line with the secondary research, which gave them more validity. However, because the products' target user became the hearing individual, the participation of specialists and deaf individuals became more useful as a sort of supervision of the effectiveness of the product rather than as a user. In the end, the results of this project became more representative of the attitudes of the hearing community to sign language.

The support can be used simply on a flat horizontal surface, attached by the suction cup, or hanging on an open drawer or a bed frame using the bottom opening and adjustment screw. This allows for the cards to be secure and visible while being used in different places around the house. This

concern for flexibility of use is also reflected on the construction of the cards which should be waterproof and resistant to damage.

The evaluation system will allow children to feel empowered to give specific feedback on their comprehension of the signing and promote two-way communication. This will allow them to make use of the sign language they are learning with their teacher when they are with their family, avoiding feelings of isolation and giving them the chance to communicate with their family in their native language, as well as helping the hearing family to feel more connected to the child and realize the advantages that sign language has for their relationships, hopefully leading them to learn it further.

Regarding the comprehension of the cards' instructions, there was a considerable difference in the results of the specialist questionnaire and the user questionnaire, being that the latter had more ambiguous ratings. This brings up potential biases that could have influenced the responses:

- Familiarity with sign language might make it easier to understand the illustrations and descriptions.
- The ambiguous responses of the users to the cards might be due to unfamiliarity with sign language.
- It is hard to predict how people interpret drawn and written instructions (referring back to semiotics and semantics) and this can be influenced by their state of mind in the moment in which they were answering the questionnaire.

These biases could be managed through an in-person user test that would gather users (ideally hearing adults and deaf children), and a sign language interpreter to verify that the users understood the instructions properly. Another type of testing that should be performed would be on the support piece's use in the home of a family with children, to understand how well it satisfies the goals that it was built on.

Because the accuracy of the drawings is crucial to the success of the product's performance, the prototype only included words and sentences that I felt I could draw accurately, since illustration is not my expertise, and some hand forms were too difficult to draw clearly. If this project was to advance, it would need more involvement from a sign language interpreter and an illustrator familiar with anatomical drawings to minimize errors, increase learnability, efficiency, and

memorability, for an overall higher level of usability, especially as the number of words and sentences is increased. The whole product also still needs a more definitive physical prototype with better finishes and functionality, which wasn't made due to time constraints.

It is natural to see the main product created in this project as the cards rather than the support piece. The latter fits better into the product design category, which is the context in which this project is being made, while the former fits better into the communication and graphic design categories. Future additions to the product could include other ways to display cards or reference posters, educational materials, as well as be part of a larger effort to introduce Portuguese sign language to the general population, through an educational program. This would involve different professionals and collaboration with educational institutions and institutions that work with the deaf community, in the public and private spheres.

Chapter 7 Summary

After the user testing, another iteration was made for the support piece and the cards, informed by the users and specialists feedback. This is by no means a final version of the product which requires other types of resources to be fully realized.

In the discussion, the user experience and the products were analysed against methodological theory, and potential biases and suggestions were presented. This research revealed that people are open to learning sign language, which reveals the possibility of creating more resources for hearing people to have more and better access to sign language. It also shows a different approach to universal design based on the principles of equity and speculation anchored on changing the perception of sign language as a minority method of communication.

The limitations in this project are mostly based on the low number of participants and participants of the deaf community. Therefore, the project needs to reinforce these aspects if it is to continue in the future. Other suggestions for the future of this project include improved prototypes and more types of user testing.

Conclusions

A hearing parent and a deaf child face challenges in their communication that require a mutual adaptation that is mostly up to the parent as the biggest influence in the child's development. Access to their native language, sign language, is crucial for a deaf child's development and the design methodology can create tools to make this process less gritty. The product that was created in this project hopes to help the parents that are reluctant to learning sign language become more familiar with it and understand the value of communicating with their child in a mutually beneficial way. This will be done with the sign language cards and the support piece that will allow their use in the house to be more flexible and practical.

This research was inspired by a project that joined different technological features to create a wearable device that would address different communication needs of deaf people, with the main feature being sign language translation. I expected to be led to a different version of this product but found the perspective that hearing people are an important part of the inclusion of deaf people into society. The primary research supported this and revealed an interest in making that effort, suggesting that is just a matter of how that possibility is presented. The main target user of this product is hearing parents of deaf children because the children's development is at stake, but it was found that some people believe that sign language could be more universalized through its inclusion in basic education.

For the support piece, the key aspects are its ability to be practically used around the house and make the use of the cards easier and more intuitive, along with an evaluation system that empowers the child. The key aspect of the success of the cards as a learning tool is in the quality of the illustrations and descriptions. To achieve the goal of the product, illustrators, sign language teachers and in person user testing would be necessary to improve the usability parameters.

The research shows the possibilities of 'designing with disability' by challenging people to rethink communication to include sign language. It is possible to build a future where sign language is more widely used, it's all a matter of creating tools and spaces that make learning it more intuitive. Seeing signing as an extension of reading, writing, and speaking would only add to the human expression and reduce inequalities, and the research suggests that most people agree with that, they were just never given the opportunity to expand on those abilities.

This project is a starting point for what could be a universe of learning implements that make learning sign language more accessible not only within the family but in society as a whole by exploring the possibility of bringing it to schools and the wider public.

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Appendix A

Research phase questionnaires

Table A1. Questionnaire about communication of people with hearing loss - specialists

	Questions	Answers	Type of answer
1	What is your age group?	15 – 25 26 - 35 36 - 50 51 - 65 65 +	Multiple choice
2	What is your gender?	Female Male Prefer not to say	Multiple choice
3	How do you describe your relationship with the deaf community?	Family member of deaf person Health Specialist Other	Multiple choice
4	If you are a health specialist, what is your specialty?	Social intervention Psychology Speech therapy Doctor Nurse Other	Multiple choice
5	What is the age group where you observe the most communication difficulties amongst people with hearing loss? (order the answers from biggest difficulty to lowest)	0 - 6 7 - 14 15 - 25 26 - 35 36 - 50 51 - 65 65 +	Ranking
6	Why?		Open ended question
7	For individuals with severe to profound hearing loss what are the biggest communication difficulties? (order the answers from biggest difficulty to lowest)	Communicating with hearing people Literacy Communication with other people with hearing loss Accessibility to sound alarm Learning sign language	Ranking
8	Do you know another relevant situation that wasn't mentioned?		Open ended question
9	What assistive technologies do you believe to be the most	Hearing aid Cochlear implant	Ranking

	useful? (order the answers in order of preference)	Subtitles FM System Detection of babies' cry Translation of texts and audio to sign language Instant transcription of voice to text Audio induction loop	
10	Do you know another assistive technology that you believe to be relevant?		Open ended question
11	Thank you for participating. If you have any commentary or suggestions, feel free to write it down.		Open ended question

Table A2. Questionnaire about communication of people with hearing loss – deaf people

	Questions	Answers	Type of answer
1	What is your age group?	15 – 25 26 - 35 36 - 50 51 - 65 65 +	Multiple choice
2	What is your gender?	Female Male Prefer not to say	Multiple choice
3	If you are a person with limited hearing, how do you classify it?	Moderate Severe Profound	Multiple choice
4	Are there any details about your condition you would like to add?		Open ended question
5	How long have you been deaf?		Open ended question
6	How do you rate your speech capabilities?	0 – Doesn't speak 1 2 3 4 5 6 – Speaks comfortably	Multiple choice
7	How do you classify your fluency in sign language?	1 – Doesn't know 2	Multiple choice

		3 4 5 6 – Is fluent	
8	In which situations do you most struggle to communicate with hearing people? (order the answers from biggest difficulty to lowest)	Interactions with health professionals Interactions with educational institutions Interactions with hearing children Interactions with state institutions Interactions with commercial establishments	Ranking
9	Do you know another relevant situation that wasn't mentioned?		Open ended question
10	What difficulties do you find on your day to day? (order the answers from biggest difficulty to lowest)	Access to information Access to entertainment Communication with people with hearing loss Learning sign language Accessibility of sound alarms Literacy	Ranking
11	Do you know another relevant situation that wasn't mentioned?		Open ended question
12	What assistive technologies do you believe to be the most useful? (order the answers in order of preference)	Hearing aid Cochlear implant Subtitles FM System Detection of babies' cry Translation of texts and audio to sign language Instant transcription of voice to text Audio induction loop	Ranking
13	Do you know another assistive technology that you believe to be relevant?		Open ended question
14	Thank you for participating. If you have any commentary or suggestions, feel free to write it down.		Open ended question

Table A3. Questionnaire about communication of people with hearing loss – other members of the deaf community

	Questions	Answers	Type of answer
1	What is your age group?	15 – 25 26 - 35 36 - 50 51 - 65 65 +	Multiple choice
2	What is your gender?	Female Male Prefer not to say	Multiple choice
3	How do you describe your relationship with the deaf community?	Family member of deaf person Health Specialist Other	Multiple choice
4	What is the age group of the deaf people you know?	0 - 5 6 - 14 15 – 25 26 - 35 36 - 50 51 - 65 65 +	Multiple choice
5	How do you communicate with deaf people? (order the answers in order of preference)	Sign language Writing Gestures Phone	Ranking
6	Is there another communication method you find relevant?		Open ended question
7	What assistive technologies do you believe to be the most useful in your interactions with deaf people? (order the answers in order of preference)	Hearing aid Cochlear implant Subtitles FM System Detection of babies' cry Translation of texts and audio to sign language Instant transcription of voice to text Audio induction loop	Ranking
8	Do you know another assistive technology that you believe to be relevant?		Open ended question
9	Thank you for participating. If you have any commentary or		Open ended question

	suggestions, feel free to write it down.		
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Table A4. Research contacts

Online presence	Name	Research method
Website	Federação Portuguesa Das Associações De Surdos	Questionnaire
Website	ACSA - Associação Cultural De Surdos Da Amadora	Questionnaire
Website	ASLC - Associação De Surdos Da Linha De Cascais	Questionnaire
Website	APS - Associação Portuguesa De Surdos	Questionnaire
Website	CERCI - Cooperativa de Educação e Reabilitação de Cidadãos com Incapacidade	Questionnaire
Website	Associação Nacional E Profissional Da Interpretação - Língua Gestual	Questionnaire
Website	Afas - Associação De Familias E Amigos Dos Surdos	Questionnaire
FB group	Surdez E Surdos Oralizados	Questionnaire
FB page	Surdez & Deficiência Auditiva	Questionnaire
FB page	Surdez: Silêncio Em Voo De Borboleta	Questionnaire
FB page	Grupo De Estudos E Pesquisas Sobre Surdez	Questionnaire
FB page	Crônicas Da Surdez	Questionnaire
Superprof.pt	Cristiana Ferreira	Interview

Table A5. Thematic analysis of the questionnaire about the deaf community's communication needs

Themes	Frequency	Content
Needs	3	Need to learn their native language. Bilingual education. Prefer sign language to other methods of communication.
Children	5	Have access to technology. Have support. Read lips. Innate communication needs to be stimulated. Doctors suggest cochlear implants and discourage learning sign language. Not having access to a natural language delays cognitive and emotional development.
Young adults	2	Don't want to learn to speak. Knowledge of the schools of reference and technology facilitates the use of LGP and speech.
Adults	2	Don't want to learn to speak. Lost contact with LGP. Have dormant tongue. Are more isolated.

Elderly	3	Belong to deafness support groups or other forms of community. Looks for support with social work services. Have other needs that get in the way of their independence.
Hearing people	2	Need to adapt to deaf people's needs by learning LGP.
Difficulties	3	Can't hear children crying. Socialization.
Assistive technology	1	Applications and online platforms for LGP interpretation.
Assistive services	2	LGP interpreters. Training for health professionals.
Methods of communication	3	Speaking through the caregiver. Importance of language acquisition for cognitive development.

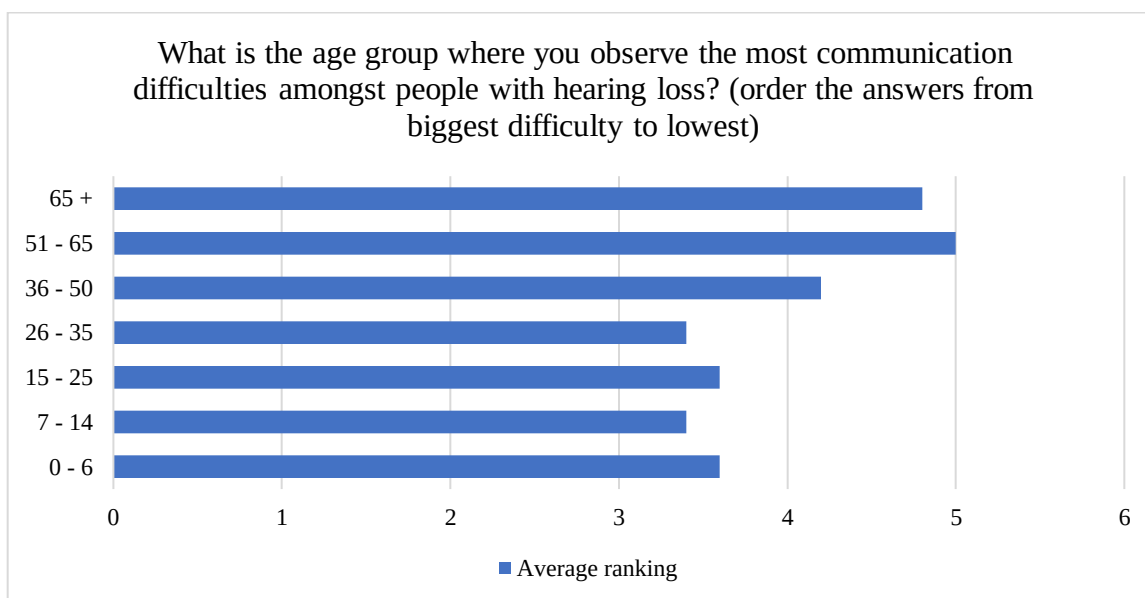


Figure A1. Graph showing the average ranking for the question 'What is the age group where you observe the most communication difficulties amongst people with hearing loss?'

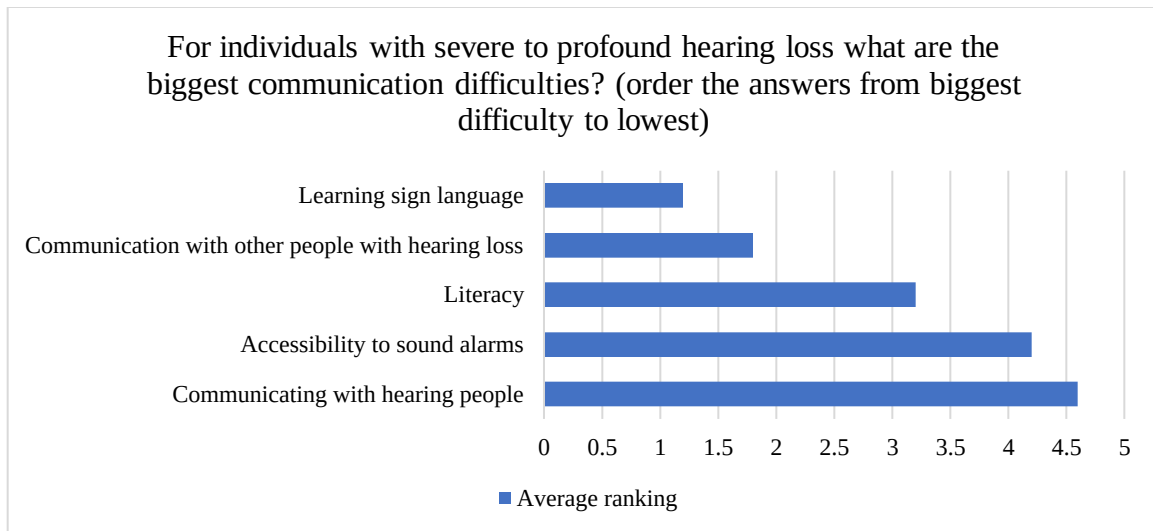


Figure A2. Graph showing the average ranking for the question 'For individuals with severe to profound hearing loss what are the biggest communication difficulties?'

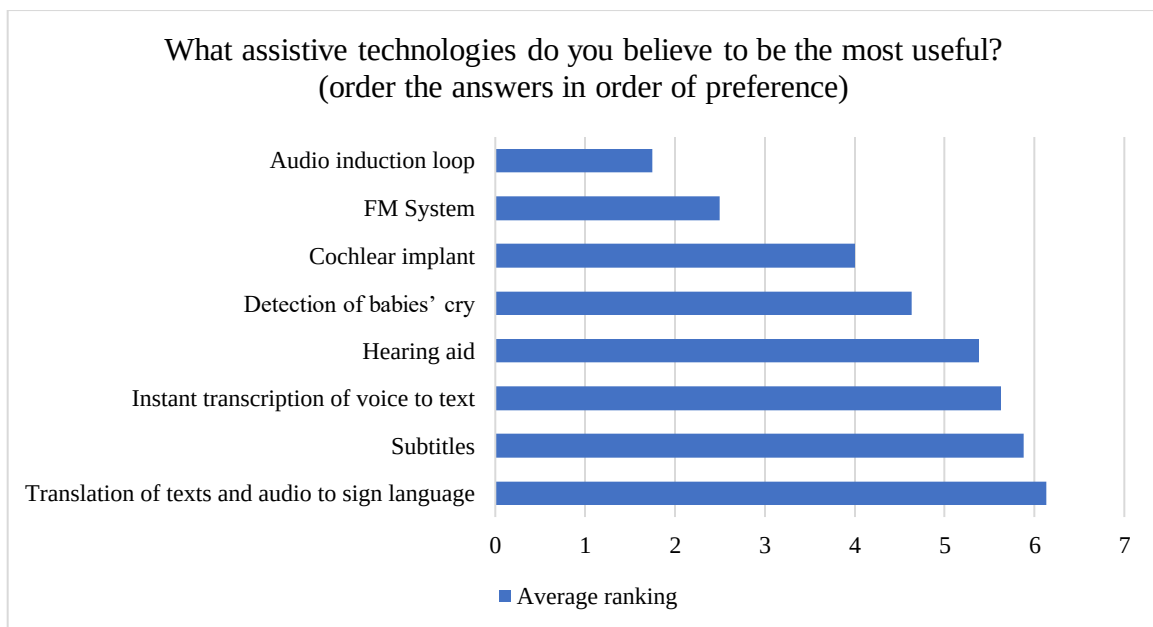


Figure A3. Graph showing the average ranking for the question 'What assistive technologies do you believe to be the most useful?'

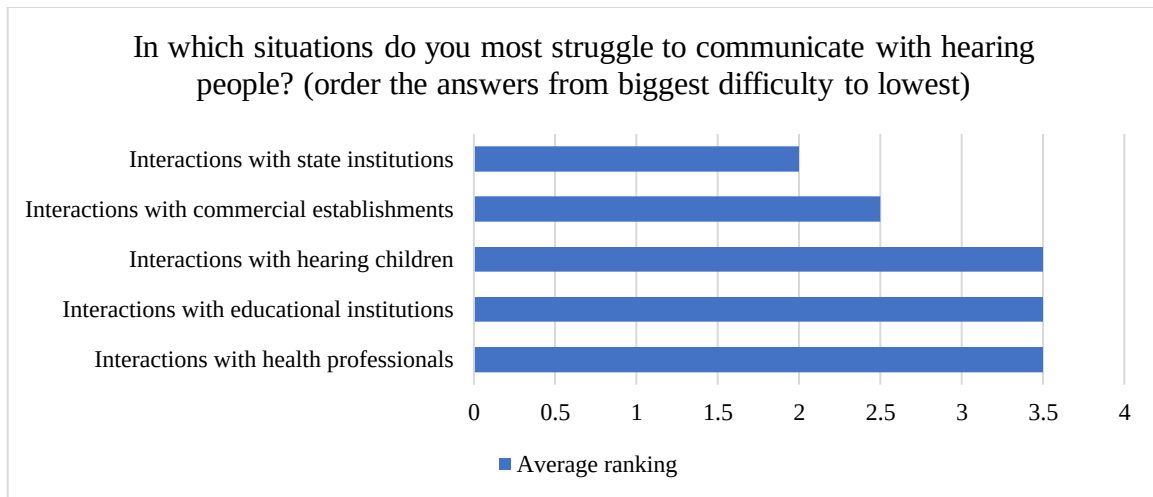


Figure A4. Graph showing the average ranking for the question 'In which situations do you most struggle to communicate with hearing people?'

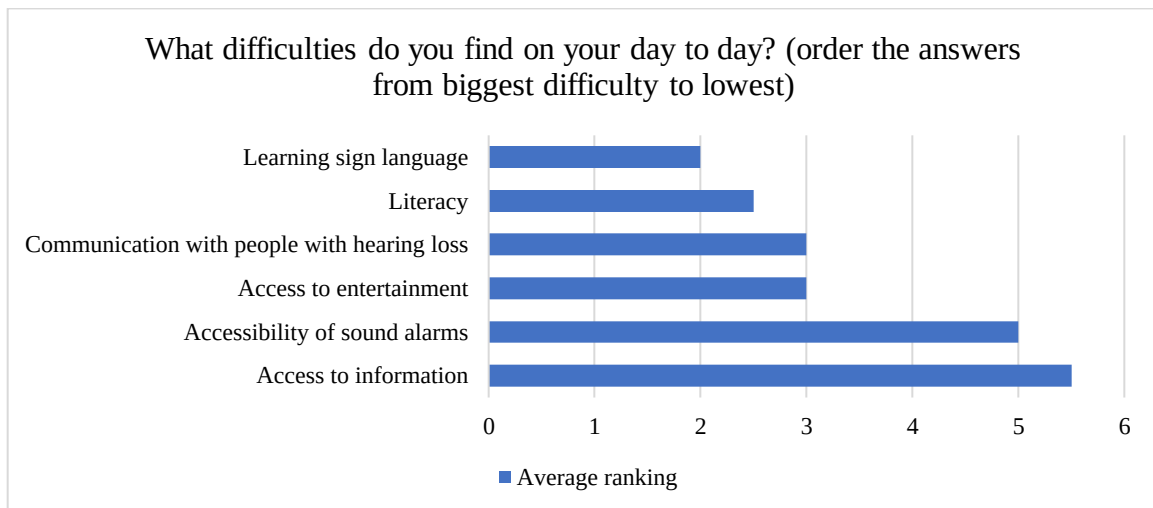


Figure A5. Graph showing the average ranking for the question 'What difficulties do you find on your day to day?'

Appendix B

Content definition questionnaires

Table B1. Ranking of parent's words and sentences

Questions/Answers	Average ranking
Rank the words and sentences you use the most with your children during wake-up time (from the most repeated to the least repeated)	
Wake up.	2,97
Get dressed.	2,89
Brush your teeth.	2,36
Wash your face.	1,78
Rank the words and sentences you use the most with your children during mealtime (from the most repeated to the least repeated)	
Come eat.	2,86
Just a little more.	2,08
You can leave the table.	1,06
Rank the words and sentences you use the most with your children during play time (from the most repeated to the least repeated)	
What do you want?	2,53
Wait.	2,42
Let's clean up.	2,25
Slowly.	2,81
Rank the words and sentences you use the most with your children during bedtime (from the most repeated to the least repeated)	
It's time to go to bed.	1,83
Put on your pyjamas.	1,17
Rank the words and sentences you use the most with your children during hygiene (from the most repeated to the least repeated)	
Do you need to go to the bathroom?	2,08
Let's brush your teeth.	2,75
Let's take a bath.	3,56
Let's brush your hair.	1,61
Rank the words and sentences you use the most with your children when leaving the house (from the most repeated to the least repeated)	
It's almost time to leave.	2,39
Get your things.	2,03
Put on your shoes.	2,89
Are you ready?	2,69
Rank the words and sentences you use the most with your children related to emotions (from the most repeated to the least repeated)	
Is everything okay?	2,03
How was your day?	2,61
How do you feel?	1,36

Appendix C

Content definition activity results

Table C1. Children's words and sentences

Meals
Put the food on the table Lunch Let's eat It's time to eat Egg Meat with rice Thank you It's good I really like the food I love the food I want more I want to repeat Please Can you put a little bit less We eat fruit Do not give farts at the table Snack Lunch Dinner Breakfast I ask for cereal I can get everything (food) myself I have to go [get food] with my mouth shut My breakfast is yogurt, a cheese triangle that is made of cow and banana I ask my parents for food I eat porridge and drink milk I get the bananas by myself
Playtime
We play with the toys Legos I play restaurant I play shops with my sister I'm pretending to make food, I have a play kitchen Me too We play with the dogs on the street, they poop and pee on the street I've already broken my head Talk about the planet
Sleep
I watch a little bit of television

I can't sleep I wash my teeth I go to bed I see a story You need to put on your pyjamas Parents say goodnight I get out of bed to go to my parents' bed I'm going to my brother's bed I don't get out of bed I like to snore Parents put me to bed
Hygiene
Pooping Showering Wash hands The parents help take a bath and wash the bottom Brushing teeth The toothpaste burns The parents don't help brush teeth My sister threw the paper into the toilet Cannot pee outside the toilet Have to wash your hands without spreading water Turn off the faucet
Outings
School Park Walk Café Library Vacation I'm going on a plane on vacation I talk to my parents: I love my parents, I love my siblings We can't run away from them Put on shoes We pee Have breakfast We poop Play soccer I see books with mom I eat at the cafe, I drink juice I drink coffee I love milk with coffee I ride my bike We want to see a movie

I went to the movies with my sister

Be very quiet

We ate popcorn at the movies

I go to the shops by boat

I'm going to the pool

Appendix D

User testing questionnaires

Table D1. Product evaluation questionnaire for specialists

Questions	Answers
What is your age group?	
What is your gender?	Male Female
What is your specialty?	Open answer
Can you understand the instructions in the 'Good morning' card? [Illustrated Instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear
Can you understand the instructions in the 'Good morning' card? [Written Instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear
Good night [Illustrated instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear
Good night [Written instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear
Please [Illustrated instructions]	0 -Incomprehensible 1 2

	3 4 5 6 -Clear
Please [Written instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear
Washing the face [Illustrated instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear
Washing the face [Written instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear
Sleep [Illustrated instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear
Sleep [Written instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear
Eat [Illustrated instructions]	0 -Incomprehensible

	1 2 3 4 5 6 -Clear
Eat [Written instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear
Wait [Illustrated instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear
Wait [Written instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear
How do you evaluate the product concept?	0 - Terrible 1 2 3 4 5 6 - Excellent
How do you evaluate the product learnability?	0 - Difficult to learn 1 2 3 4 5 6 - Easy to learn

How do you evaluate the graphic identity of the product?	0 - Ugly 1 2 3 4 5 6 - Attractive
How do you evaluate the usefulness of the product?	0 – Not useful 1 2 3 4 5 6 – Very useful
Do you think this is a product that could familiarize people with sign language?	Yes No
Do you think this product could lead people to learn sign language?	Yes No
Do you think it could be used in communication between hearing parents and deaf children?	Yes No
This product was made for families of deaf children, would you recommend the product for other uses? Which ones?	Open answer
Se tiver alguma observação adicional sobre o produto, esteja à vontade.	Open answer

Table D2. Product evaluation questionnaire for users

Questions	Answers
What is your age group?	
What is your gender?	Male Female
Do you have any relationship with the deaf community?	Yes No
If you answered yes, what is the relationship?	Open answer
Can you understand the instructions in the 'Good morning' card? [Illustrated Instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear

Can you understand the instructions in the 'Good morning' letter? [Written Instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear
Good night [Illustrated instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear
Good night [Written instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear
Please [Illustrated instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear
Please [Written instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear
Washing the face [Illustrated instructions]	0 -Incomprehensible 1 2 3 4

	5 6 -Clear
Washing the face [Written instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear
Sleep [Illustrated instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear
Sleep [Written instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear
Eat [Illustrated instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear
Eat [Written instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear
Wait [Illustrated instructions]	0 -Incomprehensible 1 2

	3 4 5 6 -Clear
Wait [Written instructions]	0 -Incomprehensible 1 2 3 4 5 6 -Clear
How do you evaluate the product concept?	0 - Terrible 1 2 3 4 5 6 - Excellent
How do you evaluate the product learnability?	0 - Difficult to learn 1 2 3 4 5 6 - Easy to learn
How do you evaluate the graphic identity of the product?	0 - Ugly 1 2 3 4 5 6 - Attractive
How do you evaluate the usefulness of the product?	0 – Not useful 1 2 3 4 5 6 – Very useful
Do you think it's a product that could help you become familiar with sign language?	Yes No

Do you think the product could lead you to learn sign language if you interacted with deaf people in your day-to-day life?	Yes No
Se tiver alguma observação adicional sobre o produto, esteja à vontade.	



Figure D1. Sample of cards evaluated in the questionnaires

Table D3. Results of the feedback questionnaires for specialists and users - comparison

	Specialists	Users
Can you understand the instructions in the 'Good morning' card? [Illustrated Instructions]	5	3,37
Can you understand the instructions in the 'Good morning' letter? [Written Instructions]	5	3,37
Good night	5	3,37
	5	3,44
Please	4	3,48
	4,5	3,48
Washing the face	4,75	3,30
	4,75	3,22
Sleep	5	3,52
	5	3,52
Eat	4	3,22
	3,75	3,22
Wait	4,75	3,41
	4,75	3,37
How do you evaluate the product concept?	5,5	5,48
How do you evaluate the product learnability?	5,25	5,52
How do you evaluate the graphic identity of the product?	5,25	5,30
How do you evaluate the usefulness of the product?	5,5	5,70
Do you think this is a product that could familiarize people with sign language?	4 0	26 1
Do you think this product could lead people to learn sign language?	4 0	27 0
Do you think it could be used in communication between hearing parents and deaf children?	3 1	
This product was made for families of deaf children, would you recommend the product for other uses? Which ones?	'Sign language students' 'People who work with autistic people'	

	‘Early childhood educators’ ‘Children's sector’ ‘Kindergartens’	
If you have any additional observations about the product, feel free to present them.	‘The cards with the figure with the brown skin should have the lighter clothing to facilitate the shapes.’	‘The instructions for ‘eat’ were not clear on whether the mouth or the fingers were supposed to be in kiss shape.’ ‘It is important that the material is easily accessible to encourage young people and children to learn sign language.’ ‘Easy to understand and of great help.’ ‘It's very useful’ ‘Excellent initiative’ ‘In the first instance, it's all understandable.’ ‘Very interesting product in the educational area.’ ‘I think it would be very useful to have a discipline on sign language, from primary to secondary [school]. For all people, should have the opportunity to learn this language, to be able to communicate with children, adults and the elderly deaf/mute. They, in turn, will live in community on a personal, social and professional level.’

Appendix E

Sample of sign language cards



Figure E1. Portuguese Sign Language card for 'mother' (front)



Figure E2. Portuguese Sign Language card for 'mother' (back)

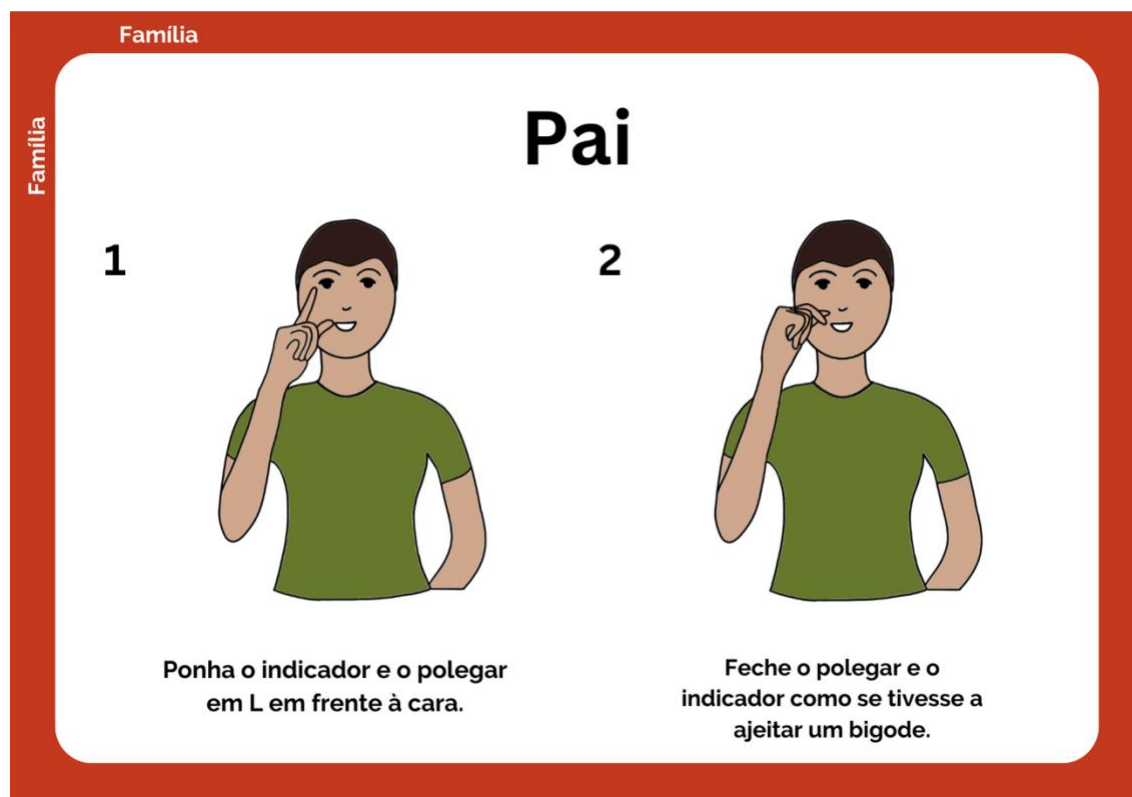


Figure E3. Portuguese Sign Language card for 'father' (front)



Figure E4. Portuguese Sign Language card for 'father' (back)

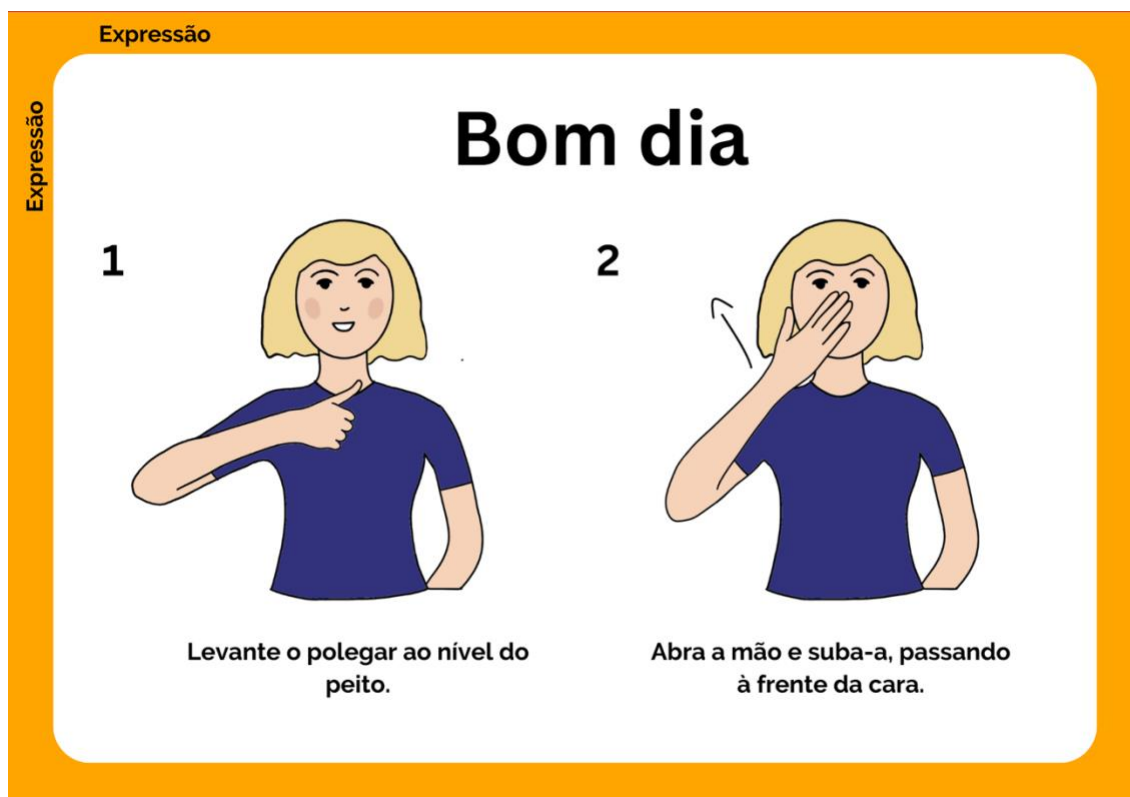


Figure E5. Portuguese Sign Language card for 'good morning' (front)



Figure E6. Portuguese Sign Language card for 'good morning' (back)

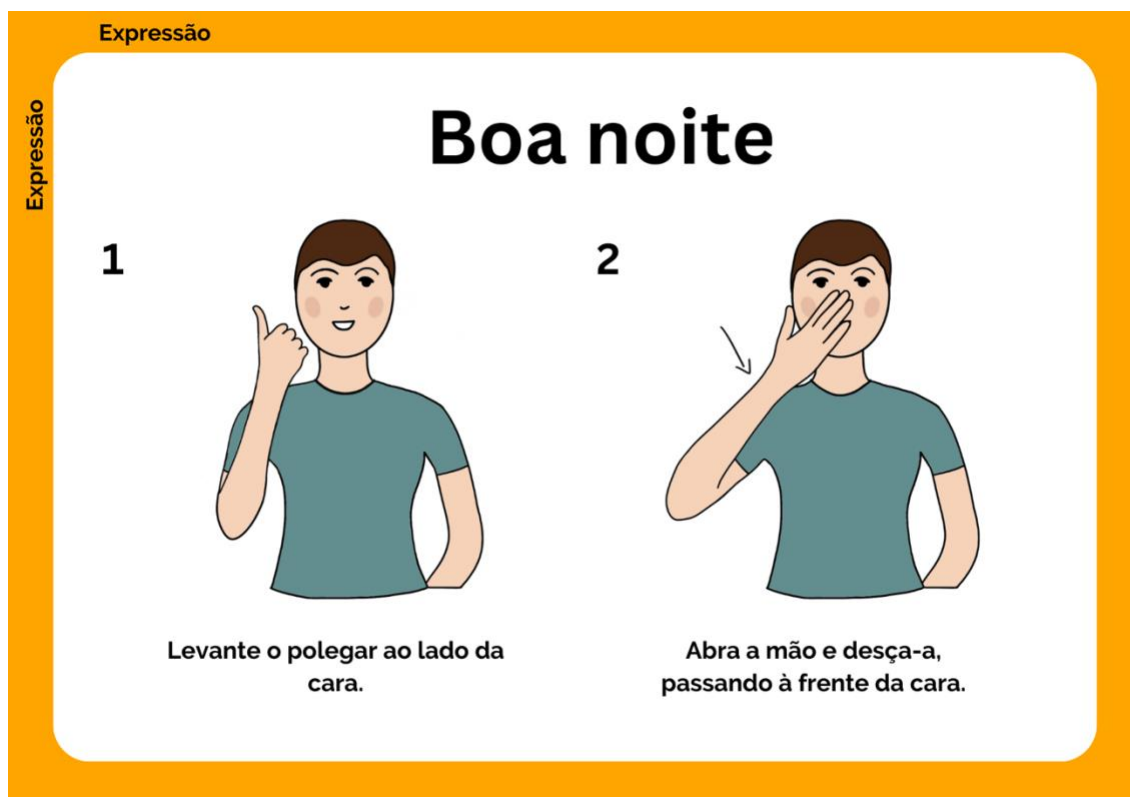


Figure E7. Portuguese Sign Language card for 'good night' (front)



Figure E8. Portuguese Sign Language card for 'good night' (back)



Figure E9. Portuguese Sign Language card for 'por favor' (front)



Figure E10. Portuguese Sign Language card for 'por favor' (back)

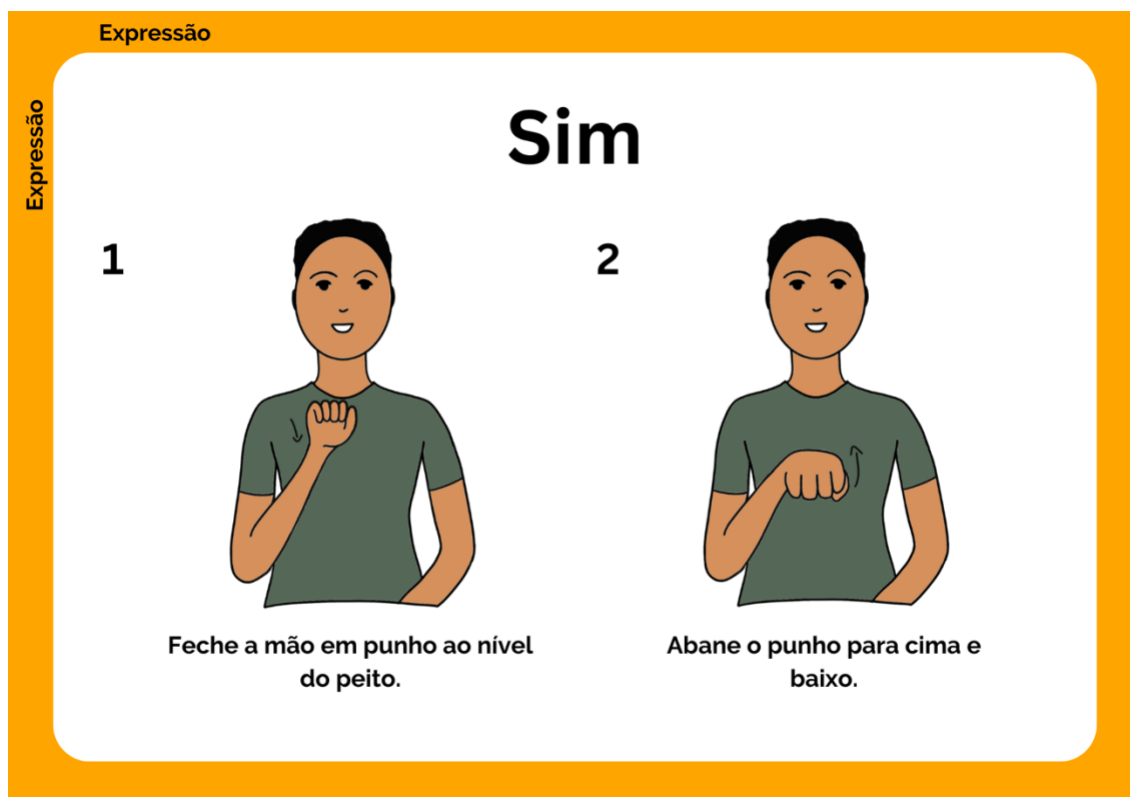


Figure E11. Portuguese Sign Language card for 'yes' (front)



Figure E12. Portuguese Sign Language card for 'yes' (back)



Figure E13. Portuguese Sign Language card for 'no' (front)



Figure E14. Portuguese Sign Language card for 'no' (back)



Figure E15. Portuguese Sign Language card for 'to eat' (front)



Figure E16. Portuguese Sign Language card for 'to eat' (back)

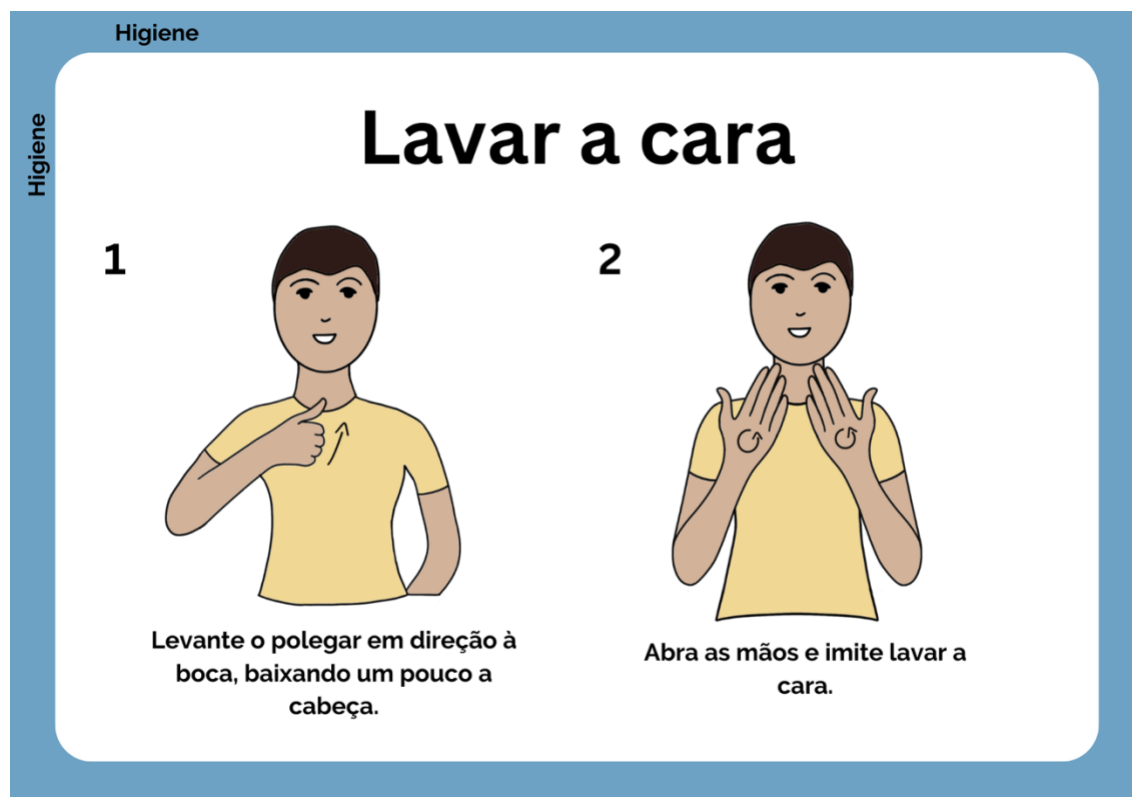


Figure E17. Portuguese Sign Language card for 'washing the face' (front)



Figure E18. Portuguese Sign Language card for 'washing the face' (back)

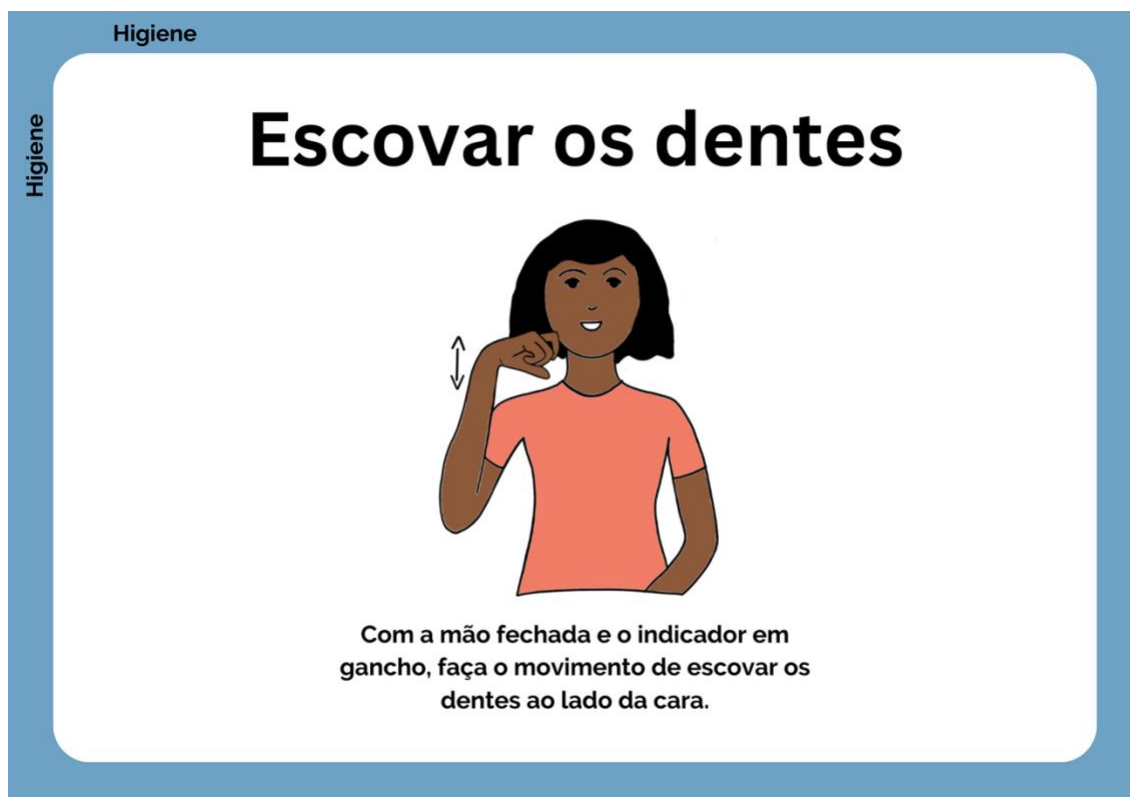


Figure E19. Portuguese Sign Language card for 'brushing teeth' (front)



Figure E20. Portuguese Sign Language card for 'brushing the teeth' (back)



Figure E21. Portuguese Sign Language card for 'to sleep' (front)



Figure E22. Portuguese Sign Language card for 'to sleep' (back)

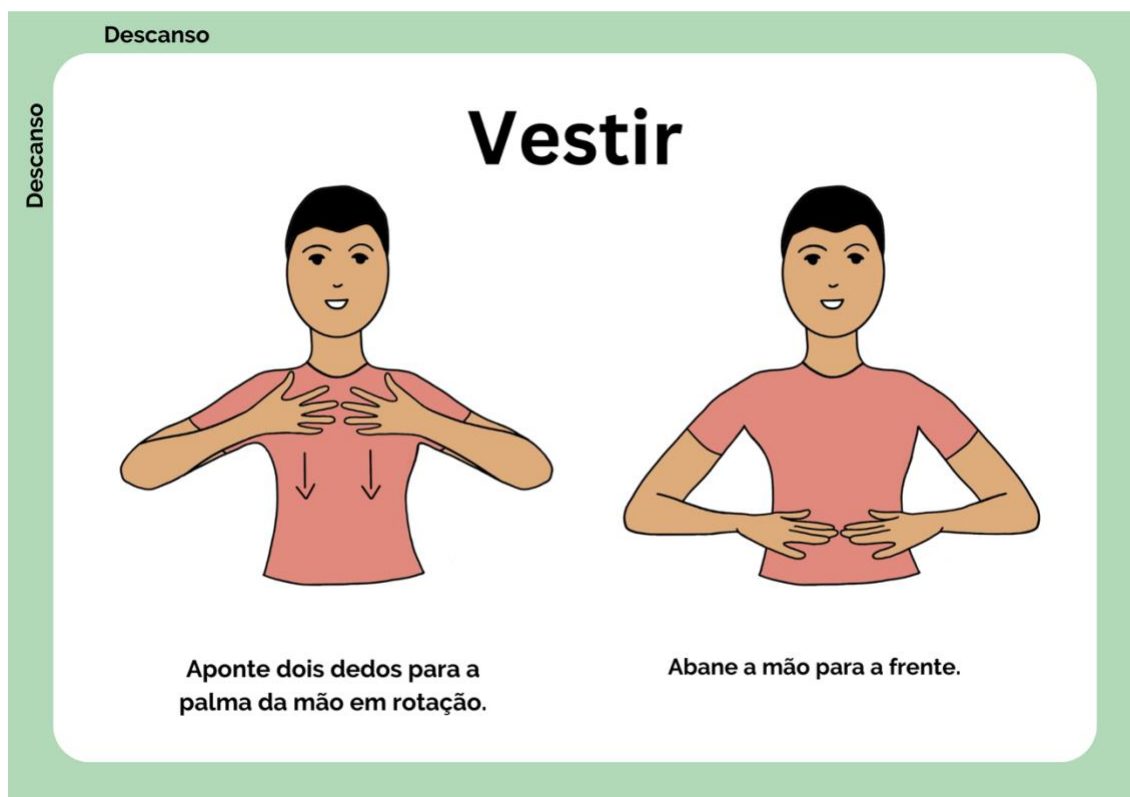


Figure E23. Portuguese Sign Language card for 'to dress' (front)



Figure E24. Portuguese Sign Language card for 'to dress' (back)



Figure E25. Portuguese Sign Language card for 'wait' (front)



Figure E26. Portuguese Sign Language card for 'wait' (back)

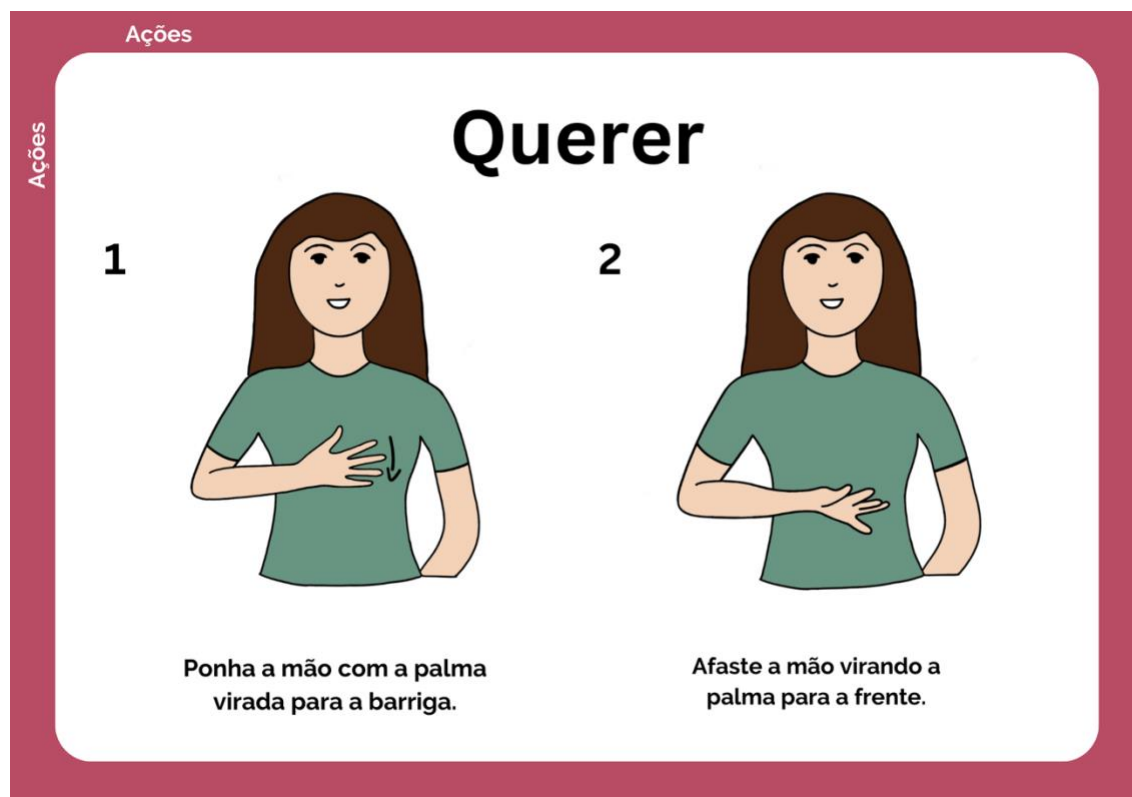


Figure E27. Portuguese Sign Language card for 'to want' (front)



Figure E28. Portuguese Sign Language card for 'to want' (back)

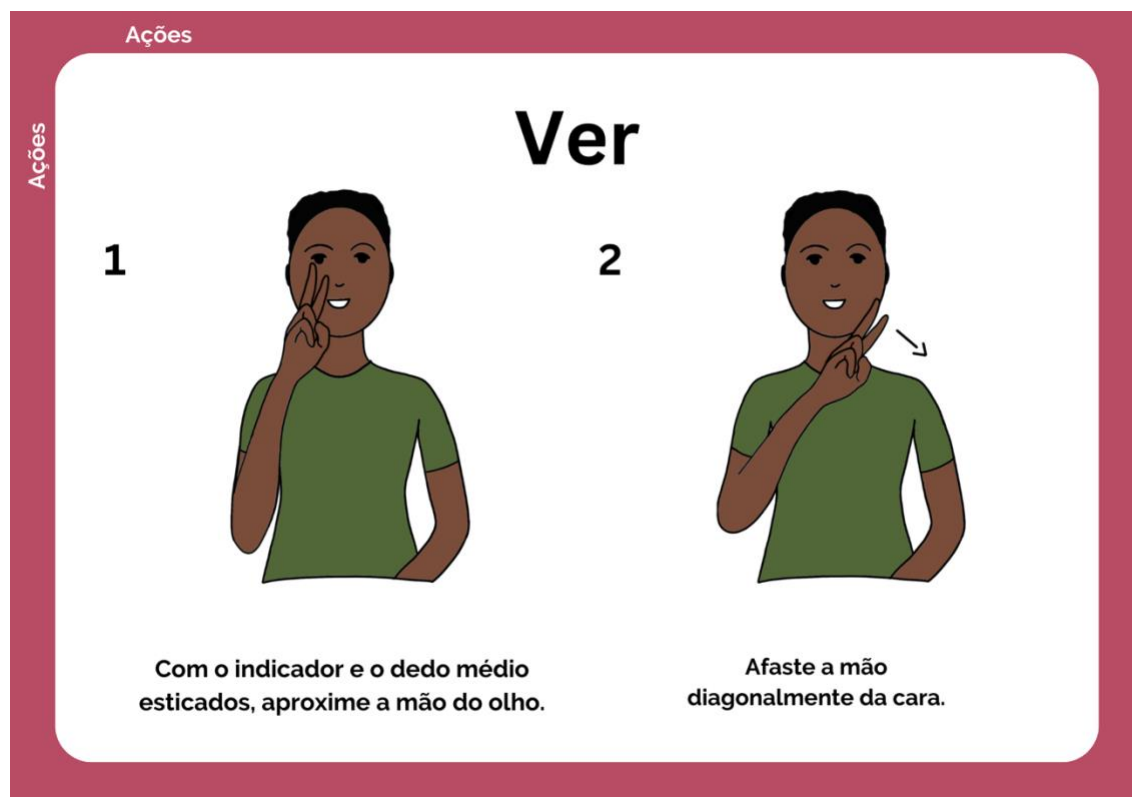


Figure E29. Portuguese Sign Language card for 'to see' (front)



Figure E30. Portuguese Sign Language card for 'to see' (back)

The IADE logo consists of the letters "IADE" in a bold, sans-serif font, enclosed within a white rectangular box that has a diagonal cut on its right side.

2023

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