

A Community Driven Dictionary for Portuguese Sign Language

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Thesis to obtain the Master of Science Degree in

Computer Science and Engineering

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October 2025

Declaration

I declare that this document is an original work of my own authorship and that it fulfills all the requirements of the Code of Conduct and Good Practices of the Universidade de Lisboa.

Acknowledgments

First and foremost, I would like to thank **Francisca Ordaz** for her recommendation in pursuing a dissertation under the guidance of Professor Hugo, as well as for her previous work in the Annotation Platform, which set an excellent precedent for our work, and without her, none of the work would have been possible.

I thank **Patrícia Piedade** for her onboarding in my internship. Her guidance and knowledge at the beginning of this project were crucial for me to shape it and get it started. Also, a huge thanks for being my Interaction Design teacher; that experience was very cool.

I would also like to thank **Ana Henriques** for all her availability and sympathy in designing all the annotation for the platform, without her art, the project would not have been possible.

I thank **João Nogueira** for his guidance in the projects and technology stack, which were vital for me to start my Project, as well as his help with other projects over at ITI.

To **Mara Moita**, I extend my thanks for testing the dictionary in the schools; it was vital to get children's feedback, and it set a foundation for our work.

To **Helena Carmo**, for utilising our annotation module so thoroughly and giving us feedback, as well as helping populate the dictionary.

I massively extend my thanks to Professor **Paulo Vaz de Carvalho** as he was a fundamental part of our journey. From translating sessions with the DHH community to testing all the modules of the dictionary, the annotation, and the crowdsourcing, and populating them. Not only that, but his kindness and eagerness to help and give feedback were essential to this Project, and it would not have worked without him. Um forte abraço, Professor.

To the children at **IJRP** and **EREBAS**, my humblest thanks for all your help. I hope you can procure all that you look for in life.

To the **DHH Community** in Portugal, I hope I was able to help, even in the slightest of ways, so you can be more represented and have more resources—my kindest thanks.

I thank Professor **João Guerreiro** for all his feedback in our session at my Project's defence. It was very valuable feedback that deeply solidified our work.

For her guidance, sympathy, patience and knowledge, I would love to thank Professora **Isabel Neto**,

as all her input and help in mediating sessions, talking of our work and helping in the schools (and all the free car rides!), massively boosted the work I was able to produce in the platform.

To Professor **Hugo Nicolau**, I extend all my thanks for not initially knowing me and taking a chance on me, as well as giving me this once-in-a-lifetime opportunity to create a project that helps a community, and for all your sympathy, knowledge and patience with my work. Without your help, none of this would have been possible.

To my friends from FCUL: **Bruno Brandão, João Funenga, João Pena and Fabiana Silva**, thank you for sticking with me through all these years and for our random talks over everything; they have made my mind more at ease and enabled me to push forward.

To my friends from IST: **André Alves, Guilherme Gago and Miguel Nunes**, it has been my honour to go through these two years with you. It has been a lot of fun, and if I could, I would do it all over again with you all.

À minha 'Ti **Celina**, que já não está connosco, que me viu crescer, penso em si todos os dias. Obrigado por tudo.

Aos da Guarda, à minha tia **Luísa** cuja compaixão e carinho me acompanham todos os dias, à minha prima **Paula** que nunca me esqueço das gargalhadas e da ternura, e ao meu tio **Cardoso**, que já não estás connosco, que nunca me esqueço das galhofas que demos e das piadas que partilhámos. À minha prima **Miano** e ao meu primo **Mike** que já são muitos anos de camaradagem e de batota, o meu forte abraço a todos.

To my goddaughter **Aurora**, whom I wish all the best and hope she can meet all her life goals while being the happiest possible, next to her crazy godfather and uncle. To my sister-in-law **Leonor**, my gossip and tea companion, I wish her all the happiness and the best in life, with many more gossips to come. Moreover, to my brother, **Rodrigo**, who supported me during my highest and lowest, made my childhood both heaven-on-earth and a living hell, and helped me grow and overcome my most significant obstacles and limits—tight hugs to all of you.

À minha avó **Ibraíma**, que também me viu crescer e que é uma parte fundamental da pessoa que sou hoje, um obrigado não é suficiente pelos sacrifícios que fizeste por mim, e pelo companheirismo e amor que me deste a vida toda. Um beijinho enorme.

Aos meus pais, **Graça e José Santos**, quero agradecer todos os meus anos, todos os meus feitos e toda a paciência que tiveram comigo, nos meus percalços e nas minhas vitórias. Agradeço-vos por todos os anos que me criaram, e todo o amor e educação que me deram, que abriram portas a todas as oportunidades que tenho.

To my life partner, **Rita Dias**, I have nothing but love for you. Thank you for all these amazing years together, supporting me at my lowest, for your help, and for the moments we have shared. I hope there are many more chances we can look forward to.

Last, and certainly not least, to my best friend **Nilô**. For always sticking with me, being by my side every single day, always listening to what I have to say, with no judgments or hard feelings, only love and a wagging tail. I know you will never be able to read this, but most things I do, I do them for you. You got me through the Master's so I could hopefully provide you a better life someday. You are my motivation. I love you, Nilão.

We acknowledge the support of DCitizens, funded by the European Union's Horizon Europe Framework Programme under grant agreement 101079116, and DCLGP (2022.06596.PTDC) funded by FCT

This Project would not have been possible without all of you, and it has been one of the greatest honors of my life to be a part of. Thank you.

Abstract

Portuguese Sign Language (Lingua Gestual Portuguesa, LGP) is a young language officially acknowledged by the Constitution of the Portuguese Republic in 1997. The natural language of the Portuguese DHH (Deaf or Hard of Hearing) community, lacks standardized mechanisms to keep up with emerging terms. Communities decide which sign to use based on a temporal or local basis, creating multiple signs for different regions. Some signs are used, while others are lost. This lack of standardization creates obstacles to language growth, preservation, learning, communication and collaboration between LGP signers. This work proposes a community-driven dictionary for the DHH communities dispersed throughout Portugal propose, deliberate, and accept new signs. The solution consists of a crowdsourcing platform with deliberative mechanisms, allowing users to submit and deliberate sign entries. These mechanisms also allow users to participate in a community setting, engaging in the platform and with each other. Our development process followed a User-Centered Design approach to engage with the DHH community. Towards the aforementioned, we organized a workshop, collected data through a journey map, and refined our data into Empathy maps. We used said data to implement the features of the community, through iterative phases to check the features with the Community, and ensuring a fair representation. We analyzed user participation, with forms, appraised opportunities and difficulties of the platform through thematic analysis. In this project, we want to empower the Portuguese DHH community to take ownership of LGP through a community-based web platform.

Keywords

Portuguese Sign Language; LGP; Online Sign Language Dictionary; Crowdsourcing; Deliberation Mechanisms; Governance Mechanisms

Resumo

A Língua Gestual Portuguesa (LGP) é uma língua recente, oficialmente reconhecida pela Constituição da República Portuguesa em 1997. Sendo linguagem natural da comunidade Surda Portuguesa, tem a falta de mecanismos padrão para o rápido avanço de termos emergentes. As sub-comunidades do país escolhem que gesto utilizar com base em temporalidade e localidade, criando várias variantes para diferentes regiões. Alguns gestos são usados, outros perdidos. A falta destes mecanismos padrão cria obstáculos no crescimento, preservação, aprendizagem da língua, cria uma falta de comunicação e colaboração entre gestuantes de LGP. Este trabalho propõe um dicionário gerido pela comunidade Surda de Portugal, de maneira a que possam propor, deliberar e aceitar novos gestos. Esta solução consiste numa plataforma de crowdsourcing com mecanismos de deliberação, permitindo aos utilizadores submeter e deliberar propostas de gestos. Estes mecanismos permitem aos utilizadores participar num ambiente de comunidade, interagindo assim com a plataforma e os seus utilizadores. O processo de desenvolvimento seguiu uma abordagem de Design Centrado no Utilizador de maneira a interagir com a comunidade Surda. Organizámos um Workshop, colecionámos dados seguindo um Journey Map, centralizámos estes dados em dois Empathy Maps. Implementámos as funcionalidades, seguindo um processo iterativo de forma a manter contacto com a comunidade Surda, garantindo uma forte representação. Analisámos a participação, pontos positivos, negativos e melhorias, a partir de Análise Temática. Com este projeto, queremos que a comunidade Surda Portuguesa possa ficar responsável pela sua Língua, a partir de uma plataforma web que represente a sua comunidade.

Palavras Chave

Língua Gestual Portuguesa; LGP; Dicionário Online de Língua Gestual; Crowdsourcing; Mecanismos de Deliberação; Mecanismos de Governância

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Acronyms

APIs Application Programming Interfaces

ASL American Sign Language

BaaS Backend as a Service

CSL Chinese Sign Language

DHH Deaf or Hard of Hearing

KRSL Kazakh-Russian Sign Language

LGP Língua Gestual Portuguesa/Portuguese Sign Language

LIBRAS Brazilian Sign Language

LIS Lingua Italiana dei Segni, Italian Sign Language

LSA Latent Semantic Analysis

LSE Spanish Sign Language, Lengua de Signos Española

NZSL New Zealand Sign Language

ODNZSL Online Dictionary of New Zealand Sign Language

SPAs Single Page Applications

SSR Server-Side-Rendering

STEM Science, Technology, Engineering, and Mathematics

1

Introduction

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In Portugal, the *Língua Gestual Portuguesa*/Portuguese Sign Language (LGP) is a visual-gestural language which performs a very significant function as a communicating and cultural identity means of expression of the Deaf Portuguese communities. It is an accepted expression of culture by the Portuguese Constitution since 1997 and is recognized as an instrument for access to education and equal opportunities¹.

It means the learning of LGP is vital in ensuring the active integration of Deaf people into the community and society. Several specific educational programs are being developed to promote LGP, including designing the curriculum for Deaf students [2].

Like any other language, sign languages are dynamic and constantly evolving. Linguistic change occurs due to changes in culture, society, technology, and the relationships between different speech communities [3].

Crowdsource is, characterized by the Oxford Dictionaries, the activity of getting information or help for a project or a task from a large number of people, typically using the internet². When applied to a language, crowdsourcing can allow an organic evolution of a language contributed by its community.

1.1 Problem

There is a gap in mechanisms to deliberate new terms in LGP, as well as the inclusion of these new terms in a LGP Sign Language Dictionary, leading to a lack of consensus regarding emerging new LGP terms among Deaf or Hard of Hearing (DHH) community members, thus limiting language growth and communication, which includes collaborative standardized processes for creating, discussing, and agreeing on new signs for emerging terms in LGP.

Furthermore, LGP users are a linguistic minority, are geographically dispersed and do not have a method to submit new signs to deliberate with the Portuguese DHH Community and accept these new submissions, therefore making it difficult to reach a consensus on emerging terms, limiting deliberation, communication, knowledge learning, and language development.

There has been similar work in the area of sign language dictionaries in other countries [4–10]; however, there is not a single platform for a crowdsourced sign language dictionary coupled with deliberation mechanisms for sign gesture proposals.

Furthermore, existing dictionaries usually focus on expert-driven approaches [4–10], that is, laboratory methodological steps, leaving no room for community-based contributions.

As well as for existing crowdsourcing platforms for sign languages that do exist [5, 11–22], there is a lack of a platform with structured mechanisms that lets users debate and therefore come to a consensus on new signs, focusing only on immediate video submission and at most with a like-dislike ratio system

¹<https://www.portugal.gov.pt/en/gc23/communication/news-item?i=talking-hands-today-is-portuguese-sign-language-day>

²<https://www.oxfordlearnersdictionaries.com/definition/english/crowdsourcing>

and a comment section. There is also a tendency to focus on more centralized and better-known sign languages, such as American Sign Language or Chinese Sign Language.

The **main limitation**, however, is that previous approaches have not addressed how to integrate community-driven processes to evolve and debate LGP and have also not addressed decentralized methods for dispersed members throughout the country.

1.2 Approach

In this work, we focused on creating a crowdsourcing platform, a web-based platform that allows users to create, update, and contribute to a sign with their videos and discussions.

We implemented consensus-building mechanisms, integrated into the platform, such as comment sections, a voting system, expert moderation teams which include the Portuguese DHH community itself, with the help of knowledgeable linguists.

The crowdsourcing module also reinforces existing resources, as it will be built on top of a dictionary, and each user will contribute to it, letting the dictionary flourish and helping the LGP language evolve.

For our investigation methodology, we used a User-Centered Design³ approach, built upon the principles of iteration and collaboration. Groups of people from the DHH community and the people responsible for the Dictionary from Universidade Católica Portuguesa, also a part of the DHH community, contributed, in an iterative process, to the design process and, therefore, provided feedback, suggested ideas, and participated in the decision-making of the crowdsourcing module and platform, which resulted in a product specifically tailored to the needs of the Portuguese DHH community.

All of this will empower the Portuguese DHH community to take ownership of their language and shape it the way they are intended to, through a crowdsourcing web-based platform that fosters inclusivity, linguistic development and cultural identity.

1.3 Goals

Community-driven Dictionary: With this work, we expect to have a design contribution of a community-driven framework for crowdsourcing the evolution of LGP and sign languages in general, with the main focus being on consensus-building mechanisms and participatory engagement.

We expect to contribute with a web platform prototype that will let LGP users propose and deliberate on new and existing signs, letting them contribute with their videos and other ways of participating through various deliberative and governance implemented methods such as a like-dislike system, comment sections through video or text and user contributions, therefore providing sustainable mechanisms

³<https://www.interaction-design.org/literature/topics/user-centered-design>

for language maintenance and evolution.

Design Led by the DHH Community: We expect to contribute with a formative study, which happened in the form of a workshop with a focal group of five DHH Portuguese participants, and focused on the flow of the platform on the "Proposal"- "Deliberation"- "Acceptance" process of a new sign in LGP. This formative study answers the following research questions, "What do the Deaf or Hard of Hearing expect from a LGP crowdsourcing platform?", "How will we operationalize the deliberative mechanisms?" and "What challenges arise in the validation process, and how can these be mitigated?"

Field Deployment and Evaluation: We deployed the platform and collected data in two different instances: a first-cycle school deployment to evaluate the annotation functionality and overall user experience and refinements to the dictionary, and the crowdsource deployment, where we deployed our dictionary to the general audience, gaining insights on the dictionary platform, its positive and negative aspects, feedback on the different features, and inquires over its potential.

A Platform used by the community: After our work has been concluded, the platform will continue to be deployed, and the community will use the platform to deliberate new terms to evolve and maintain its language, therefore letting the LGP DHH Community take ownership over their language.

Building these community-driven language resources will help make the language dynamic, relevant and attempt to survive the test of time whenever newer terms emerge.

1.4 Thesis Structure

The thesis will be structured as follows:

Chapter 2 outlines and sets the basis for understanding fundamental concepts of Sign Languages, the history and importance of LGP, and Deliberation Mechanisms and Governance in Digital Platforms.

In Chapter 3, we take an overview of available Digital Sign Language Dictionaries, some available Crowdsourcing Systems, Deliberation Systems, and discuss what each of these systems offers and, most importantly, do not offer, as we identify the gap in the literature.

In Chapter 4, we discuss the formative studies about the crowdsource module, conducted before the implementation of the Dictionary and all its features. In this chapter, we also mentioned the system's architecture, all the modules implemented with their features, most notably the Sign Search Engine and its algorithms, and the two distinct dictionaries present in the platform.

In Chapter 6 we discuss our Usability Evaluation for the Crowdsource Module, including our participants, the procedure, the method of data collection and analysis, its findings, limitations and discussion of the overall study.

For Chapter 5, we go in-depth regarding our main feat, the deployment in schools, and the various iterations made to the dictionary platform, including its User Interface, the number of sign entries

annotated for children, and the changes made to the annotation module.

Finally, in Chapter 7 we conclude our thesis with our significant achievements, limitations and some of the future work that could be done with the platform.

2

Background

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This section will explore Sign Languages and Portuguese Sign Language History, featured in the 2.1 section. Furthermore, we will also approach some democratic and deliberation models, at section 2.2. Finally, we will review governance and its mechanisms, discussed in section 2.3.

2.1 Sign Languages and Portuguese Sign Language History

LGP, short for *Lingua Gestual Portuguesa*, or Portuguese Sign Language, has been acknowledged as an official Portuguese language since 1997 by the Constitution of the Portuguese Republic. There are approximately thirty thousand Deaf people who communicate through LGP¹. However, we cannot address LGP without first understanding its history, which is closely linked to deaf education in Portugal [2].

Throughout the document, there will be different uses of the word Deaf, capitalized, and deaf, uncapitalized; we need to distinguish them, as the difference is quite significant.

Deaf with a capital 'D' extends beyond the medical definition caused by hearing loss. It signifies cultural and societal identity, gathering a community that shares a common language, usually sign language, while also experiencing hearing loss. This term emphasizes a sense of belonging and community.

Meanwhile deaf with a lowercase 'd' refers to the medical condition of significant hearing loss, used in clinical and audiological contexts to describe individuals who have limited or no hearing capability, focusing then on the physical aspect, from various ranges, mild to profound used in medical diagnosis and health discussions, rather than the belonging of a specific cultural group².

Sign Languages, fundamental to communication for DHH (Deaf or Hard of Hearing) communities worldwide, are performed through physical movements rather than spoken dialogue. The origins of sign languages and LGP are still the focus of investigation.

The earliest reports of Sign Language Education go back to sign language creation within monasteries [23], leading us to the first Sign Language report, which can be attributed to Pedro Ponce de León [23].

It was the creation of Deaf Institutes at the end of the eighteenth century that served as a vessel for the creation of the first Deaf communities; of significant consideration, the first deaf school opened by Abade de L'Épée in 1760, the *Institution Nationale des Sourds-Muets à Paris* [24].

Outside the classrooms, some natural sign languages were used to communicate between deaf students, their professors and deaf auxiliary personnel. The model of the *Institution Nationale des Sourds-Muets à Paris* would expand throughout the nineteenth century, throughout Europe and America, thanks to the efforts of Abbot Sicard [24].

¹<https://portalvozes.com/a-evolucao-da-lingua-gestual-portuguesa/>

²Definitions by: <https://accessible.com/glossary/deaf-vs-deaf>

There were some Deaf Institutions that opened afterwards, such as the Real Instituto de Surdos-Mudos e Cegos de Portugal in 1823 [24].

Portugal received influence from the Paris Institute through the Swedish Professor Pär Aron Borg (hired by the Portuguese king, D.João VI), who would fund the Real Instituto de Cegos e Surdos-Mudos. There was a teaching method for in-class activities and a natural sign language for the Deaf to communicate among themselves within the Portuguese Institute, between deaf children. In 1828, Pär Aron Borg returned to his country, leaving the Institute in the care of his brother, Joham Borg, who, not long after, passed away. The Institute then came under the guidance of the Portuguese Professor José Crispim da Cunha and, in 1834, integrated into Casa Pia de Lisboa. In 1860, the Deaf teaching methods in Casa Pia de Lisboa became extinct [24].

There were some initiatives to create classes and colleges for the Deaf community. The Colégio de Surdos-Mudos de Guimarães, of greater renown, by Priest Pedro Maria Aguilar. In 1905, Nicolau Pavão de Sousa, Professor from the Instituto Araújo Porto, and in consequence of the Milan Conference³, established the pure oral method. It would begin the Oralist Period for Deaf teaching, which lasted until the 1980s. There are no references from 1905 until 1974 of gestural communication between the Portuguese Deaf Community [24].

In 1974, the phonetics laboratory of the Faculdade de Letras da Universidade de Lisboa started a collaboration with the Divisão de Ensino Especial (Special Education Division) da Direção Geral do Ensino Básico, with the primary purpose of having an education on the domain of the linguistic of special education teachers, in particular, of Deaf or Hard of Hearing people, for the development of pedagogic material for the Portuguese language. During this collaboration, there came to be some reflections on the nonsuccess of the oralist teachings in Portugal and alternative communication methods being used in other countries [24].

Despite the oppression that the Portuguese Deaf community went through during the Oralist period, their natural language was able to survive and evolve, and despite being banned in the Milan Conference mentioned above, young Deaf individuals secretly used it to communicate among themselves, similar to what happened in other countries. There were some sports groups where the Deaf community could join and talk with each other about their struggles and day-to-day occurrences. In 1958, the first Portuguese deaf association was created, the Associação Portuguesa de Surdos. This union was further strengthened by the events occurred in April 25th, 1974⁴, the democratization of Portugal, allowing the Deaf community to reinforce their bonds, their cultural identity, and letting the community acknowledge that they have an identity and their language, that distinguishes and values them. On November 15th 1995, the Portuguese Deaf Association, led by Professor Helder Duarte, had the initiative to officially recognize

³Conference in Milan that lead to the pure educational oral method for the Deaf, throughout all Europe, and banishment of sign languages: https://en.wikipedia.org/wiki/Second_International_Congress_on_Education_of_the_Deaf

⁴The Carnation Revolution, the day the Portuguese got their democratic liberty: https://en.wikipedia.org/wiki/Carnation_Revolution

LGP and therefore gathered representatives from Deaf associations across the country, Deaf parents and associations, Professors, linguists, young Deaf people to discuss strategies to achieve this mean. This initiative lasted for years, ever since the foundation of their association in 1958. However, it was catalyzed by the Carnation Revolution and ended in July 1997, when it was unanimously approved by the Portuguese deputies. Other achievements followed, such as bilingual teaching of Deaf youth, where their first language would be LGP and their second language would be "traditional" Portuguese, as well as more accessibility features for the Deaf community, such as captioning and interpretation of spoken Portuguese shows, and more quality of life features and improved human-rights in workplaces [24].



Figure 2.1: Cover image of the seventh issue of the second series of Deaf Culture 2023, the main Source used for our Portuguese Sign Language History section. Cover: © António Cabral and Cristina Gil.

Sign languages gained recognition as fully developed natural languages, with grammar and structure similar to spoken languages [1]. Research from Tenant and Brown [1], in ASL, some parameters characterize the complexity and expressiveness of signs. These include the hand shape, palm orientation, location and movement, the latter adding several meanings to a sign, such as variation in volume, the sense and adverbial aspects. All these parameters collectively enhance the sign's specificity. Non-manual parameters, such as body and facial expressions, head position and mouth movement, collectively add a semantic depth to the message. The language also has a spatial dimension parameter known as the signing space.



Figure 2.2: The Signing Space, taken from *The American Sign Language Handshape Dictionary*, by Tenant and Brown [1]

In LGP, there are similar components, and it shares the same parameters as ASL. A gesture is described by position, the types of gestures, hand configuration, movement, orientation and facial expression [25, 26].

Therefore, evolving sign languages signifies community-owned language development and growth in preserving and building on a language representing the culture and experiences peculiar to the individuals within it, as well as the language evolution through daily interactions and organic discussion within the community that creates new terms and signs. The structure in sign languages, so elaborate, rich, and full of nuance, is by no means some kind of translation of spoken language but an independent one that possesses all properties of grammaticality, syntax, and semantics. As with the development of LGP, specificity and depth in sign language communication depend on several parameters: hand shape, movement, palm orientation, location, and non-manual signals such as facial expressions and body postures. These and the spatial dimension of signing make sign languages as subtle and dynamic as spoken languages. It is, therefore, important that awareness of the community's role in developing their language and sensitivity to those variables within schools and society continue to enable signed languages to grow and flourish as a rich resource for communication and the expression of culture.

2.2 Deliberation Mechanisms

Democracy can be a collective term for many regimes, such as radical democracies or even moderate ones [27]. Schmidt [27] argues the list goes on as these include radical democracies, moderate democracies, battles between parliamentary and presidential governments, majoritarian versus consensus democracies, and even established democracies opposed to partial democracies.

Deliberation is a cornerstone of democratic Governance and is about the citizens' role in their decisions through informed and reflective discussion. Deliberative democracy is the key idea, which is a theory stating that getting a trusted democracy is not only a result of a vote but also a consequence of logical talks where different views are expressed. Social scientists maintain that when people discuss issues, they develop the capability to understand each other, are less inclined to take polarized positions,

and, therefore, their decisions enjoy higher legitimacy [28]. The outcome of the practical application in the context of the democratic process of the people is seen as one that directly yields a better quality of democratic decision-making by involving diverse viewpoints and or arriving at everyday decisions [29].

This section will treat items evidenced in **bold** as important deliberation mechanisms.

The Wikipedia page for democracy has a vast list of its types⁵. Ranging from direct democracy, deliberative democracy, representative democracy and its subtypes, such as parliamentary democracy, and type location-based democracies, like workplace democracy, ethnic influence democracies, religious democracies, and even others, such as hybrid regime democracies, for example, the liquid democracy.

According to Morlino [30], a "good" democracy presents a stable institutional structure that realizes the liberty and quality of its citizens through the legitimate and correct functioning of its institutions and mechanisms. This broadly legitimate regime completely satisfies its citizens regarding the quality of its results.

Direct democracy is a term that encompasses a variety of political processes, all allow ordinary citizens to vote on laws directly rather than candidates for office, ranging from the old town meeting assemblies to the most modern elections, in which citizens **vote either positively or negatively, on specific laws listed on the ballots, known as ballot measures or propositions**⁶. These ballot measures differ in how they originate in the ballot, **they can originate through an initiative, that is, a new law proposed by an ordinary citizen, that is qualified to be chosen after collecting a predetermined amount of signatures**. The measures can also be a **referendum, a petition referendum, a vote on a law already approved by the legislature, either to contest its rule or to clarify it, qualified by the ballot and by a collection of votes**. There are also **legislative measures, or legislative referendums, that are placed on ballots directly by the legislature, either to gather public opinion or requirement of widespread approval** before a law can be taken into place [31]. Matsusaka [31] argues that an issue of direct democracy, and a recurrent criticism, is that ordinary voters lack the expertise to make policy decisions.

Deliberative approaches in engaging with communities are characterized by processes of reasoning, where participants are given a chance to reflect, discuss, and think [32]. Quoting parts of *deliberativecitizenship.org*⁷, "(...)Rarely these days do persons who are neither family members nor intimate friends gather to take account of their differences and mutual interests(...). Deliberation, therefore, is not simply "talk about change," but a central step in the process of advocating for and enacting change. Without the agreements, negotiation, and new alliances that deliberation can yield, change is difficult or even impossible.". Parkinson [33] also argues that in its normative version, deliberate democracy is based on the principles of reasoning between people as its guiding political procedure rather than bargaining be-

⁵https://en.wikipedia.org/wiki/Types_of_democracy

⁶A ballot measure is a law, issue or question that appears on a statewide or local ballot for votes of that jurisdiction to vote, definition by: https://ballotpedia.org/Ballot_measure

⁷<https://deliberativecitizenship.org/frequently-asked-questions/>

tween competing interests. The political act, the essential of giving, weighing, accepting or rejecting the proposals, and the deliberation are public acts, not private acts of voting. Therefore, democracy could be compared as a forum for the creation of public agreements, where the better argument is exercised, and to ensure that public reason is not dominated by private power in public discussion, deliberative democracy requires equality between participants [33].

Furthermore, deliberation requires **community engagement** [32]. According to Gregory et al. [32], community engagement is the **process of involving the community in planning and developing policies and services**. They also argue deliberative approaches to community engagement **center on involving the community in deliberation about several issues**, in the ideal case leading to concrete proposals that can and are adopted by policy makers [32].

Parliamentary democracy is the world's most popular democracy. Around a third of the world's population uses this regime. Most citizens accept parliamentarians as their conduct for popular representation, and it has widespread support from the scholarly community. Two fundamental and central ideas regarding the conventional understanding of parliamentary government exist: parliamentary supremacy and the **unified power**. The parliamentary government originally meant parliamentary supremacy; it implies that the parliamentary front bench is the focus of executive decision-making. Parliamentary supremacy came to be an extensive delegation to the cabinet⁸, resting on their threats of resignation or dissolution [34].

Furthermore, parliamentarism has taken a more consensual form, in which cabinet coalitions⁹ are more frequent. In the coalitional systems, the catalyst of decision-making has shifted from the parliamentary front bench to party organizations outside the parliament, therefore becoming understood as a unified government system, represented by elected candidates [34].

Workplace democracy is a group of systems for workers or their representatives to exercise power. The idea of a democratic work organization has regained traction in recent decades, after its forgetfulness until the late 1970s. Some arguments have been made to grant self-management to workers, from self-organization of work in production units to strategic decisions regarding hiring policies, product development, and commitment to social and environmental values. There have also been organizational solutions to democratizing the workplace, such as **reforms of hierarchical structures, delegation systems based on workers' representations as well as more involved forms of workers' direct participation through work councils** [35]. It is argued that workplace democracy and capitalism are incompatible; therefore, for workplace democracy to work, there would need to be a reform of the entire economic system [35].

⁸Group of people with the constitutional or legal task to rule a country or state or advise a head of state, usually from the executive branch. Source: [https://en.wikipedia.org/wiki/Cabinet_\(government\)](https://en.wikipedia.org/wiki/Cabinet_(government))

⁹Government by political parties that enter into a power-sharing arrangement of the executive. Usually, it occurs when no single party has achieved absolute majority after an election. Source: https://en.wikipedia.org/wiki/Coalition_government

Liquid democracy is a form of Proxy voting¹⁰, where an electorate **engages in collective decision-making through either dynamic representation or direct participation**. Using **elements from both direct and representative democracy**¹¹. Voters in a liquid democracy **have the right to vote directly on policy issues**, like direct democracy, as well as **having the option to delegate their votes to someone who will represent them in their best interests**, on a single policy issue, on one or more policy areas, or all policy issues in all policy areas, as a flexible delegation component. **They can also delegate those votes received via delegation to another representative, in meta-delegation components, as well as terminate the delegation of their votes at any time**, also known as an instant recall component [36]. Regarding the egalitarian justification of this democracy, the members of the liquid democracy are the **authors of their welfare who have the last word on deciding what is good or bad for their community** [36].

In the end, deliberation reinforces democracy through reflective discussion that is better informed and results in more legitimate and better-quality democratic decisions. Deliberation is used to greater or lesser degrees in various forms of democracy, such as direct democracy, deliberative democracy, and parliamentary democracy-from the citizen-led ballot measures of direct democracy to the representative processes of parliamentary democracy. For example, community engagement, initiative, referendum voting on laws, and workplace democracy are firmly based on active participation, reasoning, and dialogue. Innovation forms such as liquid democracy also further combine elements of both direct and representative democracies to allow dynamic citizens to take part in decision-making processes. Fundamentally, all these deliberative practices imply that democracy is not only about voting but a public accord resulting from consideration, inclusiveness, and diversity of opinions and interests.

2.3 Governance in Digital Platforms

There is no consistent meaning to the term Governance. It derives from the Greek verb *kubernan*, which means to steer a ship, which derives from the Latin verb *gubernare*, which led to the French term *gouverner*, which in turn came to originate the English terms of government and Governance. It applies to Corporate Governance, a settled meaning in business and legal circles during the 20th century, but became more common around the early 1990s. Governance is applied with much freedom to a good range of activities with a common denominator regulating social behaviour [37].

According to Fukuyama [37], the first uses of the word governance, also titled "International Government", regarding deliberate opposition to the term government, arose around the early 1990s in conjunction with massive literature on globalization. A good amount of observers noted that the ability of sovereign states to control behavior on the territory they controlled was weakened, driven by techno-

¹⁰https://en.wikipedia.org/wiki/Proxy_voting

¹¹Source: https://en.wikipedia.org/wiki/Liquid_democracy

logical change and increasing movement of people and their capital, as well as new ideas transmitted across different territories; it then culminated into international cooperation through non-sovereign bodies outside the borders of the state.

The second meaning, also known as "Good Governance", came as a synonym for effective implementation of state policy, driven by an interest in global poverty rooted in a corrupt and weak capacity state. An euphemism for traditional public administration is the implementation of policies by old-fashioned governments [37].

The third meaning of Governance, "Governing without Government", is regulating social behavior through networks and other nonhierarchical mechanisms parallel to domestic Governance. It emphasized actors outside the state, providing government-like services as complements or substitutes to traditional state institutions. [37].

Digital platforms have become intermediaries between the consumer, the producer, and service providers in modern economies. Good Governance becomes pivotal to ensure fair participation, innovation, and co-creation of value in such created ecosystems by digital platforms. There are two dimensions of governance mechanisms in digital platforms: one based on incentives and the other on control.

Incentive-Based Mechanisms: These mechanisms aim to provoke and galvanize behaviors in wanted participants within the platform. It would involve the following strategies: pricing models, reputation systems, and reward mechanisms. The platforms could apply tiered pricing to attract different user segments. Also, the contributions that provide more value may be remunerated. Reputation systems, in which users would grade other users, may also create an incentive for good interaction and building trust within the community of the platform's users [38].

Control-based Mechanisms: The mechanisms that define rules, policies, and enforcement procedures to guide the participants' behaviors within the platform. Examples include content moderation policy, user verification processes, and community guidelines enforcement. Control mechanisms should effectively prevent fraud, harassment, and other forms of misconduct that might damage the platform's integrity [38].

According to Chen et al. [38], there is a delicate balance in the interplay between incentive- and control-based mechanisms that would provide the best balance of flexibility and regulation for digital platforms. Too much control can kill user engagement and innovation, while too little might allow issues like misinformation and user exploitation to seep in. If not designed well, the incentive structure leads to unexpected behaviors that could hurt the platform's ecosystem.

Recent literature emphasizes the consideration of digital platforms as meta-organizations, or organizations that coordinate a network of autonomous entities through governance mechanisms rather than hierarchical control. This perspective emphasizes the careful design of governance structures that balance incentives and controls necessary to manage the ecosystem [38]. Chen et al. [38] also de-

bate whether it requires nuanced consideration of control-based versus incentive-based mechanisms but integrates both. Thus, careful design and balancing of both control-based and incentives-based mechanisms will enable context for fair participation, innovation, and value co-creation among various stakeholders by the platform owners.

Governance spans from corporate Governance over global cooperation beyond state borders to Governance without government. In modern economies, digital platforms act as an intermediary that needs Governance to ensure the fairness of participation, innovation, and value co-creation. The governance mechanisms on such digital platforms could be distinguished between incentive-based and control-based. Incentive mechanisms include pricing mechanisms, reputation systems, and various rewards that aim to encourage good behavior from participants. Control-based mechanisms involve content moderation and user verification-ensuring communities that guarantee users will behave well and not ill. A sensitive balance between those mechanisms is demanded: too strong control chokes innovation, and too weak control leads to mischief, such as misinformation. The growing recognition of digital platforms as meta-organizations underlines the importance of careful governance structure design, which balances both mechanisms in managing the ecosystem effectively.

3

Related Work

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This section will start with a general layout of available sign language technologies relevant to our work. Moreover, we shall tackle the available sign language dictionaries' technologies in-depth. Furthermore, we will explore crowdsourcing systems, their corresponding advantages and disadvantages. Finally, we will review some deliberation systems, their design choices and their corresponding advantages and disadvantages.

3.1 Digital Sign Language Dictionaries

Dictionaries are a fundamental tool for language erudition. Essential for vocabulary learning, acquiring new concepts and mastering previous knowledge.

Bragg et al. [4] detail a crowdsourced American Sign Language (ASL)-to-English dictionary, in which users form queries for unfamiliar signs based on sign parameters/features (as mentioned towards the end of sub-section 2.1). This dictionary utilizes Latent Semantic Analysis (LSA)¹ to enhance its search engine by focusing on the most searched signs. The system is composed of two independent subsystems: ASL-Search, an online ASL-to-English sign language dictionary that keeps records of the queries of the users to optimize its results, and ASL-Flash, an interactive tool for learning ASL, based on flash-cards, whose queries also contribute to the feature database. Some relevant contributions from this paper are the crowdsourcing of the queries for the sign search, both from ASL-Search and ASL-Flash, as well as the design of the dictionary. A significant limitation is the lack of sign corpus present in this platform. This paper also focuses on the crowdsourcing and improvement of a search engine, which is not the focus of our work.

Kankkonen et al. [5] established a community group on Facebook to crowdsource videos, as well as data and video collection at Deaf events (for example Deaf Day), for the Teckensspråkslexikon, the Swedish Sign Language Dictionary. Two relevant contributions of this paper are the objectives to differentiate different dialects and sign placements among different age groups of DHH signers and, if given various ways to sign a word, which would be appropriate for a given situation. A limitation of this work is that for mass aggregation and data collection, they depended on a specific day, Deaf Day, for a richer contribution and interaction with the DHH community as it allowed direct contact, with better control over signer metadata and responses, the videos would then be manually annotated on site. At the same time, the Facebook group served for collection, albeit poorer in content and with less contextualization.

¹https://en.wikipedia.org/wiki/Latent_semantic_analysis

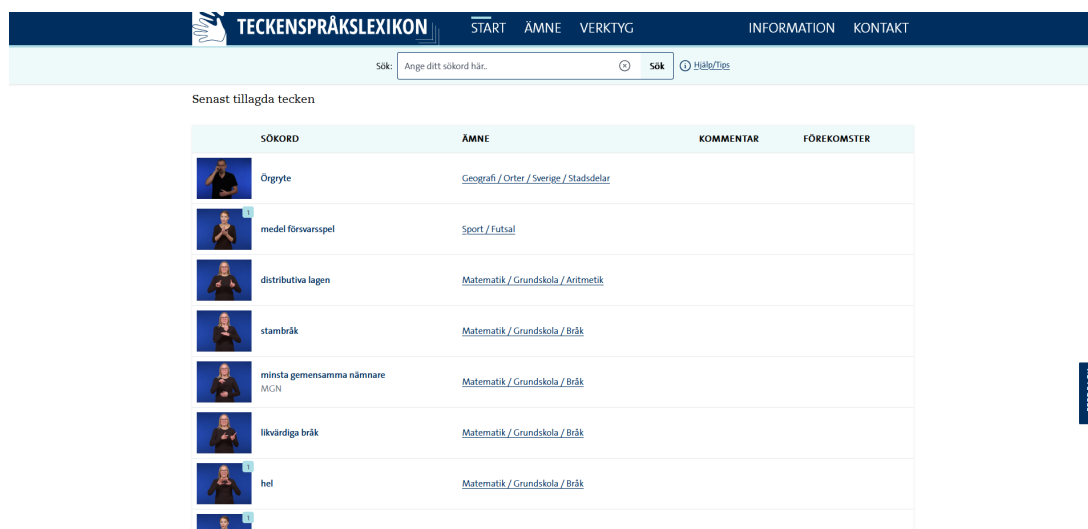


Figure 3.1: Teckenspråkslexikon, also known as Swedish Sign Language Dictionary, taken from: <https://teckensprakslexikon.su.se/>

In Spain, the first LSE-Spanish bilingual sign language dictionary was developed [6]. According to Fuertes et al. [6], they had to ensure the content of the dictionary was both accurate and realistically reflected the language, such that they compiled the most significant words from a meticulous review of Spanish Sign Language, Lengua de Signos Española (LSE) dictionaries. An important observation taken from this study was the lack of a flexible and dynamic governing body in LSE to decide which words should be included in the language or not, as well as the creation of new signs, such that it may lead to an emergence of signs that represent the same concept. Before any quality audio-visual communication systems became widespread, these new signs were confined to the regions they had emerged from and what can be denominated as geographical or regional varieties of a sign.

Similarly, Vettori [7] presents a first-attempt design of an Italian bilingual sign language dictionary, which contains definitions and examples of words in Italian and translations to Lingua Italiana dei Segni, Italian Sign Language (LIS), as well as the reverse. The author emphasizes recognizing LIS as an independent language and respecting the Deaf Community. This dictionary had its corpus built from scratch, as no LIS corpus was available. There were no frequency studies that gave them a range for each sign from which to determine the level of complexity of a sign, such that the author assigned a range from a project and published Italian dictionary and compared the frequency lists available for spoken Italian, resulting in a list of signs that appeared seemingly elementary vocabulary. This sign language dictionary was made for two groups: LIS signers, who should be able to formulate LIS queries, and hearing Italian speakers who are learning LIS. Two search engines in the dictionaries were developed, one from LIS to Italian and another from Italian to LIS. There are no findings in this paper. However, we can be inspired by its design and idea, which aligns with our work.

Vale [8] reports on a mixed method user study for the Online Dictionary of New Zealand Sign Lan-

guage (ODNZSL), focusing on questions such as who the users of the dictionary are, their motivation for consulting the dictionary, aspects of their dictionary consultation behaviour and problems they might have had with the dictionary. This online dictionary was built upon reviewed and validated data based on the earlier print of the Dictionary of New Zealand Sign Language and the Concise Dictionary of New Zealand Sign Language, from approximately 4,500 headwords. It is constituted of a home page, which provides background information on New Zealand Sign Language (NZSL), such as grammatical information regarding the number system, a finger-spelling alphabet, a help menu which contains a glossary of terms used in the description of signs in the dictionary, advice for learners with hyperlinks to learning exercises, hyperlinks to relevant organizations and a contact form that allows users to provide feedback or ask questions. There are also three search methods: Search by word, in English or Māori, a standard search box that brings predictive text suggestions in the dictionary once a user starts typing. A search by sign features allows users to select two main phonological features of a sign from a menu of images: the hand shape and the location where the sign is produced. Moreover, an advanced search allows a combination of the two aforementioned search methods, a choice of topics for a thematic search, and a list of five usage tags: neologism, archaic, obscene, informal, and rare. Some contributions that can be taken from this paper are the idea and design for the platform and their evaluation method, evaluation through log files, as they are on par with what we will be doing with our work.

Kristoffersen and Troelsgård [9] present The Danish Sign Language Dictionary, a dictionary composed of an entry header, which shows the sign headword as a photo and gloss, as well as the location and handshape of the sign appearing as icons. A video window showing the base form of the sign headword by default, with other video variations also shown but activated by clicking play buttons on different sections of the entry. A meanings window, where the meanings of the sign are shown, such as Danish equivalents, description of the usage of the sign, mouth movement, cross-references to synonyms, information about restricted use and example sentences. There is also an additional information tab with cross-references to homonyms and common frozen forms of the sign. The signs in the dictionary can be looked up through handshape; specific hand shapes for the active and passive hands can be specified, as well as the location in the body, text search, and topic search. No results are mentioned in this paper, so the contribution we can gather from the paper is the design of the dictionary platform.

Hilzensauer and Krammer [10] present SpreadTheSign², the largest online dictionary for sign languages in the world, covering more than half of European Sign Languages as well as non-European, targeted to deaf vocational students traveling to other countries, sign language interpreters and all people interested in sign languages that want to learn or compare signs from different sign languages. It started as a vocational dictionary but is no longer limited to vocational topics. Fifteen partner countries, including Portugal, translated a list of English words and sentences to their national and national sign

²<https://www.spreadthesign.com/en.us/search/>

languages. There are no evaluations in this paper. Therefore, the contributions we can gather for our work are the dimension of the crowdsourcing work made among all fifteen partner countries, harnessing nearly 15,000 signs for each country, and the idea for the dictionary.

3.2 Crowdsourcing Systems

Crowdsourcing can be described as the gathering of a diverse crowd of people with commonly aligned goals to improve a particular idea and/or produce content.

Among the earliest efforts to create a collaborative space for knowledge gathering, Cavender et al. [11] pioneered the first crowdsourced video-sharing forum for sharing ASL Science, Technology, Engineering, and Mathematics (STEM) signs and terminology and further discussing them. Said platform is a web resource that provides a path for collaboration and discussion of ASL terminology for STEM topics. This forum platform relies on the contributions of users to thrive in the way of video posts, with no previous technical skill required. The platform is hosted online, has star ratings, promotes the highest-rated content, obscures the lowest-rated ones, and includes text comments; furthermore, a quick-capture applet to record videos in the web browser window. The forum was divided into categories for better workflow. Some limitations are the lack of variety in STEM signs, as with the star rating, the promoted content made the other newly published signs with lower ratings fall in popularity, being less accessible. It also fell short of reaching a mass audience due to the lack of signs that did not generate discussion, lacking signs where the discussion was sparse for debate.

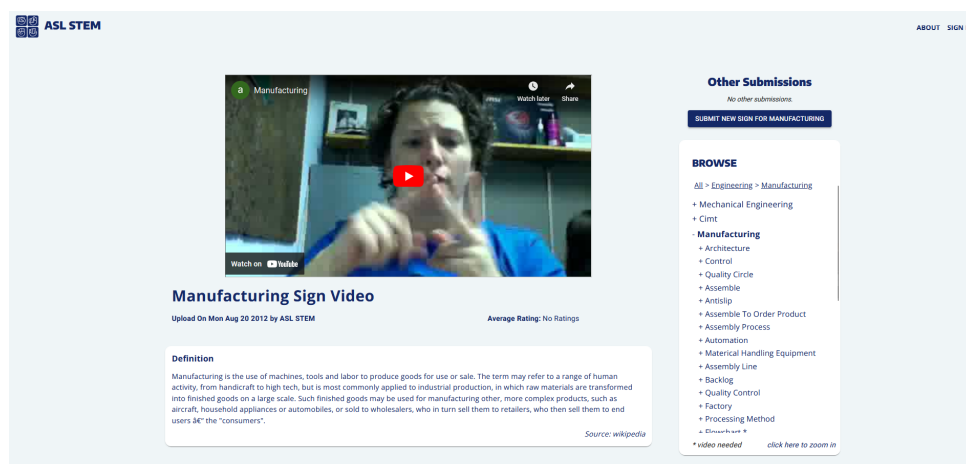


Figure 3.2: ASL STEM Forum user interface, taken from: <https://aslstem.cs.washington.edu/term/Manufacturing>

In an early application of crowdsourcing for sign language, de Amorim et al. [12] applied a crowdsourcing method for sign boundary identification in pre-recorded videos that features Brazilian Sign Language (LIBRAS) interpreters, the goal in mind being the crowdsourcers successfully identifying signs

with the delimitations established, correctly identifying the signs themselves and the delimited signs being able to be used. These video boundaries were established from the processing of contributions from various contributors in many countries, none of these supposedly having known LIBRAS or any other sign languages prior.

In Africa, Soudi et al. introduced AfricaSign, an online platform to share user-uploaded videos and a description of a digital avatar sign regarding STEM signs [13]. It is very diverse, as the website has a map of the continent of Africa. When clicking on each country, the signs for each language and/or dialect/regionalism are displayed for every logged user. It promotes diversity in the various sign languages present in Africa. The main drawback is that the information is only accessible to users who are logged in and is also limited to STEM signs. The interface is also quite dated and, therefore, not user-friendly.

Another approach came from Glasser et al. [14], who created and developed a bilingual Wiki interface to create and consume ASL content. They explored the crowdsourcing capabilities of English-to-ASL translations to break and advance the barriers of sign language research and technology. The users were provided with a reading mode and a recording mode for each article entry to translate the content written on the pages (usually ripped from trusted sources such as Wikipedia), with an applet to record videos on the web browser. The biggest drawback found relevant to our work was the lack of natural interaction with the interface, which is usually only used for a continuous hour. After said use, there was a questionnaire with interviews with a researcher.

Following through a more gamified approach, Bragg et al. [15] suggested and implemented ASL Sea Battle, a gamified Sign Language data collection platform, which used the familiar game of Sea Battle to collect and label real-world sign language videos, with an introductory example video to improve the robustness of sign language recognition and translation systems. A novel approach to online games and forums, as rather than having written or spoken language, it has a mix of both ASL and English. It incorporates the traditional game with a twist: a word selection guesses each square, and after gesturing, it reveals whether the guess was a hit or a miss. Limitations can funnel themselves to misunderstandings and uncertainties on whether or not the users had to follow the example video for gesturing strictly or if they could provide their twist to it, as it was not clear by the authors what they wanted to be gestured, or how strictly they wanted it signed.

In a related study, Tang et al. [16] reached positive results for the community-based requests about the growth and maintenance of Chinese Sign Language (CSL). This work is a qualitative study regarding the translation to written Chinese from CSL and Signed Chinese videos in various video-sharing platforms, improving co-creation in information accessibility.

Limitations are asserted as including a Deaf Professional for analyzing the data and conclusions of the work done, which may not harbor the complete representation of the Deaf community. Furthermore, participants were recruited via purposive sampling, which does restrain the variety and representation

of Deaf communities within China.

Mukushev et al. [17] presents a methodology to crowdsource data collection for a large-scale sign language independent dataset for the Kazakh-Russian Sign Language (KRSL). They first designed a research protocol involving the Deaf community throughout the research process and performed a crowdsourcing campaign to rally 50 KRSL and perform 173 sentences with 43,250 video samples. This work stands out as most collections of sign language videos represent singular words and gestures, not sentences. This work is vital in representing realistic life situations and enhancing the sign language database with continuous signing. Limitations are the lack variety and personal flair of continuous signing, as users had to follow a video prompt.

Building on the theme of crowdsourced data for sign language, and akin to [15], Bragg et al. [18] conduct a user study to break down the barriers of small sign language dataset and lack of diverse signers in real-world settings, with the help of crowdsourcing, as complex labeling problems lead to limited scaling. The results were positive, as their findings suggested that a crowd of signers could generate high-quality video recordings and perform reliable quality control. The most notable limitations include a lack of continuous signing and an imbalance between gender diversity.

Similarly, Jung et al. [19] also developed a test platform for increased dataset variability; sign language videos are recorded in a lab-like environment, with precondition criteria that must be met regarding quality. While the study was successful regarding sign language data variation, it still adhered to guides, which can limit a more personal flair and gesture variation.

Outside the domain of sign language, crowdsourced video captioning systems [20, 21] have been implemented before without the employment of monetary rewards [20]. Kacorri et al. [20] made use of two game-like modes in their platform: a type-mode for user-listening and transcription of the captions and a fix-mode, the users are given an Automatic Speech Recognition transcription and asked to check and further edit the contribution.

Similarly, Huang et al. [21] tested a crowdsourcing platform for the editing and fixing of automatic speech recognition captioning for individuals with hear-impairment, second language speakers with low proficiency, second language speakers with high proficiency and native speakers. Their results suggest that each crowd-worker group has different strengths and needs, so each group can make separate contributions and complement each other.

Furthermore, in these systems, Karamad was a voice-based crowdsourced platform deployed for 6 months that allowed workers in underserved, low-resource and hard-to-reach areas to complete crowd-work with low-end phones. Services and tasks such as translations, video captioning, dataset generation, accessibility, disability, health, literacy, employment, and surveys on demographics were included. Even without airtime subsidies, training or advertisement of the financial incentives, Karamad successfully attracted 725 contributors and a substantial amount of tasks completed [22].

3.3 Deliberation Systems

An important foundation of this work is Deliberation Systems. They are a place for people to debate issues and give their input, weighing the pros and cons of their decisions and informing themselves of what they stand for and what other individuals with contrary beliefs also strive for [39].

Deliberative democracy has created opportunities for us, as a society, to normalize the participation and representation of people with normal faculties as well as people with cognitive and physical disabilities, and it is up to us to make better use of a mainstream presence of discursive representatives to ensure so [32, 33, 40]. Afsahi [40] goes into great depth on how we can include mainstreaming methods of integrating assistive communication devices and tools, most notably rehabilitation and treatment services. Moreover, most vitally, these can include reducing barriers to electronic communication and accommodating diverse conditions and needs. This is important in enhancing the accessibility to online democracy tools, available information and services that can make cognitively disabled individuals be heard in their communities.

The proper design considerations for Deliberation Systems [41–43] are fundamental and must be considered. Decisions about complex policy issues are made without considering all the extensive options available and the consequences each might carry [41], especially when we are trying to address and connect isolated crowds [43] scattered throughout the country.

As mentioned before, there should be guidance in deliberative systems to let people reflect and debate on trade-offs and other perspectives than their own [39]. Kriplean et al. [39] proved it with ConsiderIt, using framing interactions around a list of pros and cons that participants create, adopt and share. As well as weighted preferences, in which participants can indicate how strongly they feel about particular pros and cons, which allows for nuanced input rather than simply agreeing or disagreeing. There are also aggregated insights where collective input is visualized by summarizing the pros and cons contributed by a group of users. ConsiderIt has facilitated engagement through moderators who guide the discussion, surface the important arguments, and keep deliberation constructive.

According to Paul et al. [44], a deliberative system can be compared to a Q&A site, such as Quora³. People often seek to enhance their knowledge and improve their online information by seeking feedback from friends and families on generalized social networks or even specialized Q&A websites. As they have gained popularity in recent years, it is essential to understand how users judge the authoritativeness of their content and among themselves, how they can build reputation, identify and promote high-quality content [44].

Loomio is a decision-making platform designed with processes to assist groups with collaborative consensus-focused deliberation/decision-making⁴. Local activists developed Loomio due to frustration

³<https://www.quora.com/>

⁴Definition: <https://en.wikipedia.org/wiki/Loomio>

with the lack of available tools to aid in deliberative decision-making processes effectively [45]. Jackson and Kuehn [45] argue that Loomio moved the general assembly to an online space, re-asserting communal space for discussion, unveiling the potential for online technology to go beyond mobilization and into sustained collection action, followed by the opinion that collecting and hearing each view, aggregating and re-broadcasting proved to be an unwieldy and exhausting process. Loomio is a social network that enables groups to interact through thread-based conversations. Topic threads progress to a proposal stage, allowing more deliberation and discussion, allowing a participant to vote on the resolution, and attempting to rationalize the political process of the general assembly more efficiently and inclusively. Suppose an initial discussion occurs when creating a discussion thread/proposals/polls. In that case, it only concludes when a member turns it into a concrete proposal that invites everyone in the group to engage. A common occurrence is that participants who had not previously participated return and express their opinions on aspects of the conversation that were overlooked [46]. After the previously mentioned step, the screen is divided into two sections: one for discussing the issue and the other for voting on the specific course of action. As a final step, users can provide a summary explaining their voting rationale when voting. They can modify their votes after engaging in the discussion, given they do it before the established deadline of the proposal [47]. The users can formalize ideas into proposals for group consideration and use polls and decision tools, either binary polls, Multi-Option Polls, or Ranked Choice Voting (members rank options in order of preference). There is also Consensus Building; participants can express their stance on a proposal using a range of responses, such as "Agree", "Abstain", "Disagree", or "Block" in case of strong opposition, halting the proposal until resolved. Deliberative feedback enables participants to improve proposals and decisions based on iterative feedback, and facilitates engagement with the help of moderators or facilitators. One consequence and a gap in the literature is that this platform is tailored to discuss governmental issues and does not focus on sign language dictionaries. Another issue is that while available to various communities, it is a paid platform, a Software as a Service (SaaS), ready to be tailored to each community [46].

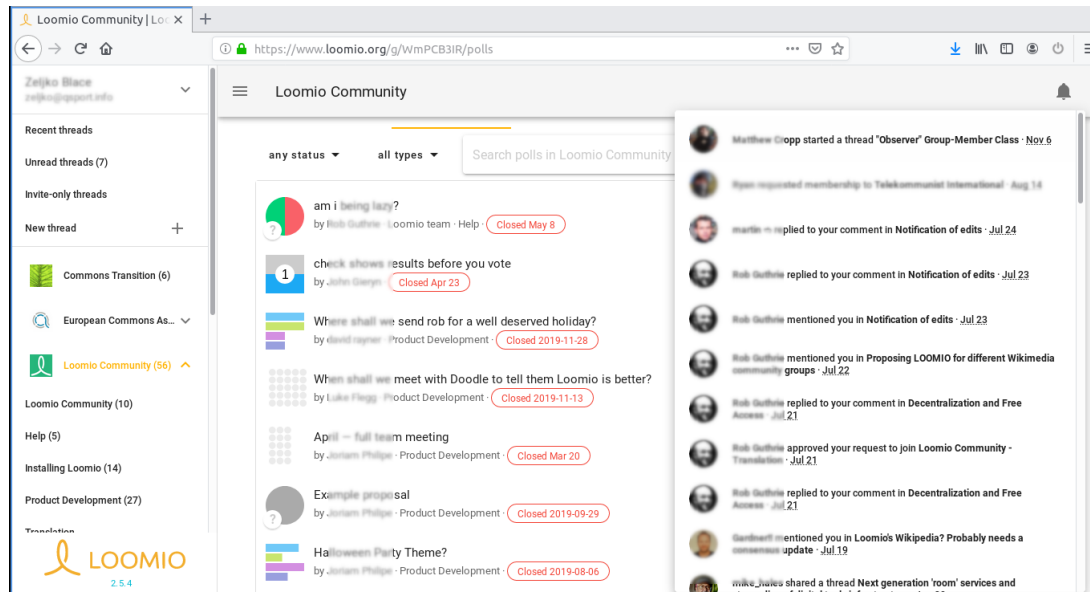


Figure 3.3: Loomio version 2.5.4 screenshot, taken from: https://commons.wikimedia.org/wiki/File:LOOMIO_interface20201218_2.png

The Deliberatorium is a form of online collaborative argument mapping, deployed by the Massachusetts Institute of Technology (MIT), with influence in communication issues observed in social media and wiki platforms [46]. It is directed to the question of climate change⁵ [48, 49]. Klein [48] argues large-scale deliberations are complex processes, with emergent properties that often prevent users from adequately harnessing the collected knowledge of a community. Klein [48] also debates collocated meetings are expensive and prone to effects such as polarization, power dynamics and groupthink; while influenced by social media to enable more concurrent input, still conscious it will typically generate "more heat" than light when debating complex, controversial topics. In another paper related to the Deliberatorium, Klein [49] divides deliberation technologies based on structure content; one of these categories is time-centric tools such as email, chat rooms and web forums, where content is organized based on when a post was contributed. While these allow for large communities to weigh in on topics of interest, they come with a few negative consequences of design, such as Scattered content (as the name implies, content in these tools is typically scattered, which results in difficulty in finding all contributions on a topic of interest), Low Signal-to-noise Ratio (content captured in these tools tend to be voluminous and highly repetitive), Balkanization (users often tend to assemble into groups that share the same opinion, and gives an example there is little cross-reference in republican and democrat forums) and Dysfunctional Argumentation (not enforcing any standards concerning valid argumentation, posts are often bias-based, rather than logic-based). The idea behind the Deliberatorium was simple: a platform with a tree-like structure and symbols with articles on climate change where users had to position a post within this tree

⁵<https://en.wikipedia.org/wiki/Deliberatorium>

after selecting the appropriate top-level branch and consequently finding the right sub-branch until they were in the category they desire. The posts are logically positioned under the categories they refer to, ensuring this content is coupled correctly with a question. After reading or posting, each user crossed a point, or square, if they agreed with the shown opinions, allowing them to engage with the entire debate rather than just selected threads. Each unique point presents itself only once, enhancing the signal-to-noise ratio as well as emphasizing the diversity of arguments that emerge during a debate, aiming to capture both the dominant opinions as well as various threads of argumentation [46]. A particular gap we found was the lack of moderation in this platform, something we would like to tackle; it does not focus on any sign language, nor does it "feed" a sign language dictionary, and it is only accessible to members of the MIT.

Better Reykjavik is an online engagement platform used for crowdsourcing solutions to urban challenges developed and launched by the Icelandic Citizens Foundation in May 2010 [50]. According to Lackaff [51], the citizens of Reykjavik are allowed to submit, debate and prioritize policy proposals and ideas, and Bjarnason et al. [50] debates it allows residents to vocalize, and debate a variety of ideas which they believe are of crucial importance, and gives voters a direct influence on decision making. It is divided into projects. It has a participatory budgeting project called "My Neighborhood", where residents and the city administration collaborate to determine the amount of capital invested for future construction and maintenance projects within the ten central neighborhoods of the city; through a forum, it encourages residents to participate, propose, discuss and assess various ideas and project proposals [46]. Through the website, the citizens select ideas from within the budgetary constraints, and hereafter, citizens can create their list of priorities within the budget framework and vote on the projects they believe should be implemented [52]. The project "Your Voice At The City Council" allows every citizen to submit original ideas and solutions to municipal issues within the city. Most recently and similarly to "My Neighborhood", in 2017, the project "Reykjavik's Education Policy" serves as the crowdsourcing of ideas to co-create the city's education policy on the platform through a forum. These three projects have the same objective: to increase the capacity of consultation and influence the citizens of the city in its decision-making processes. They all have policy crowdsourcing as their core and share the same deliberation features. All residents of Reykjavik can propose ideas for improving the city, which leads to public discussion, where the users can comment on the ideas given, which can also lead to the use of voting mechanisms, upvotes and downvotes, which leads to the most popular ideas being ranked higher. City officials then review the ideas, assessing the feasibility of the proposals, as well as the budget and impact. The level of participation in the project is something we are interested in, as over 70,000 residents of Reykjavik, in a population of approximately 131,000, have engaged with the platform, with more than 53% participation at a certain point [46]. However, according to Adenskog [52], the use of the platform has been decreasing, only used in "moments of crisis", and citizens do not debate day-to-day situations.

A gap we are looking to explore is that the website is not focused on sign languages or feeds a sign language dictionary.



Figure 3.4: A screenshot from Better Reykjavik, taken from: https://citizens.is/portfolio_page/better_reykjavik/

3.4 Discussion

Table 3.1: Comparative table among digital sign language dictionaries

Dictionary	Sign Language	Number of Signed Videos	Still in use
[4]	American Sign Language	Thousands*	No*
[5]	Swedish Sign Language	21,603	Yes
[6]	Spanish Sign Language	9,000+	Yes
[7]	Italian Sign Language	1,000+	No
[8]	New Zealand/Maori Sign Language	4,500+	Yes
[9]	Danish Sign Language	2,000	Yes
[10]	Arabic, Belarusian, Bulgarian, Chinese, Croatian, Czech, Danish, English, Estonian, Finnish, French, German, Greek, Hindi, Icelandic, Italian, Japanese, Latvian, Lithuanian, Persian, Polish, Portuguese, Romanian, Russian, Serbian, Slovak, Spanish, Swedish, Turkish, Ukrainian and Urdu Sign Languages	610,000+	Yes

Table 3.1 reveals a paradox in current sign language resources: while dictionaries like SpreadTheSign [10] have achieved impressive scale (610,000+ entries across 32 languages), they remain fundamentally passive repositories. The User-powered American Sign Language dictionary [4] and Swedish Sign Language dictionary [5] with 21,603 signs demonstrate technical capacity for video collection. However, none provide mechanisms for DHH communities to deliberate on contested signs, regional variations,

or evolving terminology. This represents a critical gap: existing dictionaries enable the consumption of meaning but not its negotiation. Moreover, the abandonment of e-LIS [7] as merely a prototype and the reliance of user-powered dictionaries on external platforms like SigningSavvy highlights a sustainability problem. These systems lack indigenous ownership models that would ensure long-term community stewardship and sustainability.

Table 3.2: Comparative table among crowdsource systems

Crowdsourcing Systems	Purpose	Ways to Participate	Communities of use	Strong Points	Weak Points
[11]	Debate STEM signs in ASL.	Record sign videos. Comment and rate submissions.	ASL Community.	First forum to debate ASL STEM videos.	Lack of signs and discussion. Antiquated UI and participation mechanisms.
[12]	LIBRAS data collection.	Identify signs with and without delimiters.	LIBRAS Community	All delimited LIBRAS signs were identified with the crowdsource method.	Video sample was minimal. Some segmentation could be improved via crowdsource.
[13]	Submit STEM videos in African Sign Language.	Submit/record sign videos Describe the sign using an avatar	African DHH STEM Community	STEM sign video collection in many African languages and dialects.	Restricted Access. Antiquated User Interface.
[14]	Create and consume ASL content	Reading and recording mode	ASL community	Reading and recording interfaces were easy to use. Useful Bilingual content.	Limited use. Lack of diversity of participants. Gaps due to lack of interest.
[15]	ASL data collection	Recording and captioning signs while playing an altered version of Sea Battle	ASL Community	Game preference. Entertainment and social benefits.	Small set of individual signs explored
[16]	Growth and maintenance of CSL	Through social platforms WeChat and KuaiShou	Chinese DHH Community	Improved sign language information access.	Need of a professional, lack of representation of DHH communities.
[17]	KRSL data collection	Campaign rally to record 43,000+ samples	Kazakh-Russian DHH Community	Large amount of sign variation	Skewing of results due to tutorial watching.
[18]	ASL data collection	Record, and fill gaps in missing videos	ASL Community	Community engagement Scalability and Diversity	Limited participant pool
[19]	Sign language dataset variation	Record videos following guides	Korean DHH Community	Gesture variability	Lab setting
[20]	Crowdsource video captions	Submit video transcriptions	ASL Community	Enhanced engagement through gamification	Limited participant pool
[21]	Crowdsource video captions	Identify caption errors, correct caption errors	Chinese DHH Community	Capitalize on different backgrounds Inclusivity	Limited videos Limited participant pool
[22]	Assignment of jobs to the community	Contribute to sign datasets	Pakistani residents in low-resource areas	Diverse Task Support, Accessibility, Inclusivity, Scalability and Sustainability.	User training and support Quality assurance

The crowdsourcing systems in Table 3.2 showcase innovative engagement mechanisms—from video-board games to job-based participation—yet they reveal a fundamental limitation: communities contribute labour but not governance. While systems successfully collect datasets, create captions, and correct errors across African, American, Brazilian, Chinese, Kazakh-Russian, Korean, and Pakistani DHH communities, participants remain confined to predefined tasks. The noted "superficial participation mechanisms" and "lack of discussion" indicate these platforms treat DHH users as data sources rather than decision-makers. The first-ever forum for debating ASL STEM videos represents a promising exception; yet, Table 3.2 suggests that this remains isolated rather than integrated into broader crowdsourcing infrastructures. The gap is clear: existing systems harness collective intelligence but do not channel it into collective decision-making regarding language standards, resource allocation, or platform governance.

Table 3.3: Comparative table among deliberation systems

Deliberation System	Community	Deliberation Goal	Deliberation Mechanisms	Strong Points	Weak Points
[39]	Any	Structured, collaborative deliberation	Pro/Con Framework Weighted Preferences Aggregated Insights Moderated Engagement	Encourages Reflection and Thoughtfulness Balance of Perspectives Support for Individual Expression Accessible and Scalable	Limited depth of engagement Over reliance on self reporting Potential for information overload Participation bias and superficial contributions
[44]	Any	Knowledge sharing and informed discussion	Crowdsourced Perspectives Argument Aggregation Upvotes Moderated Engagement	Reputation as a deliberation incentive User-curated credibility Encourages diverse perspectives Support for expertise recognition	Reputation bias Barriers to new voices Echo chambers and groupthink Limited interactions between users
[45]	Any	Collaborative decision-making	Discussion Threads Proposal Creation Decision Tools Moderated Engagement	Focus on Inclusive decision-making Structured decision-making process Support for asynchronous deliberation Focus on consensus-building	Risk of decision fatigue Potential for power imbalances Dependence on community engagement Dependence on digital literacy
[48]	MIT Community	Large-scale, structured deliberation	Argument Mapping and Visualization Issue Framing and Exploration Interactive Deliberation Forums	Structured deliberation process Harnessing collective intelligence Iterative feedback and refinement	Scalability challenges Risk of groupthink Potential for dominant voices
[51]	Reykjavik Citizens	Citizen-driven participatory democracy	Idea Submission Public Discussion Voting Mechanism User Reputation and Moderation	Enhanced Citizen Engagement Direct influence on policy making Strengthens democratic governance Structured deliberation	Risk of low participation Potential for polarization Vague influence on actual policy Exclusion of non-digital participants

Table 3.3 highlights a mismatch between deliberation technology and the requirements of the DHH community. Most systems serve "any community" with generic mechanisms (voting, discussion threads, proposal creation), yet none address the unique challenges of sign language deliberation: how do you structure visual-spatial argumentation? How do you moderate debates when linguistic norms are themselves contested? The Deliberatorium [48] and Better Reykjavik [51] demonstrate that community-specific design matters, yet no equivalent exists for DHH communities. Furthermore, identified weaknesses—"reputation bias," "barriers to new voices," "echo chambers," and "limited interactions between users"—are particularly problematic for sign language contexts where linguistic legitimacy is already disputed and regional/national variants compete for recognition. The risk of amplifying existing power imbalances in sign language communities has not been addressed.

Notably, these three domains—dictionaries, crowdsourcing, and deliberation—operate independently. No existing system enables DHH communities to simultaneously: Document sign language through crowdsourced contributions, deliberate on contested signs, regional variations, and emerging terminology and decide democratically on standardisation questions and resource priorities Sustain community ownership over linguistic resources The state-of-the-art provides components but not integration. Our solution addresses this synthesis gap by creating a centralised community platform, tailored to the Portuguese DHH community to document sign entries, with crowdsourcing methods to propose, debate and accept a new sign entry, ensuring that sign language documentation becomes an act of community self-determination rather than passive data collection.

4

Online Portuguese Sign Language Dictionary (DCLGP)

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This chapter outlines our original approach to the Dictionary. We also showcase the architecture of the platform, as well as iterations based on user feedback. We go in-depth regarding the modules we implemented into the dictionary. In the end of this chapter, we discuss the navigation flow of the dictionary and its features.

4.1 Approach

As seen in section 1 and section 2.1, there is a lack of representation when it comes to Deaf people, as well as a lack of methods that allow for a democratic, dynamic and organic evolution of the LGP. The lack of representation can lead to a lack of governance, as mentioned in section 2.3 and to creating various signs for the same word.

As mentioned in section 1, the evolution, learning and growth of LGP is hindered by a lack of standardization mechanisms when newer terms arise. As noted in sub-sections 3.1, 3.2, 3.3, and summarized in sub-section 3.4, there is a lack of a sign language dictionary that gathers the DHH community, through crowdsource work, and allows said community deliberate on propositions for new sign gestures, through deliberation mechanisms.

We implemented new mechanisms for deliberation, based on the deliberative democracy discussed in sub-section 2.2, on what might be the adequate way to gesture a sign. We implemented these methods in order to standardize these terms across the community, through deliberation, giving users a chance to reflect and discuss, based on the principles of reasoning. Regarding the structure of the dictionary crowdsource module web page, we were inspired by the sign language forum by Cavender et al. [11], as it was the first platform with the most goals aligned with ours, sharing sign language videos. We were also inspired by the Swedish sign language dictionary by Kankkonen et al. [5], as they explored differentiation in dialects for sign gestures and sign placements among different age groups in DHH signers, further exploring given the signs, which would be more appropriate. These contributions are severely important to our work, as we also want to tackle those questions in our national sign language, LGP.

We used a User-Centered Design approach, which is founded on the core principles of keeping the needs and contexts of users in mind at every stage of the design process. It is an approach wherein, at every step, right from ideation to implementation, users are kept in mind through their feedback and requirements shaping the product. The goal was to create a product that allows the LGP to become more dynamic, in which the Portuguese DHH community had mechanisms to promote new terms and influence the transversal and adequate usage of new concepts and gestures. The product is tailored to the needs of the LGP DHH Community to help them reach their objectives better.

We implemented a Dictionary Platform with a search-sign engine that is intrinsically connected with

the annotation module of the platform, which we also implemented in the platform. To evaluate our annotation module and search engine, we deployed our Dictionary Platform to first-cycle schools, validating the annotation and ensuring our user experience was also validated through various iterations, refining our platform.

As previously mentioned, we also implemented crowdsourcing features, including comment sections (both video and text), a voting system, user reputation, and sign-in entry moderation. We tested these crowdsourcing features through a usability evaluation and a crowdsourcing deployment to the general DHH community.

4.1.1 Formative Studies

Before our design and implementation of the Crowdsourcing module, we needed feedback from members of the DHH community. Through the reading of background and related work, we could verify one of the main issues present in deliberative platforms, with a focus on DHH communities, and that is the lack of a mechanism to propose, discuss and accept a sign entry into a dictionary or repository. Therefore, we organised a workshop to debate the "Proposal"- "Deliberation"- "Acceptance" flow a sign proposal could have in the platform, through a workshop.

In this workshop, the participants filled their respective Journey Maps with ideas. A Journey Map is a visual tool that traces a user's experience through different stages of a process, capturing key aspects at each step. In our case, we structured the map around three main phases—Proposal, Deliberation, and Acceptance—representing the flow of submitting a sign entry through the crowdsourcing module. At each phase, participants documented: **User actions:** What users do at this stage; **User needs:** What users require to complete their actions; **Gains and losses:** Positive outcomes and pain points experienced. The Journey Map skeleton used in the workshop is shown in Annex B.4 (Figures B.1, B.2, and B.3). This framework served to invoke discussion among participants about the user experience throughout the entire process of contributing to the sign language database. By mapping out these touchpoints, we were able to identify critical moments where users might face challenges or experience satisfaction.

Following the workshop, we consolidated all the gathered data into Empathy Maps to better assess the community members' needs when making a proposal. Towards the end of these studies, we also sketched an original flow of the crowdsourcing module. We presented it to the members of the DHH community, who identified several flaws. We then revised the module to overcome these issues, presenting the final design in Section 4.2.

We had four participants in the workshop session: two linguists, a DHH community member and a Sign Language to Portuguese translator.

We had some limitations however which is the lack of feedback from the DHH community member,

as they did not fill out the Journey Map, nor is the voice from the translator discernible, therefore we are missing one of the results.

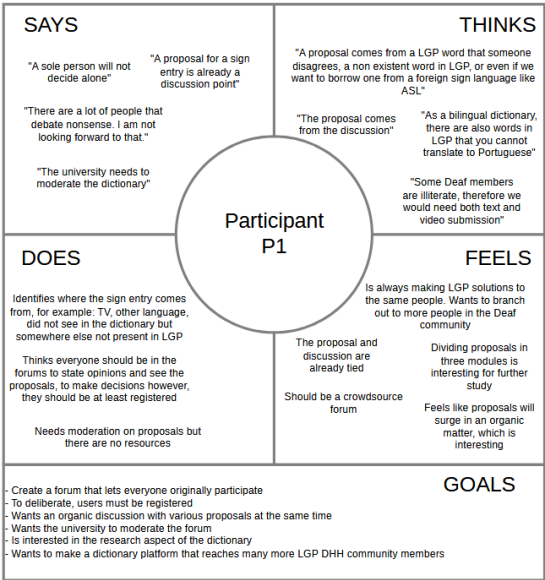


Figure 4.1: Empathy Map for Participant 1

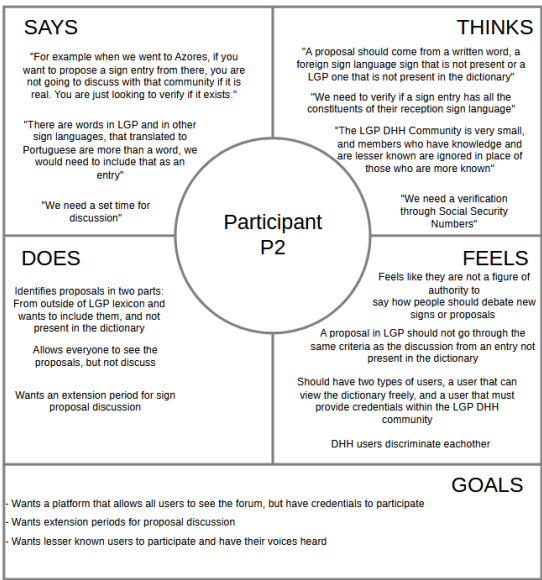


Figure 4.2: Empathy Map for Participant 2

Our participants' opinions were similar in this workshop session and during data gathering. They both wanted a platform that reached out to more community members. It was not tailored to more well-known community members, higher in the hierarchical pyramid, as lesser-known members might have more hidden knowledge. Both participants insisted that the forums be open to everyone to talk; however, the deliberation of the signs must have a registration on the platform with credentials. These proposals can be divided into three categories: missing sign entries from the dictionary or a sign they saw on television or social media that is not available, a new word that is not available in LGP or an entry in another language that is also not available in LGP. These proposals should have a set time interval and, if need be, an extension of the time interval if there is a need for more discussion. Furthermore, the platform should have a moderation team to remove necessary posts or members. One participant mentioned the scientific potential of the platform and would be interested in exploring it.

With these results in mind, we developed an initial schematic for a prototype:

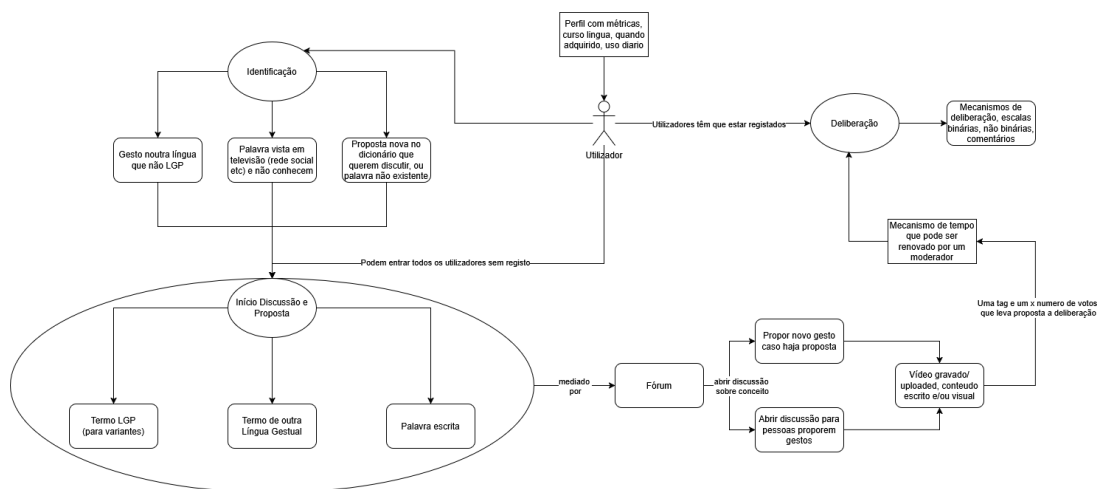


Figure 4.3: Original solution diagram

This original solution encompasses all the significant points discussed in the workshop: The identification of a term, either through television or social media, or an entry present in another sign language and not LGP, or a new term that overall does not exist in LGP. To start a proposal and discussion, all users, even those not registered, can participate, discussing variants of LGP terms, a written word or even a non-existing term from another sign language. These discussions are submitted to a forum, and members can submit their proposals for that term or discuss them through uploaded videos or text. It would implement a time mechanism for discussion with possible renewal upon request. For deliberation of proposals, a user must have been registered with their credentials and further personalisation of their information, such as what language course they possess, or an education, when acquired and their daily use of LGP. The deliberation would have mechanisms such as comments and scales.

Upon further analysis by everyone on our team, we concluded that this solution would lead to a significant bottleneck. Lesser-known variant submissions would be obscured, as either people would not know the author, or would not speak the dialect present in different regions of the country, therefore mainly leading to the non-inclusion of the proposal into the dictionary, which comes from a lack of discussion, votes and awareness. Therefore, to counter this issue, we developed the following solution:

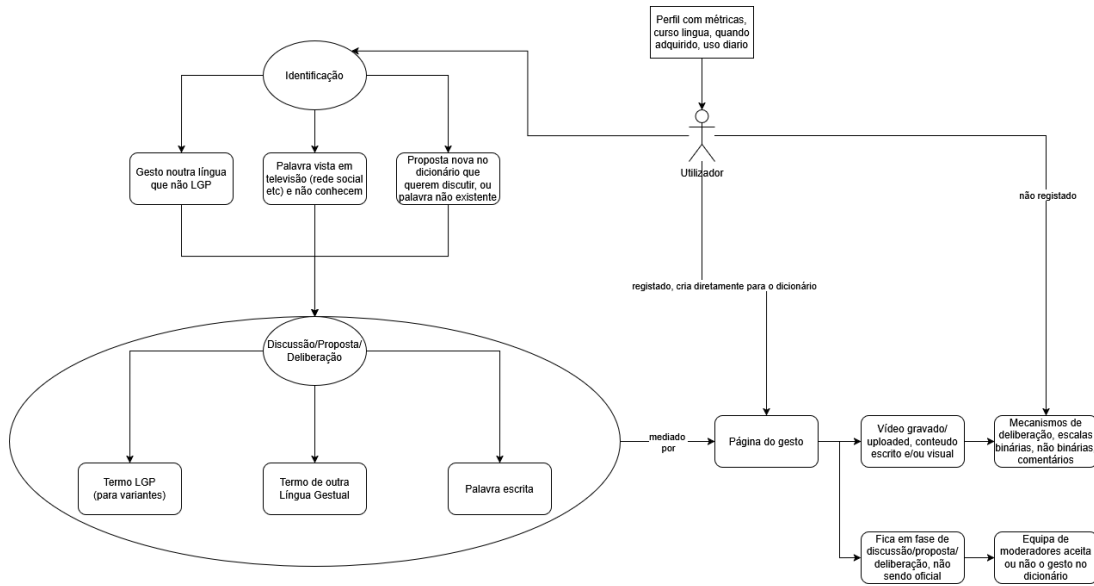


Figure 4.4: Second solution diagram

We maintained the idea behind the identification and submission of sign entries. However, we removed the forum idea, as this would potentially lead away users with its nested format. Instead, users can access a sign entry page or the dictionary and submit their sign proposal. There is no time period for discussion; the proposals are now organic and happen simultaneously, and can be interacted with continuously. A moderator team can still accept or not, a sign entry into the dictionary, and even remake the proposal to fit more professional recording standards.

4.2 Architecture

We implemented our crowdsourcing module on an instance of the DCommunity platform. The DCommunity platform, created and initially developed by João Raimundo Nogueira at the Interactive Technologies Institute¹, serves as a centralized medium to gather users whose issues are less represented. The platform has been an ongoing work and a culmination of different Master thesis projects, and we thought it fitting to integrate our crowdsourcing module into this platform.

A relevant project was the LGP annotation platform, developed by Francisca Ordaz at the Interactive Technologies Institute, guided by Professor Doutor Hugo Nicolau and Professor Doutor Paulo Vaz de Carvalho in collaboration with Universidade Católica Portuguesa. This annotation platform was a separate website for the LGP DHH community, and served to annotate each entry of the dictionary with its phonological features, such as hand configuration, orientation, location (in the body), movement, and facial expressions. Originally, these annotations already had the logic behind the search engine, that

¹<https://interactive-technologies-institute.github.io/community-website/>

is, to delegate a 0 to 1 flag on an array position, and that position corresponded to the index of the parameter.

The aforementioned project is of significant importance to our work, as we integrated the annotation module into the Dictionary platform itself and built our crowdsourcing module on top of the dictionary.

The architecture of the platform is as follows, as shown in Figure 4.5.

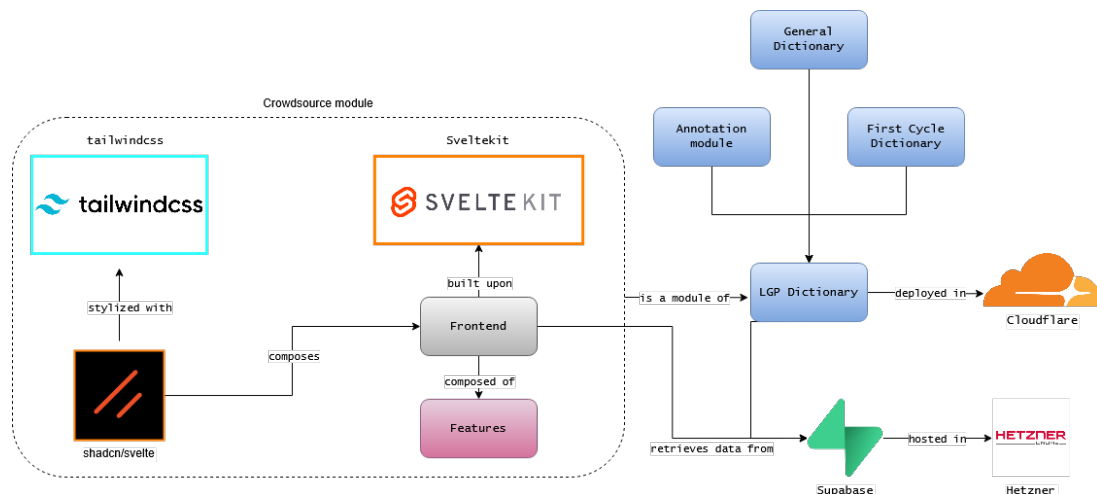


Figure 4.5: Platform architecture

Let us go in-depth with respect to the technology stack of the system:

Database - We used **Supabase**², an open-source alternative to **Firestore**³. **Supabase** is known as a **Backend as a Service (BaaS)**⁴, a service that provides an easy backend implementation for web developers, as it was useful to facilitate the work done on the web-based platform. It comes with several features such as authentication, **Application Programming Interfaces (APIs)**⁵, storage for the videos, vector integration for the features search and a **Postgres**⁶ relational database. It reduced the workload on the backend implementation with a database connection and reduced the issues of implementing an authentication technology for the platform, allowing us to focus solely on the web frontend development side, including the features. The database was also crucial to our development, as the crowdsourcing module was heavy on videos, either for signing or for debating signs, as the **DHH** community is much more accustomed to signing instead of typing in forums.

Frontend web development - For our frontend web development, we used **Svelte**⁷ and **Sveltekit**⁸.

²<https://supabase.com/>

³<https://firebase.google.com/>

⁴https://en.wikipedia.org/wiki/Backend_as_a_service

⁵<https://en.wikipedia.org/wiki/API>

⁶<https://www.postgresql.org/>

⁷<https://svelte.dev/>

⁸<https://svelte.dev/docs/kit/introduction>

Svelte, using **Typescript**⁹, which was very useful in building components for our web application, as it focuses on building said components and **Single Page Applications (SPAs)**¹⁰, ensuring the content for the users is dynamic and loads in fast time, removing unnecessary encumbrances for the users such as reloading the page for an update on content, making it a good choice for a great user experience. Sveltekit provided us a complete application framework for building modern web apps, including all the advantages of Svelte (component building and SPAs) as well as **Server-Side-Rendering (SSR)**¹¹ which automatically renders pages on the server for better performance on the user-side, a file-based routing system¹², and Integrated Development Tools, for handling data fetching and state management. For the styling of our application and components, we used **TailwindCSS**¹³, as it allowed us to style our pages directly, giving us much more flexibility and ease of use in implementing styles. For our component library, we used **shadcn-svelte**, an open-source component library that offered a wide range of UI components, designed to be highly modifiable, and uses TailwindCSS for styling, which made it easy to customize the components to match our design system, as well as being flexible in the import of needed components, which kept our application lightweight.

We created an infrastructure that enables further developers of the platform to create and implement additional modules easily. One such example is the work of Matilde Tocha, who created and implemented a didactic LGP on the platform for a Portuguese bilingual game for Deaf students, to be used in-class, called LGP4Fun.

4.3 Implemented Modules

In the following section, we will discuss the implemented modules in depth.

4.3.1 Dictionary

The platform houses a dictionary for LGP, which contains all the dictionary entries that the linguists annotated and are available to the public.

Labeled in numbers, the main dictionary view is composed of:

1 - Search Engines Bar: The method to search for sign entries. We implemented two search engines for the dictionary: The first, which we denominated the Sign Search Engine, comprises five categories for the sign search: configuration, location, orientation, movement, and facial expression. Users can select the illustrations they believe are the most adequate for their search and press the search button. The engine will then return the most approximate results based on the search query.

⁹<https://www.typescriptlang.org/>

¹⁰https://en.wikipedia.org/wiki/Single-page_application

¹¹<https://www.sanity.io/glossary/server-side-rendering>

¹²<https://svelte.dev/docs/kit/routing>

¹³<https://tailwindcss.com/>

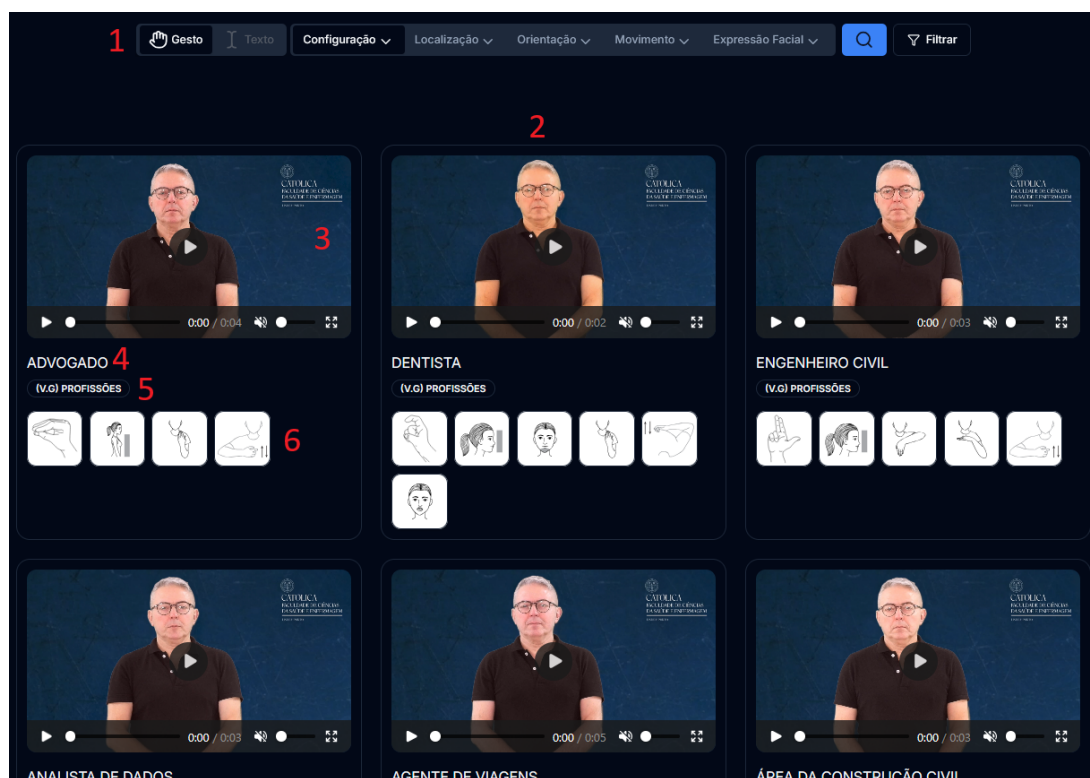


Figure 4.6: Main page for the dictionary module

More details on the implementation are discussed in the Annotation Module implementation, as it is intrinsically connected to it.

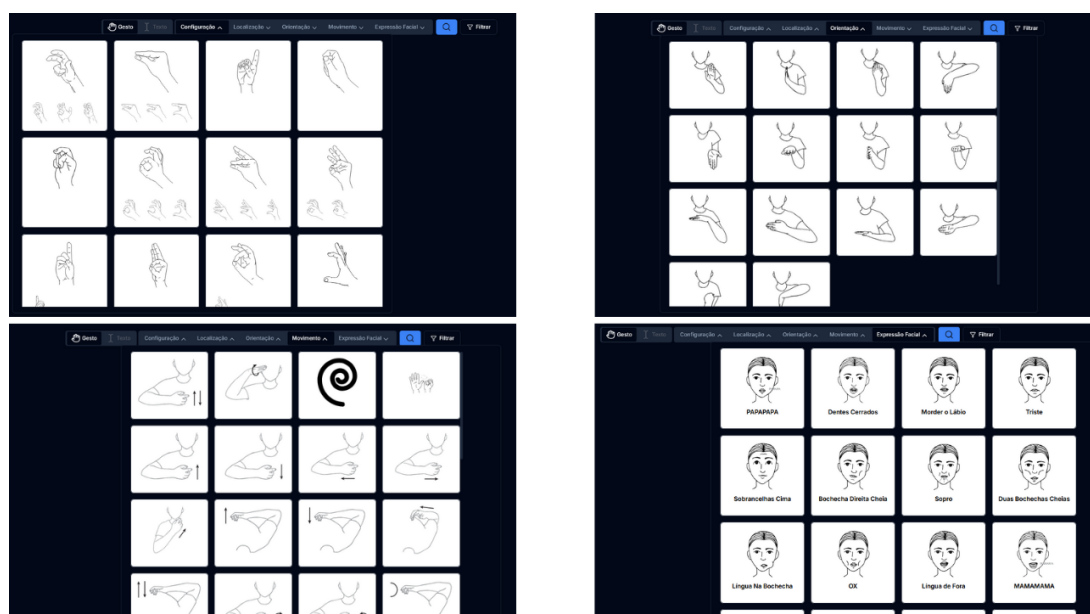


Figure 4.7: The various categories for the Sign Search Engine, showcased are: Configuration, orientation, movement and facial expression

Lastly, we also implemented a filtering system to our dictionary, so users can filter the signs according to its themes.

2 - Dictionary Grid: The display method we decided to implement comes as a grid. For improved ease of access and viewing, we showcase nine signs per page, with videos already loaded so the user can visualize various signs readily.

3 - Sign Video: For each query result, each sign must have a readily available video so the user can verify if the sign they searched for is correct.

4 - Sign Name: For each query result, each sign must have an associated alias so the user can identify the gesture with a name.

5 - Sign Theme: Each sign must have an associated theme to group them in their respective categories.

5 - Sign Annotation: Each sign has phonological annotations assigned to it. These serve to illustrate how a gesture is made, as well as to search for it in the Sign Search Engine.

Furthermore, when clicking on a single sign, other than the existing showcased features, such as the sign video, name, theme, and annotation, it also includes some other characteristics. We shall go into depth regarding them in the following subsection.

4.3.2 Sign Page Layout

We initially had various ideas regarding the sign page layout, and how to better convey information for the LGP DHH community. Deaf Communities are primarily visual-spatial communities; therefore, the visual hierarchy had to be very well-defined. We designed our sign page layout according to the following mockup made in Figma:

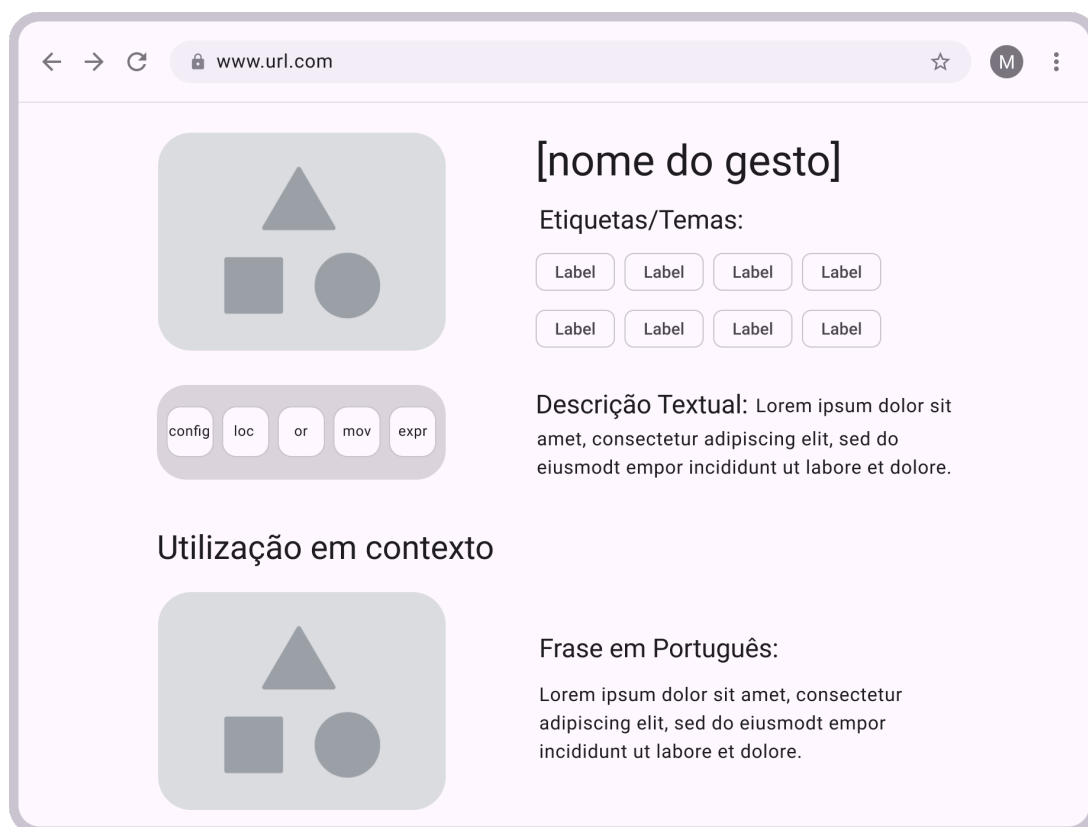


Figure 4.8: Initial mockup for the Sign Page Layout

We prioritised the showcase of the video first, on the left, as Deaf communities rely mainly on vision; therefore, the video must be bigger than the name. Below the video is the phonological annotation of the entry. We added the name of the sign entry to the side, with the themes below. There is a description of the video.

Below, and purposely isolated, is the video of the sign entry used in a sentence (in context), as signs may differ when used alone versus in a sentence. On the right side of the context video is the sentence translating that video to Portuguese.

We implemented the mockup like so:

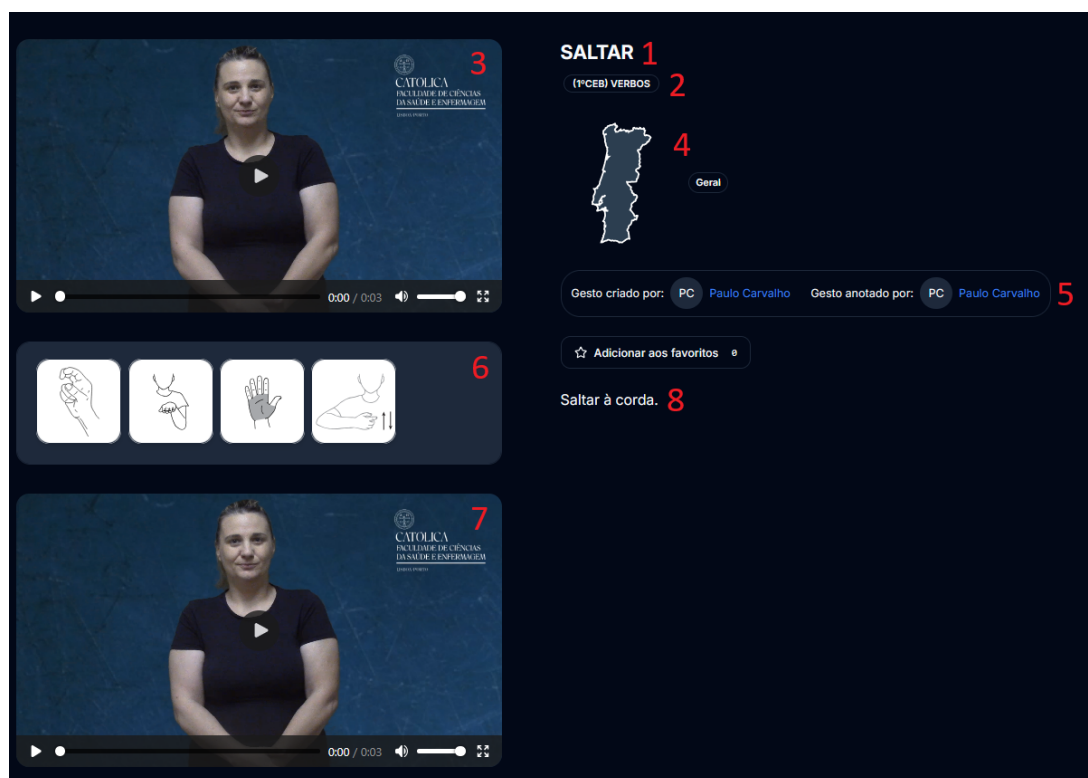


Figure 4.9: Page for the sign verb "SALTAR"

Labeled in numbers, we have the following:

- 1 - **Entry name:** This part of the sign page is related to the name assigned to the sign.
- 2 - **Themes:** Used to differentiate between signs and categorise each entry.
- 3 - **Video:** The main video for the sign is a visual showcase of how to gesture the specific sign.
- 4 - **Origin:** The primary origin for the sign, with a map display for its location. The sign can either be a general sign, in which an SVG of Portugal is displayed, or a specific district, which will showcase the SVG of said district.
- 5 - **Original creator and annotator:** Each sign can be created by a regular user or a linguist, but can only be annotated by a linguist. This component is related to the crowdsourcing module, which we discuss in the following subsections.
- 6 - **Annotation:** The visual annotation for the sign, used for the sign search engine. The annotation is possible due to the annotation module, which we will discuss in the following subsection.
- 7 - **Context video:** It serves as a contextual video for the sign. While the first video refers to the sign in isolation, this video gives an example of said sign in a sentence.
- 8 - **Context sentence:** It is related to the context video, and serves as a direct translation of the context video.

For the dictionary to work and for entries to be showcased to users, these sign entries must be

annotated. We will now go into depth into the explanation and implementation of the Annotation Module.

4.3.3 Annotation Module

This module, initially a work of Francisca Ordaz at the Interactive Technologies Institute and Universidade Católica Portuguesa, was deployed to annotate a repository of sign entries.

As the original plan was to grow a Sign Language Dictionary and feed the Sign Search Engine, we ported this feature into the platform to centralise not only the resources, but also facilitate the user experience for the linguists who annotated these entries and feed the dictionary directly.

Already implemented were the functions to upload the main sign video for a sign entry, name the sign entry, the ability to delegate several phonological parameters to an entry and the assignment of a singular theme.

In this case, an annotation of a sign entry is all the information that pertains to the sign. It spans from the phonological characteristics, such as the hand configuration, location, orientation, movement and facial expression, its name, the video, and so forth. Let us go into detail on what constitutes a sign annotation.



Figure 4.10: The various characteristics of the annotation module

Similar to a sign page, it must have all those previously mentioned components. Technically speaking, this can be described as the backend for the linguists to feed the dictionary and annotate the features for each sign. There were some already implemented aspects to the annotation, we improved upon those and implemented some others not yet mentioned, such as the textual description, upload of context videos, sign origin, a context text, its frequency and annotation level. Labeled we have:

1 - Entry name: The name of the sign entry.

2 - Themes: Delegate any string as a category for the sign.

3 - Video: The main video for the sign is a visual showcase of how to gesture the specific sign; in this case, the linguists must upload a video of the sign entry from their local storage to the platform.

4 - Phonological Annotation: In this component, the linguists selected phonological annotations from each of the five parameters: Configuration, location, orientation, movement and facial expression. Usually, most signs are composed of these five total parameters, each parameter with an individual

entry. However, there are exceptions, such as sign entries with only three parameters or a parameter with more than one entry. For the phonological annotations to appear in the dictionary, the linguists must select them. Selecting these annotations is crucial for the Sign Search Engine to work. We will discuss the algorithm behind the engine after the listing.

5 - Textual Description: Directly linked to the entry name and video, the description aims to describe or exemplify the sign.

6 - Context Video: The original video is the individual gesture of the sign entry. These signs change context in the flow of conversation or a sentence. In this component, linguists upload the video from their local storage to the platform, where the sign entry shows in the context of that sentence. As the original plan was to grow a Sign Language Dictionary and feed the Sign Search Engine, we ported this feature into the platform to centralise the resources and facilitate the user experience for the linguists who annotated these entries and feed the dictionary directly.

7 - Origin: This component is a list in which the linguist can select if the sign entry pertains to any specific district of Portugal (Madeira and Açores included). It can also be a general entry.

8 - Context sentence: It is related to the context video, and serves as a direct translation of the context video.

9 - Frequency: Only viewable to linguists and developers, this frequency component regards how much the sign entry is used in the current vocabulary of the community.

10 - Annotation Level: Also crucial to the Sign Search Engine, this Annotation level spans from 0 to 2, not annotated, partially annotated and thoroughly annotated, respectively. This allows linguists to resume their work when needed and keep track of the annotation status. An entry must be fully annotated (2) to be showcased in the public and first cycle dictionary.

Regarding the Sign Search Engine, we have implemented an algorithm based on the phonological features of the signs. Each sign has an Annotation Array, a three-hundred-position-sized array, initially filled with zeroes (0). Each phonological feature has an entry in a table with information such as ID, name and parameter type. In this case, when a linguist annotates a sign entry, if they select a specific phonological parameter entry, the ID of that parameter is the index on the Annotation Array, which turns into one (1).

The same logic applies when a user searches the Sign Search Engine. There is a local search Annotation Array, with three hundred zero-filled positions (0). The user then selects the phonological parameters they are interested in querying, and the respective indexes based on the parameters' IDs are turned into one (1).

With that local search array, we then make a comparison with the annotation arrays of all the fully annotated signs in the dictionary.

```

1 DECLARE
2     distance INTEGER := 0;
3 BEGIN
4     IF cardinality(array1) != cardinality(array2) THEN
5         RAISE EXCEPTION 'Arrays must be of the same length';
6     END IF;
7
8     FOR i IN 1..cardinality(array1) LOOP
9         IF array1[i] != array2[i] THEN
10             distance := distance + 1;
11         END IF;
12     END LOOP;
13
14     RETURN distance;
15 END;

```

Listing 4.1: Hamming Distance Algorithm

The comparison and data fetching logic is as follows: First, the sign must be thoroughly annotated (with a value of 2). Suppose the result from the Hamming Distance algorithm comparison between all the Annotation Arrays in the dictionary and the query array is 0. In that case, it is supposedly an exact match, and that result comes first. However, there are exceptions in this use case. Users can either make mistakes in the query or in what they believe they saw. Therefore, we need to guard against these situations with some error safeguards. In this case, if it is not an exact match, we first display results with the most exact positions; more matching positions are prioritized in the results showcase, therefore having a smaller Hamming Distance. If none of these cases have happened, we first showcase signs with minimal distance between them. Lastly, as the base case, we search for earlier ones in the array to alleviate memory usage in the database.

```

1 BEGIN
2
3 RETURN QUERY
4 SELECT
5     *
6 FROM signs
7 WHERE CAST(signs.is_annotated AS INTEGER) = 2
8 ORDER BY
9     -- Primary: hamming distance (0 = exact match comes first automatically)
10    hamming_distance(signs.annotation_array, query_array),
11    -- Secondary: count matching positions (more matches = higher priority)
12    (
13        SELECT COUNT(*)
14        FROM generate_series(1, LEAST(array_length(query_array, 1), array_length(signs.
15            ↳ annotation_array, 1))) AS i
16        WHERE query_array[i] = 1 AND signs.annotation_array[i] = 1
17    ) DESC,
18    -- Tertiary: find the minimum position where both query and sign have value 1
19    (
20        SELECT MIN(i)
21        FROM generate_series(1, LEAST(array_length(query_array, 1), array_length(signs.
22            ↳ annotation_array, 1))) AS i
23        WHERE query_array[i] = 1 AND signs.annotation_array[i] = 1
24    ) NULLS LAST,
25    -- Final: prefer signs with earlier 1s overall
26    array_position(signs.annotation_array, 1)
27 LIMIT limit_count offset offset_count;
28 END;

```

Listing 4.2: Code for the Sign Search Engine

4.3.4 Crowdsourcing Module

Our crowdsourcing module primarily serves the purpose of feeding the dictionary itself with new entries not present in it, in such a manner that provides equalitarian debates, voting mechanisms and a sense of ownership and governance through it.

Since the primary objective is to feed the dictionary with missing sign entries, we aimed to create a main page for this module, where all users can visualise all the proposals in the dictionary. We

denominated this page the "Crowdsourcing Hub". There are some options available regarding searching for various sign proposals. Their standard order is alphabetical, with nine signs per page, implemented with pagination. A user may search for a proposal by text, by typing out the name of a proposal. The Sign Search Engine is not present in this module, as annotations must be made by a professional, in this case, a linguist, after the gesture has been approved.

Furthermore, users can filter out proposals by theme and order signs by the number of comments, number of votes, and the date it was submitted, from ascending to descending and vice versa.

Users must be able to submit new sign proposals. In that regard, users have two ways to submit them. If there are signs missing from the dictionary and an user wants to add a proposal, there is a button for it in the Crowdsourcing Hub to submit a new proposal.

Similarly to the sign annotation interface, users can type the name of the sign proposal and submit a video showing the sign they wish to propose. What used to be the sign description is now adapted to a "description video", whose primary function is for the user to record their reasoning on why they signed the way they signed the gesture. Like the sign annotation, the proposal also presents the ability to choose where the proposal stems from, in the country.

The other option occurs when a user might have found a general variation of a sign they wish to procure; however, their specific variation, personal or from the region the user stems from, is absent. In this case, the user can submit a variation directly on the sign page through the proposal button for variational submission.

Our other implemented features for the crowdsourcing module, embedded in a proposal page, are comprised of:

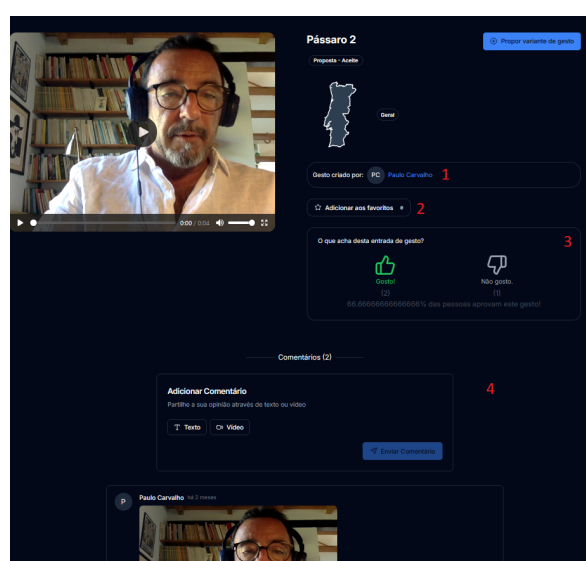


Figure 4.11: Crowdsourcing features in a sign proposal

1 - Sign Ownership: We added this feature to increase the governance of the platform. When each sign entry is proposed, it delegates its authorship to the original submitter, so users can verify if the original creator is a brand-new member, what contributions they have made, or if they can be trusted.

2 - Add to Favourites: We have added this functionality so users can follow their favourite signs and proposals, to keep up with the discourse, and participate in its debate.

3 - Voting System: A "Thumbs-Up and Thumbs-Down" system, in which users can express their agreement or disagreement with a proposed sign entry.

4 - Comment Section: Furthermore, we have also implemented a comment section, present in the form of nested comments, with the option to create or reply to a comment in the form of a video, to facilitate DHH dialogue, as well as text commentary.

5 - Profile Customization: Users can freely customize their user page with information they may find pertinent sharing, such as their name, a brief description, the recording of their sign name (a specific gesture assigned to a person in the DHH community), age, gender, communication languages, professional occupation as well as an optional phone number for administrators and moderators to contact them if need be, for a discussion on sign proposals. When implementing this feature, we also aimed to deepen governance with it.

6 - User contributions: Users can verify their contributions to the dictionary platform, ranging from sign proposals, positive and negative votes, and comments left on other signs on their page. Users can also visualise other user contributions by visiting their profiles. Once again, when implementing this feature, we aimed to boost the mechanisms of digital governance.

7 - Moderation Page: In order to boost governance, we added a moderation module for an eventual moderation team. When a user submits a signed proposal, it is immediately added to the discussion of the overall community. However, it has also been added to a moderation hub, where the team can give approval, reject, or send comments for improvements to the submission.

The platform is deployed, and available at [Dicionário LGP](#). The source code is also open-sourced and is available in [Github](#).

5

Sign Language Dictionary Deployment In Schools

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In this chapter, we will go through the validation of our annotation module and the sign-search engine, through a deployment in two separate first-cycle schools, with two entirely Deaf classes as well as the original study and use of the annotation module to annotate entries for use in class, which stemmed the changes to not only the first-cycle dictionary, but also the general dictionary.

5.1 School Deployment

We started with a school deployment to enable linguists, teachers, and children from the LGP DHH community to test our prototype, allowing us to gain context for validating our annotation feature.

Mara Moita and Paulo Carvalho from Universidade Católica Portuguesa, who work in Deaf Studies with the DHH community, conducted a study with the children. We will not be reporting data on the study and the children, other than age and the level of hearing impairment; however, it is important to note what tasks the children underwent, which influenced the design of the dictionary, as it was conducted by linguists with support of the primary teachers of each class, some of them also being a part of the DHH community, therefore leading to a more rigorous testing and feedback.

In order to evaluate sign entries and a dictionary only for first-cycle students, we created a different module which we denominated as the "First-Cycle Dictionary", which contains only entries with first-cycle themes.

What distinguishes the "General" Dictionary from the First Cycle Dictionary is a simple backend query, in which we only showcase the results that are, first, annotated. Second, have a specific string in the themes; in this case, if the sign has a theme containing "1ºCEB", it is showcased in the First Cycle Dictionary.

The algorithm used for the filtering:

Listing 5.1: First Cycle Dictionary Filtering Algorithm

```
1  async function getSigns(): Promise<Sign[]> {
2    let query = event.locals.supabase
3      .from('signs')
4      .select('*', { count: 'exact' })
5      .eq('is_annotated', 2)
6      .or(`theme_flattened.ilike.%1CEB%,theme_flattened.ilike.%DACTILOLOGIA%`)
7      .range((page - 1) * perPage, page * perPage - 1);
8
9    // ...
10
11    return signs as Sign[];
12  }
```

The algorithm searches for the entries in the database of the dictionary, in which it selects all annotated entries, and joins all the entries that include either the "1ºCEB" string or "DACTILOLOGIA", which are the letters of the sign alphabet.

In the first session, the children were introduced to the Dictionary Platform, which at the time included the first-cycle dictionary. The following sessions had the children utilise both the sign-search

engine, through the various phonological elements, and the text-based search engine, as well as the components implemented within them, such as the filter button to allow filtering by themes.

While we previously deployed our annotation module and the first-cycle deployment allowed us to validate our annotation, we also wanted to verify if our sign-search engine was validated, which is deeply tied with the annotation module.

5.2 Annotating for the First Cycle

Before deploying the platform in schools, we needed to prepare all the work that users would experience, ensuring it would function correctly on the sign-search engine. As this was the very first step at the time, most features in the annotation module were not available. As the deployment and testing took place from May to July, these preparations occurred from March to April. We refer to this as the Annotation Module Deployment.

We successfully migrated all the data from the previous Annotation Platform. However, this entire set of data had to undergo revisions to its annotations and themes; therefore, there was an urgency to adapt and improve the existing annotation module for school deployment.

Over the course of this annotation period, two linguists used the annotation platform to annotate 777 sign entries for the children, covering 59 distinct themes that aligned with first-cycle teaching themes, in order to test the children's lexicon in these various themes.

This annotation consisted of assigning phonological parameters (configuration, location, orientation, movement, and facial expression) to sign entries, as well as assigning names to the entries. It also involved uploading a video of the sign entry, delegating themes, providing a textual description, a context video, and the translation of the context video. Furthermore, linguists also annotated the origin of the sign (whether it was a general/country-wide sign entry, or specific to a region of the country)

Over the duration of the school deployment and through the attended sessions, we received feedback from students, linguists, and Professors. This data collection was compiled through personal notes taken during the sessions. These notes were later transcribed into an implementation table.

When not present, and when feedback was received remotely, either through emails from professors and linguists, phone calls from linguists, or video calls with linguists, we wrote the feedback for backlogging purposes to be implemented later.

As there was a massive influx of user requests for implementation and refinement, we decided to create a singular point of request from users, a spreadsheet of requests and priorities, made available to linguists, where they could write down their requests or issues on the platform, with a level of priority (ranging from low to urgent). This spreadsheet was implemented during deployment and was designed to register requests and bugs related to the use of the dictionary in schools and the backend annotation

module.

5.3 Participants and Duration

This study was conducted in two schools, Instituto Jacob Rodrigues Pereira and EREBAS, with 16 children. The interval of ages in the children ranges from 7 to 12 years, and their hearing impairment ranges from moderate to severe.

The study lasted 2 months, from May to July, spanning eight sessions at each school, for a total of 16 sessions.

5.4 Findings

When annotating for the children, our linguists found some issues in the annotation module, as well as features and quality-of-life features they would like to see added. We gathered that some words could eventually cross into themes when annotating for the first cycle. For example, the word "VERDE", roughly translated to green, could be used in Portuguese and science contexts. It is restricted not only to the first cycle vocabulary but also to a general term. Originally, an annotator could only type a single theme for the dictionary, and this would either restrict the number of signs present within a theme, therefore causing a lack in lexicon, or have multiple copies of the same gesture with different singular themes, rendering them shallow and useless.

When porting the original database of annotations from the Annotation Platform, some of these original annotations were either too confusing or non-existent. For a new sign entry creation, we originally added a button to the dictionary, visible only to linguists, for them to create a new sign entry, and if they so wished, to annotate it immediately. However, further testing and feedback from the linguists determined that the button in the dictionary modules proved too confusing, and they would skip between the modules a lot for many new annotations.

Another issue from the mass migration from the annotation platform came from the already completed annotations. The linguists mentioned that some of these annotations were either incomplete or wrong, as another colleague did them, or it was their mistake.

A consequence of a large amount of data created is the navigation through said data. We initially implemented a pagination navigation for each of the three statuses on annotations ("Not Complete", "Partially Complete" and "Complete"), with simple buttons such as "Previous" and "Next" to allow the user to search for the entries. Although this proved helpful, the linguists gave feedback regarding a slowdown in productivity when searching for an annotation they wanted to complete.

An initial setup was made in the Annotation Platform to determine the status of the configuration. We

had previously established an annotation as complete when it had the five original configurations set, that is, configuration, location, orientation, movement and facial expression, or it could also have at least five annotations set. However, a certain number of sign entries do not have this complete setup. The dactylology sign entries are an example of this, arising only from configuration, orientation, and location. Therefore, these signs would automatically be incomplete and not showcased in the dictionary.

When porting the original dataset, according to our linguists, many sign entries were incorrectly annotated, and their feedback indicated they would prefer to create a new entry rather than fix the previous one altogether. This feedback implied there would be duplicates of a sign entry, one with a correct annotation and the other with an incorrect or incomplete annotation.

The original layout for an annotation and a sign page included simple decisions such as the Video of the sign, the sign name and the themes. Feedback from the linguists mentioned this would not be enough for a dictionary, as it would deem the entries far too incomplete for showcasing.

In the first session of the study, students were to have a first contact with the dictionary and search for the word "PAI", roughly translated to Dad or Father, through configuration, and a free sign entry also through configuration, and evaluate the experience. In this session, results were negative, with collected feedback amounting to the interface being confusing with Carousels, no verticality, and jumping through windows in the interface.

Searching through either the Sign Search Engine or the text-based search engine would initially showcase all query results. This came with many more downsides than positives, as the dictionary platform would slow down at massive levels, most times not even loading the videos on the search page.

The original version of the main page of the dictionary and search, implemented various carousels with various themes present in the dictionary. In the first session, this posed a challenge for the children and the linguists, as they were expecting a vertically searchable layout, and the divisions per theme were confusing.

This study also revealed that the students found it easier to search through the location phonological parameters, instead of configuration, which is the opposite of what occurs with linguists and DHH members of the platform.

When in-class attending, we noticed the results of our sign-search engine were positive, appearing in the first page of results, and when remotely receiving feedback there were no criticisms or problems raised with the results received.

5.5 Refinement

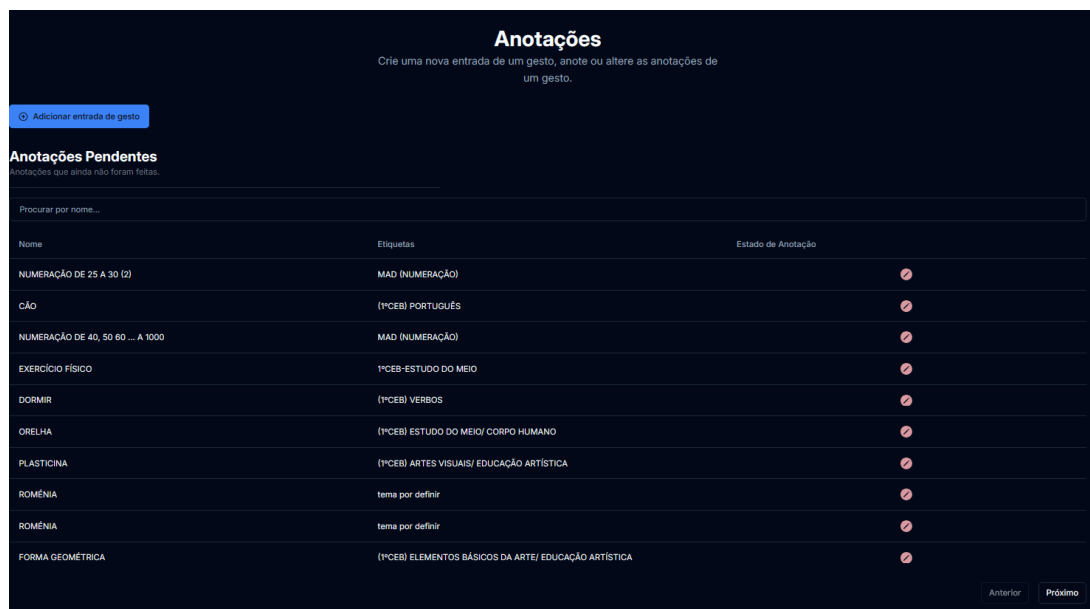
Following the feedback of the linguists and students, during the deployment of the annotation tool and the dictionary itself, we made various implementations and improvements, following a User-Centred Design and iterative methodology.

Regarding the issue of the same sign entry having multiple themes but not replicate the same entry to adhere to different themes we implemented a maximum of ten themes per sign entry to avoid replicating the entry and increase the lexicon per theme.

In order for linguists to not jump between modules, when wanting to create an annotation from scratch, and edit one, we decided to centralise this solution and replaced the button from the dictionary to the Annotation Hub at the top of the page.

In regards from the mass migration and incomplete or wrong annotations, rather than having only two sections, which were the "Annotation Not Complete" and "Annotation Partially Complete", we decided also to implement an "Annotation Complete" status and table so that the linguists could annotate incorrect sign entries, or, should they wish to change an annotation.

Regarding the navigation issues through pagination, we decided to implement a text search bar for each annotation status table, which searches for an annotation through its name. Feedback was positive for this implementation.



Anotações		
Crie uma nova entrada de um gesto, anote ou altere as anotações de um gesto.		
Adicionar entrada de gesto		
Anotações Pendentes		
Anotações que ainda não foram feitas.		
Procurar por nome...		
Nome	Etiquetas	Estado de Anotação
NUMERAÇÃO DE 25 A 30 (2)	MAD (NUMERAÇÃO)	✓
CÃO	(PCEB) PORTUGUÊS	✓
NUMERAÇÃO DE 40, 50 60 ... A 1000	MAD (NUMERAÇÃO)	✓
EXERCÍCIO FÍSICO	(PCEB) ESTUDO DO MEIO	✓
DORMIR	(PCEB) VERBOS	✓
ORELHA	(PCEB) ESTUDO DO MEIO/ CORPO HUMANO	✓
PLASTICINA	(PCEB) ARTES VISUAIS/ EDUCAÇÃO ARTÍSTICA	✓
ROMÊNIA	tema por definir	✓
ROMÊNIA	tema por definir	✓
FORMA GEOMÉTRICA	(PCEB) ELEMENTOS BÁSICOS DA ARTE/ EDUCAÇÃO ARTÍSTICA	✓

[Anterior](#)
[Próximo](#)

Figure 5.1: Annotation Hub

To remedy the issue of different annotations, and not having a requirement of all the five phonological aspects of a sign, when a linguist annotates an entry, it is now possible to set the status as they see most correct. This implementation also fixes future annotation ideas and implementations, as signs might be

missing their country region, descriptions, videos, and still be considered incomplete.

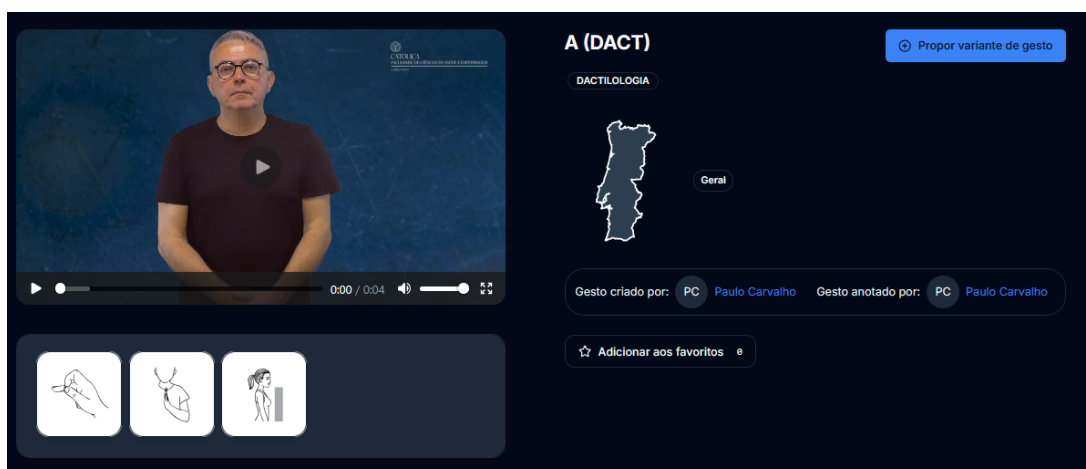


Figure 5.2: Sign page for the dactylogy A

To fix duplicate entries and the need to create an annotation from scratch, we added a Delete button to delete the sign entry from a database, fixing these issues.

With regards to the additional information addition to a sign entry, With their feedback, we eventually added various options, such as the country region the sign entry belongs to, spanning the 20 districts of Portugal (Madeira and Açores included), a description for the sign entry, a context video and a context text for the entry. Furthermore, a frequency of use scale was added, ranging from 0 to 2 (Not very frequent, frequent and very frequent).

The platform was initially conceived to be used on a desktop or laptop device. For this study, the children were to use a tablet device; therefore, we had to adapt the layout to be responsive and usable on a tablet.

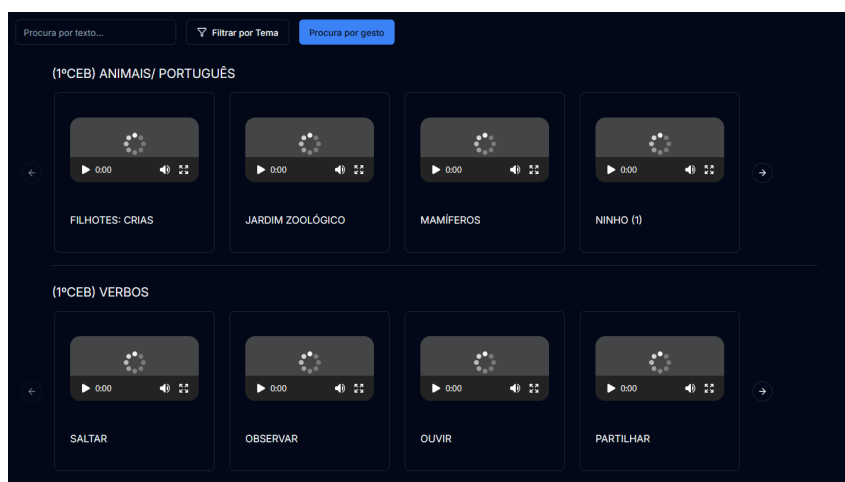


Figure 5.3: Original Carousel Implementation with all the signs loading

Regarding the issues present in the first session of the dictionary usage, instead of displaying the signs on the page, our initial version of the sign search would have had the user search for the signs and then display the search query results in a popover. This implementation posed some issues, as it would remove immersion from the user and sometimes display inconsistent results, either showcasing wrong results or none at all. Users could remedy this issue by refreshing the page, but we were not looking for this result. To counteract this implementation, we instead started showcasing the results by refreshing the original showcased signs on the query.

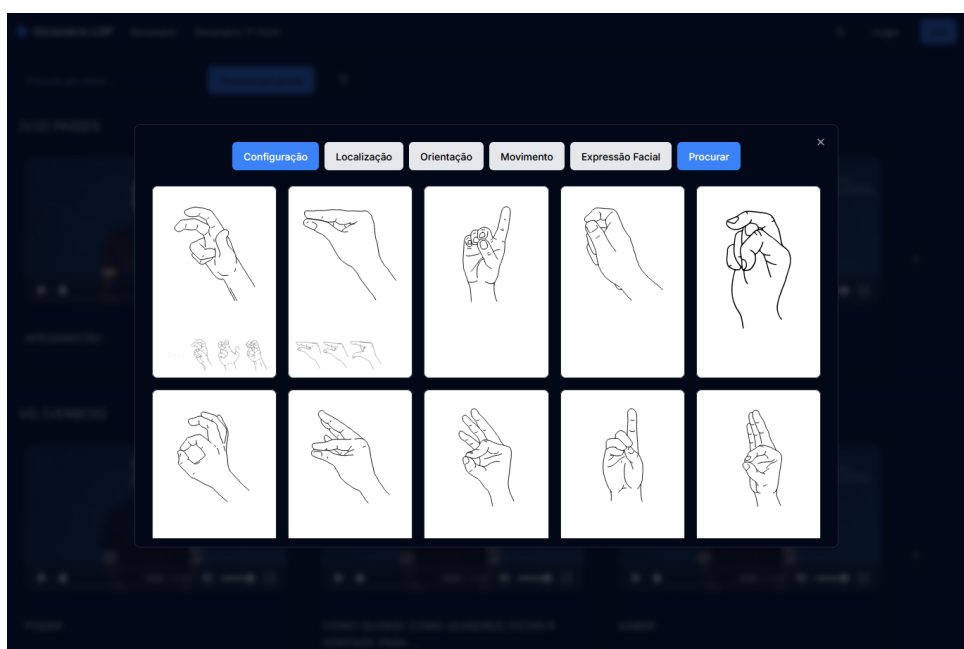


Figure 5.4: Original version of the Sign Search Engine, with the Popover menu

After feedback and meetings with the linguists and teachers, we converted the Carousels to a Grid. We also decided to remove the main page of the dictionary with predetermined showcase signs. We have now implemented a "blank" page with the search bar at the top.

To counter slow pages and non-loading sign videos, we implemented the return of only a subset of signs, in this case, only the 90 signs most approximate to the query and pagination on the queries and frontend of the dictionary. Specifically, we divided the subset of 90 signs into nine signs per page, displaying 10 pages of signs for the user to explore.

First, when changing pages or making another search in the engines, the entries of the signs would change, including their names and themes, but the previous videos from previous signs would remain. Initially, when we had the carousels and then the original grid implemented, we never encountered this issue as we loaded everything from the server. This error was an oversight on our part, as we made this component reactive afterwards.

Other than this technical error, from linguist and student feedback, they were unaware of which page they were situated in. To remedy this issue, we changed the colour of the pagination page that the users are currently using.

Other miscellaneous quality-of-life improvements include searches ordered alphabetically and when filtering through themes; if a sign has more than one theme, it only appears as a singular entry with a singular theme. Sometimes annotations also appeared in random order on the search results; we fixed this by following the standard order of Configuration-Location-Orientation-Movement-Facial Expression.

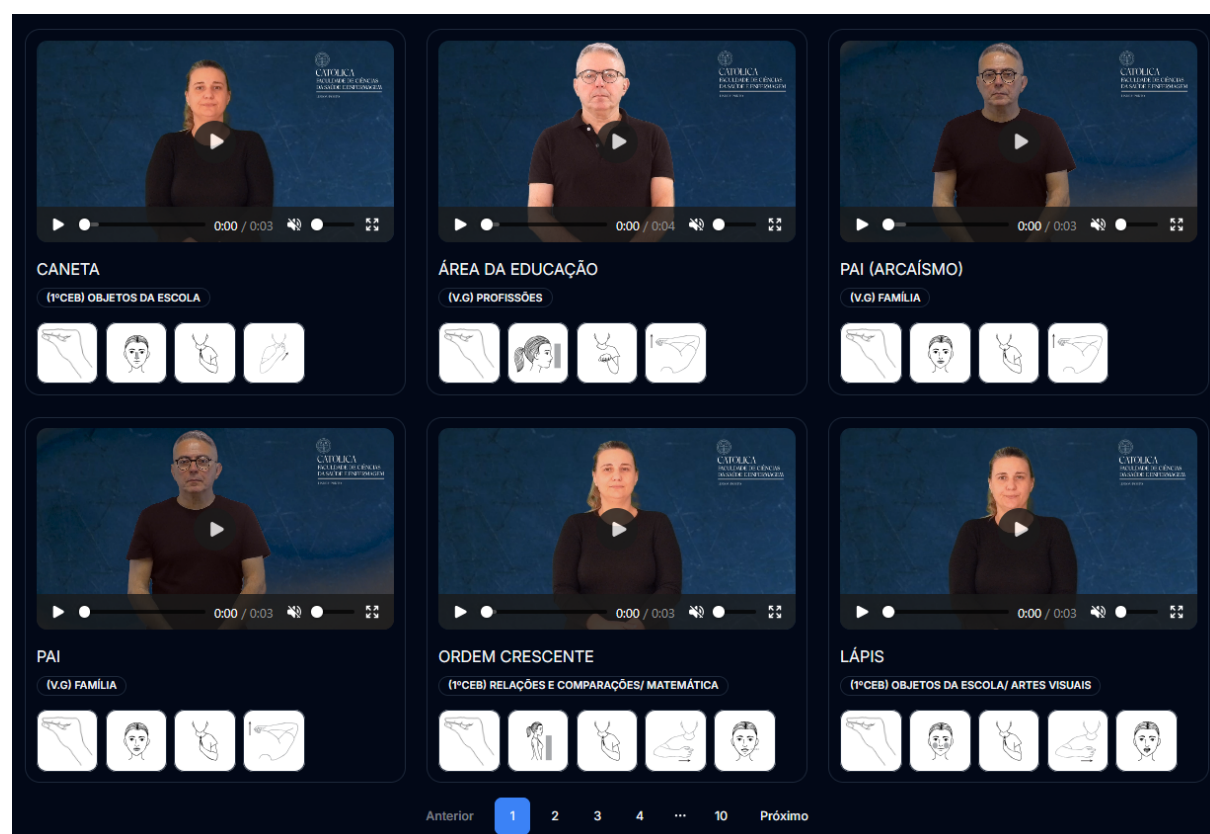


Figure 5.5: The newer dictionary grid layout with pagination

Another user experience change was regarding the annotation for the facial expression "Neutral". This expression has been hidden from the showcase to the children and the general user, as it confused them. The linguists can still visualise and insert this annotation on the module.

Due to the preference from the students in searching through location, we changed the order of the search bar, prioritizing the location first.

Furthermore, the students also clicked on the annotations to redirect them to the sign page. We added feature of redirection when clicking on annotations, to the sign entry, easing the use of the dictionary and search grid.

6

Crowdsourcing Module Deployment

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This chapter will review our Crowdsourcing Deployment. We detail our usability evaluation, its methodology, the participants, and the procedure divided into scenarios and tasks. Furthermore, we detail our findings regarding the use of the crowdsourcing module when deployed to the community. At the end of the chapter, we detail our findings, limitations as well as discuss the results of both the evaluation and the deployment.

Following the deployment in schools, and to present the Dictionary to a broader audience, our linguists annotated a total of 2,790 sign entries across 186 distinct themes. In the Dictionary are present signs used throughout Portugal, as well as regional variants from the Açores, Madeira, and Porto.

6.1 Usability Evaluation

6.1.1 Method

From this Usability Evaluation we wanted to test how the users behaved towards the module, as well as how functional it was.

6.1.1.A Participants and Procedure

For this study, we had two participants, a DHH member (P1) and a linguist (P2). These participants are experts and fluent in LGP and have some expertise with the Dictionary Platform, being accustomed to the platform itself and some of its features. We chose this purposive sampling approach to encapsulate expert user perspectives and observe varying levels of familiarity with the new participation module.

We collected data through two individual testing sessions, conducted by a facilitator using a think-aloud protocol. To evaluate the usability and flow of the crowdsourcing module, we deemed it necessary to conduct predefined tasks. We gave the participants a set of scenarios with tasks. This set of tasks was the same for both participants. We conducted a remote video session with each participant's audio and video screen recording to capture user interactions and verbal commentary. Communication in the first session occurred through LGP and a direct translation to the facilitator, and the second session occurred in Portuguese. You can verify the original scenarios and tasks in B.

The scenarios and tasks were as follows:

- **Scenario 1 - Contributing with a Sign Variation:** *Imagine you are learning Portuguese Sign Language, and the gesture for the sign "Bird" is slightly different from what you usually encounter in online sign dictionaries. You want to share your version of the sign, to further enhance the dictionary, making it more complete and representative of all manners of gesture.*
 - **Task:** Find a way to contribute with your version of the sign "Bird" to the platform.

- **Scenario 2 - Interacting with Community Content:** *You have just submitted your sign variant, and you want to verify how the community reacts to contributions like yours. You are also curious on how other people gesture, and want to show your support to good proposals.*
 - **Task:** Explore how the community interacts with sign proposals and participate in different sign variants discussions.
- **Scenario 3 - Managing Your Contributions:** *You have contributed to the Sign Language platform for some time now, and want to follow up on what you have submitted. You are particularly interested in seeing which of your contributions have been accepted by the community.*
 - **Task:** Review your proposal submission history and see the current status of your proposals.
- **Scenario 4 - Moderating Community Content:** *You are a trustworthy member of the community who has received moderation privileges. You want to help your community by reviewing new sign proposals to ensure they are up to the community standards.*
 - **Task:** Review and make decisions regarding pending sign proposals of other community members.

These tests allow us to test the core functions of the crowdsourcing components, and further allow us to verify if they are accessible to the general audience the platform is tailored for, DHH community members. These tests are also optimal in discovering the main difficulties and shortcomings of our implementation.

The scenarios and tasks were handed to the participants when the session started. Any questions in the beginning, throughout the study, or in the end were answered.

After each task, we asked each participant for their opinion on the complete task. To gather measurable data regarding the ease and pleasantness of use in each component of the module, we used a 5-Point Likert Scale, ranging from "(1) Strongly Disliked/Extremely Hard"-"(2) Disliked/Hard"-"(3) Neutral"-"(4) Liked/Easy"-"(5) Strongly Liked/Extremely Easy". After asking the opinion of each participant through the Likert Scales, we asked an open question on how they felt about the component they had just tried, allowing us to gather more data without the restrictions of the scales.

6.1.2 Data Collection and Analysis

We recorded each usability evaluation session through audio and screen recording for our data collection. The first session had to be translated with the help of an LGP linguist, and the second was with said linguist. The sessions generated qualitative data through verbal think-aloud protocols to capture participants' reasoning and feelings over the tasks. We also observed user navigation patterns and

interaction challenges during these tasks. Following the tasks, we collected participant ratings that provide quantitative usability measures, and finally had a follow-up discussion exploring broader platform perceptions and suggestions.

We followed Braun and Clarke's (2006) six-phase thematic analysis framework for our inductive thematic analysis, which facilitates and allows a flexible, systematic approach to identifying patterns across qualitative datasets. This framework was suitable for exploring user experiences and perceptions of the new module.

First Phase: Data Familiarisation - We conducted various readings of the session to gain an iterative, comprehensive understanding of the data. Our first observations noted the contrast between each participant's task completion, user interface understanding and navigation struggles.

Second Phase: Initial Code Generation - Across the entire dataset, we systematically generated codes that captured surface-level and underlying meanings of the data. Rather than predetermined codes, we developed them inductively, in such a way as to allow them to emerge organically from the experiences of the participants. We will discuss these codes further in the section.

Third Phase: Theme Development - We collated previous codes from the last phase into potential themes through various iterations of grouping and regrouping. In this phase, we mainly focused on identifying patterns across the codes and considering how they were related to the overall research questions about platform usability and community engagement potential.

Fourth Phase: Theme Review and Refinement - Themes from the previous phase were reviewed alongside the coded extracts and the entirety of the dataset to ensure coherence and clear distinction among them. We merged some of the initial themes and refined them further to capture the complexity of the experiences of each participant.

Fifth Phase: Theme Definition and Labelling - We defined some final themes with specific focus areas, which we will mention further in the section.

Sixth Phase: Report Production - All the analysis culminated into a comprehensive thematic report that attempts to join these themes together to tell a coherent story about user experiences with the module, supported by participant quotes.

We will review each developed code with participant quotes as its supporting data.

Easy Task Completion - The second participant had a more accessible experience with the tasks, often rating his likability and ease of the tasks at the maximum range of the scale (5), with quotes such as

"I thought it was super easy, 5. You just enter the participation module, and it is right there. Five.", "This is very intuitive.", "I thought the four scenarios were super easy and intuitive."

Navigation Confusion - Our first participant, however, found difficulty in navigating the interface of the platform, with quotes such as

"Where is the proposal, where is it? I can not see it.", "It is a little confusing.", "It is not easy because you have to be searching for things."

Search and Discovery Issues - Tying with the previous code, both participants, when it came to the moderation part of the tasks, to approve or mediate a sign proposal, could not initially find the option to give their opinion, with quotes such as

"The three dots... where are the three dots? How do I moderate?", "I think these three little dots... I am not sure if one should amplify them, or have a box around them, so a person can understand that there are in fact more options".

Visual Clarity Problems - Some of our visual user interface components showed a lack of distinction and clarity, often confusing our participants,

"I think participate should not be in that layout, it is confusing and you can not see it. Perhaps separated from all the dictionaries and on the right, and maybe "Participate" is not the best phrasing, perhaps "Community Participation" would be more appropriate.", "I think the background is too white, far too white." and "The design could use improvements."

Need for Visual Improvements - We received feedback from both participants denoting the platform's user interface design, often calling for a need for change,

"We need a designer... to change some things when it comes to the level of the design. I think that is my only major complaint. With more colours, the LGP symbol... we need to make it more commercial.", and "If there were less contrast, it would be easier... like, something which would stand out to click on."

Familiarity versus Novelty - While both participants were used to the platform, the first participant had a much more nuanced difficulty with the newest module, and fears for other users that might be new to it:

"I am just thinking that I am into this and making the annotations, I am used to this... Someone from outside who has never seen the platform might get confused.". However, the second member noticed a change right away: "I am very used to the platform, I noticed immediately that there was something new there."

Adaptation to New Features - Tying with the previous code, our first participant mentioned the confusion of the newer module,

"It is a new thing, I was confused. It was the first time I saw it, I saw the word "Participate", and I got confused." The second participant was much more accessible to it and had no queries

with the new module: *"I am very used to the platform, I immediately noticed something new there."*

Feature Utility - Our participants, even with their differences in opinions, both agreed on the utility of the features:

"I think it is useful." (referring to the voting and favourites crowdsource features) *"It is super useful, this is a fantastic idea."* (referring to the overall crowdsource module)

Comprehensive Functionality - We also reached out to the participants regarding the overall platform, not only the crowdsource module, with positive feedback:

"The platform has many excellent features, primarily having the possibility of having two dictionaries." *"The sign language parameter search, I mean, it is the first dictionary that does this, it is fantastic."*

Community Engagement - When asked, the participants noted the impact the platform and crowdsource module could have on the DHH community, quoting:

"(...) First and foremost, we are including them in constructing a dictionary." *"(...) in the end, we are including all society to interact with the dictionary. This is very important."*

Knowledge Centralisation and Regulation - A participant mentioned the resources in the DHH community being scattered, and the platform would be able to centralise this, quoting:

"(...) it will regulate and stabilize the language when it comes to proposals, which can be discussed inside this platform, and not be around in various social media platforms and be discussed with much nonsense."

Sense of Belonging - A participant mentioned how involving the community in a dictionary would create a sense of belonging:

"(...)you will give people a sense of belonging as well."

Pioneering Nature - As the first Portuguese sign language dictionary that has the Sign Search Engine and the crowdsource features, our participants said

"This is the first project being done of this scope." *"The sign language parameter search, I mean, it is the first dictionary that does this, it is fantastic."* *"There is nothing like it in Portugal. It is the first step, the first time you are giving it to the community."*

Research Potential - One of the participants evidenced the massive research potential, and a place where all society can join:

"The dictionary is very good not only for people who search for a sign, but also bilingual LGP and Portuguese speakers, it is a language dictionary. On the other hand, it is also possible for an investigator to do numerous research studies here, using selected parameters. How many configurations are the most used? I mean, you can do thousands of research activities here."

We refined our codes into themes, accompanied with supporting codes and their summary.

First Theme: Usability Issues - The platform has evidenced some clear usability issues across the two test sessions. While one of our participants finds the core functionality intuitive, consistent indicators present in the other participant showcase that some users may eventually struggle with navigation and feature discovery. **Supporting codes include:** Easy Task Completion, Navigation Confusion, Search and Discovery Issues, Adaptation to New Features.

Second Theme: Visual Design as an Accessibility Barrier - Across both user sessions, there were several feedback instances that the visual designs posed a critical usability barrier. The interface design hindered user task completion, regardless of expertise level. **Supporting codes include:** Visual Clarity Problems, Need for Visual Improvements.

Third Theme: Revolutionary Community Participation Platform - Both our participants recognised the platform as a groundbreaking new resource for the Portuguese DHH community. It is the first of its kind, offering opportunities for centralised community engagement in dictionary construction and linguistic standardisation. **Supporting codes include:** Community Engagement, Knowledge Centralisation and Regulation, Sense of Belonging, Pioneering Nature.

Fourth Theme: Multifunctional Research and Community Tool - The platform was valued for the potential of serving multiple constituencies simultaneously: researchers, linguists, the Deaf community and the general public. Our comprehensive features create an ecosystem for sign language documentation and research. **Supporting codes include:** Feature Utility, Comprehensive Functionality, Research Potential.

6.1.3 Findings

The thematic analysis of our user testing sessions revealed four primary themes that characterise user experiences with the crowdsourcing module of our Dictionary Platform. These themes evidence the innovative potential and challenges users face when engaging with the participation features on the platform.

Regarding the first theme, the Usability Issues, our analysis revealed a divide between in user experience with the platform and module. The first participant, with consistent high ratings of 5 out of 5, found the core functionalities intuitive and straightforward, describing the tasks as "super easy and intuitive" as well as "I thought it was super easy, 5. You just enter the participation module, and it is right there.". In opposition, our other participant experienced some navigation challenges, struggling

to locate basic functions, such as the location of our crowdsourcing module on the user interface, for example, quoted "Where is the proposal, where is it? I can not see it.". This issue demonstrates how the complexity of the platform can create barriers for sign language users. This gap was also noticeable in the moderation scenario, where one of the participants rated the experience as difficult, a 1 out of 5, due to the confusion in interface elements and the need to evidence these UI elements further.

The implications of this divide go even further beyond individual user experience. One of our participants observed, "I am just thinking that I am into this and making the annotations, I am used to this... Someone from outside who has never seen the platform might get confused.", suggesting the current design might not be user-friendly and might exclude potential community participants.

The second theme, Visual Design as an Accessibility Barrier, exposes how our visual design might be a critical usability barrier affecting users regardless of expertise levels. Participants identified the lack of visual contrast on the interface as problematic, describing it as "too white" and needing elements that would stand out, which would improve usability. Some hidden interactive elements pose some challenges; such as the three-dot element used for the moderation function was consistently hard to locate and led to an increased time to find it. Recommendations surge from these issues, such as needing a "box" around the dots to further evidence them.

Issues regarding the overall commerciality of the platform were also brought up, with the need for a culturally appropriate visual design, as well as the need for more colours and a redesigned main page layout, indicating that effective platforms dedicated to sign language require visual languages and upgrades in order to communicate with the community and relate to them.

The third theme, Revolutionary Community Participation Platform, evidences usability challenges; however, the participants recognise the platform's potential for the Portuguese DHH community. Quotes such as "This is super useful. This is a fantastic idea." evidence this sentiment, reflecting on the broader significance of the platform. The pioneering status was also consistently emphasised, with quotes such as "In Portugal there is nothing like it. It is the first step, the first time it is being done.", which further enhances the community engagement in dictionary construction, which is unprecedented.

Our two participants valued the platform's potential for linguistic standardisation and quality control. One participant mentioned how the platform could regulate and stabilise the language by offering a centralised space for proposal discussion, which limits the scatteredness and unregulated discourse of debates across various social media platforms.

For our final theme, Multifunctional Research and Community Tool, there is an emphasis on the value of the platform, in the aspect of serving multiple groups in the community, such as the Portuguese DHH community, bilingual individuals, the Portuguese speaking community, linguists and researchers, highlighting its comprehensive functionality, which included many "excellent things", which include our two dictionaries and the unprecedented parameter-based search engine. Furthermore, our participants

recognised the research potential of the platform, with various possibilities for researchers in the search engine and annotation systems. The educational potential of the platform was also evidenced through mentions of the first-cycle dictionary, demonstrating its value across different user contexts and purposes.

6.1.4 Limitations

For this study, we could only manage a small sample size of two participants. The small sample of participants limits our data collection for usability for a larger scale of users; therefore, we can only evaluate broader usability when the module is deployed.

A single session for each participant only provides a brief instant perspective rather than a longitudinal one into how users might adapt to the platform over time. The extended use of the platform could reveal different patterns of interaction and potentially different assessments, as users become familiar with the platform and its modules over time.

Our participants were already accustomed to the platform, which can skew the usability testing results. Furthermore, the first participant had their dialogue translated by the second participant; therefore, when conducting the second study with the second participant, there is a chance of result skewing as well, as the participant might have already seen the screen capture of the previous participant.

The absence of novice users in the sample is significant, considering one of the principal themes identified was the usability gap between expert and novice users. While a participant demonstrated issues in navigating the platform, both participants were fairly acquainted with the platform, which is not representative of the broader Portuguese DHH community.

While proving valuable in capturing immediate user reactions and reasoning, our think-aloud protocol might have influenced natural patterns in interacting with the platform. Our participants might have been aware of being observed and recorded, which might have affected their behaviour and willingness to express negative feedback.

While we asked for general platform opinions and potential, our scope of evaluation study focused on the new crowdsourcing module, rather than conducting an in-depth and comprehensive platform evaluation. While this does narrow the focus on participants and is an appropriate evaluation method for the research objectives, it might mean that findings might not reflect broader platform usability or user satisfaction.

6.1.5 Discussion

Our findings reveal a fundamental need to design digital platforms for sign language communities that balance functionality with accessible interfaces. Of note, the usability issues identified in the study reveal

a critical challenge: how to create tools that might serve specialised research needs while remaining welcoming to community participants.

This emphasis on visual design barriers is even further significant for sign language platforms, where visual and spatial communication is essential. Traditional web design principles may be insufficient for these communities, whose linguistic modality relies on and is inherently visual. Participant suggestions for commerciality and the incorporation of different colours and LGP logo-symbol point towards the need for a culturally responsive design that aligns interface conventions and community preferences.

To resolve this issue, we implemented a main page following a "Hero Landing" design, which features the various modalities available on the platform. The current logo is also a placeholder, which can later be replaced with one that represents the LGP community.



Figure 6.1: Newest landing page for the platform

Recognising the platform as "revolutionary" despite usability challenges suggests that innovation in community-engaged language documentation solutions can generate significant goodwill despite technical limitations. However, this patience should not overshadow the need to address accessibility barriers that might exclude potential imperative participants. The platform's success in enabling a sense of belonging and community ownership of the language and its documentation processes represents a

significant achievement in democratising linguistic knowledge creation.

Our findings have implications beyond LGP for digital documentation of minority and endangered languages in general. The tensions between comprehensive functionality and accessible design are likely endemic to specialised platforms attempting to engage with broader communities. The success of our parameter-based search and annotation systems in serving research needs, while potentially supporting community engagement, suggests models for how digital language documentation can transcend simple reference tool functionality to become a research infrastructure.

6.2 Crowdsourcing Deployment

For our Crowdsourcing Deployment, we gathered information from some participants regarding its use and their pros and cons. We also gathered opinions from the crowdsourcing module, as well as the dictionary platform overall.

6.2.1 Method

From this deployment we wanted to feedback on how the users utilized the module, including feedback on its functionality, as well as participants' opinions toward the potential of the platform.

6.2.1.A Participants and Procedure

For our deployment, we were able to gather 4 participants for feedback, with the help of a Professor from Universidade Católica Portuguesa. These four participants were part of the LGP DHH community and of the feminine gender, with different backgrounds. P1 is a LGP Professor, P2 is a LGP interpreter and a college LGP Professor, P3 did not disclose any occupation, and P4 is a LGP linguist and scholar.

In order to introduce the platform and the crowdsourcing module, we scheduled a meeting with some members of the LGP DHH community. In this meeting we presented the overall dictionary platform, with the dictionary module, both search engines, as well as the Crowdsourcing module. After the demonstration of the platform, we presented a slide presentation for the tasks we wanted our participants to complete. We gave our participants a form to fill throughout their completion of the tasks, throughout a duration of three weeks. You can verify the original form in B. The tasks were as follows:

We first asked participants to register on the platform. Following their registration, we asked users to search for the sign entry "PÁSSARO" with a given hand configuration. After completing this second task, we asked users to search for five other sign entries with any phonological parameters and to record the sign name entries and phonological parameters they found. We then asked for their feedback on the sign-search engine, including both positive and negative comments, as well as suggestions for

improvements and overall impressions. Following these tasks, we asked our participants to search for the sign entry "PÁSSARO" using the text-based search engine, and then to search once again for five other sign entries using the same method. We then asked participants to write the sign entries they searched and provide overall feedback, including both positive and negative aspects, as well as suggested improvements. Furthermore, we asked our participants to propose three new signs with our crowdsourcing module and provide feedback on the proposal process. They then voted on at least three different sign proposals, indicating whether their vote was positive or negative for each entry. Following the voting activity, participants shared their opinions on the process, including both positives and negatives, as well as suggestions for improvement. Finally, participants commented on at least five different sign proposals, using either text or video, and documented which entries they commented on and their chosen method of commentary. They provided feedback on the commenting process and its potential improvements. The evaluation concluded with two open-ended questions: how participants envisioned using the platform in their daily lives, and what potential they saw for the platform given their occupation and position within the LGP deaf and hard-of-hearing community.

6.2.2 Data Collection and Analysis

We collected responses from our users' forms and summarised them by topic, in order to focus on the most important subjects to retain from the feedback.

We will organise our positive aspects, issues, notes, improvement suggestions, concerns for the future, and key points received from user feedback, through these themes in our Findings subsection at 6.2.3.

First topic: Sign Search by Phonological Parameters - The participants used our sign search engine through the phonological parameters of configuration, location, orientation, movement and facial expression of a sign. While appreciated as innovative and with an overall good feedback, the feature presented some usability challenges.

Second topic: Text-Based Sign Search - The text search engine was found easier and more functional than the sign search engine, though users identified several limitations and areas for improvement.

Third Topic: Dictionary Organisation and Structure - Our users experienced confusion about the organisational structure of the dictionary, and suggested a more apparent separation between different dictionary types.

Fourth Topic: Proposing New Signs to the Dictionary - Our participants appreciated the community-driven approach but had some concerns about the quality control and submission process.

Fifth Topic: Voting on Proposed Signs - Our voting system was seen as accessible, but users encountered technical difficulties and raised concerns about scalability.

Sixth Topic: Commenting on Proposed Signs - Users of the platform valued the ability to contex-

tualise and describe signs, but encountered technical barriers preventing their full participation.

Seventh Topic: Technical Issues - Several technical problems hampered user experience throughout their testing.

Eighth Topic: Overall Platform Potential and Vision - Despite its challenges, users strongly endorsed the potential value of the dictionary for the Portuguese Deaf Community and beyond.

6.2.3 Findings

As mentioned in the beginning of the section 6.2.2, we will list all positive points, issues, notes, improvement suggestions, concerns for the future and key points for each topic.

Regarding our **Sign Search by Phonological Parameters**, as **positive aspects**, we got feedback that it was an innovative approach for a Portuguese Sign Language Dictionary, each video displays all LGP phonological parameters, and it was considered a pioneering and bold project worthy of support. However, there were some **challenges identified**, such as the difficulty in separating signs by parameter type; therefore, searches often returned signs with different configurations than selected. Selection highlighting was too subtle, with the blue selected outline barely visible. The Configuration table does not match familiar LGP terminology, and some configuration variants are missing. The location parameter requires a particular selection (for example, users must select "chin" rather than "head"). The Movement parameter is difficult to understand; the relationship between the arrow drawing and the actual gesture movement was considered unclear. Some relevant signs sometimes appear on later pages rather than the expected earlier ones in the results. Parameters accumulate across searches, and there is no easy way to clear previous selections. Regarding **improvement suggestions**, we gathered the need for an inclusion of introductory texts explaining how parameter selection works, and according to feedback results, should only show signs matching the selected parameters, a need to ease parameter clearance between searches, as well as an improvement to the visibility of selected elements. There is a need for the usage of established LGP terminology for configurations and a better amalgamation of configuration variants.

For our **Text-Based Sign Search**, as **positive aspects**, we gathered that the text-search engine is easy to use and works well overall, and is faster than the sign-search engine. However, there were **challenges identified**, such as several signs not being present in the dictionary, missing vocabulary, and the engine requires exact Portuguese spelling, including the accents. This poses a problem, as many Deaf users do not use accents when typing, according to feedback. Some unrelated signs also appear in the results. An example given was when searching for the word "AMAR"; some other results would appear, such as "DINAMARCA" and "AMARELO", which make sense orthographically, as "AMAR" is a constituent of these words, but do not make sense conceptually. Some regional variants are not

adequately labelled; there are multiple entries without clear differentiation. For example, there are five entries for the sign "LIVRO", and only one is marked as an archaism. Important distinctions are missing, for example, the sign "PODER" as a verb versus a noun. There are some **improvement suggestions** which include the addition of more vocabulary entries, allowing users to search without Portuguese accent marks, as well as accepting both uppercase and lowercase text, the need for better labelling of regionalisms and archaisms, and the provision of descriptions explaining differences between multiple entries.

When it comes to our **Dictionary Organisation and Structure**, we **identified challenges** such as the General Dictionary and First Cycle Dictionary being mixed on the same platform, which can lead to confusion for teachers, LGP users and hearing users. There is also no clear starting point or introductory text explaining where to begin, and the Dictionary results are not being sorted alphabetically. We gathered **improvement suggestions** like the need for a separate school dictionary into its own platform, the creation of bookmarks or clear separation between dictionary types, a division between a dedicated platform for schools/training and another for the general public, a need for introductory text explaining search functionality, and the necessity of sorting video results alphabetically.

Regarding **Proposing New Signs to the Dictionary** For the **positive aspects**, we noted the ease of uploading videos, which is interesting that the Dictionary is open to general community proposals. We also recognised the variety in signs, the archiving of rare, unknown, or extinct signs, and the platform's benefit of sharing vocabulary variations. We **identified challenges** such as user confusion when proposing for the first time, the "Name" field being confused for the name of the user, instead of the name for the sign entry, and the lack of mechanisms to correct mistakes after submission. We also gathered some **concerns for the future**, such as the visibility of the proposals. Users raised these concerns as they questioned whether the proposals should be visible immediately or evaluated first by dictionary managers. Some concerns were also raised about the risk of unrevised videos and users talking excessively in them, as well as the need for quality control. To this effect, we gathered some **improvement suggestions** such as a need for a clearer form design for submission, allowing editing or going back before a final submission, the need for a moderation team in the future in case submissions increase, and the need for consideration of whether proposals should be reviewed before public visibility.

With concerns to our **Voting on Proposed Signs**, we gathered as **positive aspects** the process being accessible and easy to use, as well as feasible and positive at the current stage. We **identified challenges** such as user difficulty in finding the vote functionality and the lack of videos to vote. Regarding **concerns for the future**, participants expressed that the process might become slow when there are many signs and an overwhelming amount of submissions to vote on, without an end in sight. An **improvement suggestion** given was the need for a management team in the future.

In respect to **Commenting on Proposed Signs**, we gathered as **positive aspects** the positive value

that describes signs that exist in daily routine for dictionary inclusion, and an accessible and easy-to-use process. **Challenges identified** include users sometimes not being able to find the comment feature.

We gathered **Technical Issues** from the feedback, with **key issues identified** such as error messages, such as Error 500: "Error fetching signs, please try again later" - appearing multiple times, video playback failures, which prevented users from opening certain videos, some users could not view own submitted videos, an inconsistent ability to view different users' videos and the need to restart the search process after errors.

Regarding **Overall Platform Potential and Vision**, we gathered its potential as an **educational tool**, valuable for classrooms, having a digital school dictionary readily available for students, helpful for LGP students, a resource not only for young students, but also for learners of the language, important for interpreter training, for example, in a Bachelor's degree, helps in clarifying doubts for working interpreters. It also shows potential **for preservation and documentation** due to the non-existence of an online LGP Dictionary platform, as well as in a historical and cultural value, it preserves the memory of signs, variations and uses over time, it archives rare, unknown, or extinct signs, documents regional variants and maintains linguistic heritage. As a potential **for the community**, it is a fundamental resource for the Deaf community, a daily reference tool, and it strengthens cultural identity. It serves as a bridge between generations and communities, while also promoting visibility and recognition of LGP. It shows great promise **for inclusion** as it allows hearing people to explore LGP autonomously, promotes correct perception of sign language, fosters respect and social inclusion and is a tool for communication between the Deaf and hearing communities. As for **unique contributions**, participants mentioned it was rare to find didactic material describing signs through phonological parameters, it was also described as a pioneering project in Portugal that responds to a pressing need, with the advantage of continuous growth in entries and a strategic resource for language preservation beyond just a vocabulary repository.

As an overall sentiment, our participants congratulated our team on its excellent work. They expressed strong support for continued development, viewing it as an essential and groundbreaking project that deserves ongoing support and improvement.

Through its use, there were proposed 19 distinct sign entries to the Dictionary, through the crowd-source module.

6.2.4 Limitations

Regarding our limitations, our platform's dissemination encountered some issues, primarily due to difficulties in recruiting participants and ensuring their adherence and participation. Of the initial 13 participants recruited for the study of the deployment, only 4 participants utilised the platform.

Of these 3 participants, only one completed the entire form in its entirety.

Even if incomplete and in low quantity, these form responses are helpful, but cannot represent the

general sentiment of the LGP DHH community, therefore offering us but a sliver of the insights.

6.2.5 Discussion

The deployment of our Crowdsourcing module within the Dictionary platform generated valuable insights into not only the platform's functionality but also its potential as a collaborative tool for the Portuguese Deaf community. Although our participant sample was small, the qualitative feedback obtained reveals important tendencies in user experience, community perception, and the challenges inherent to designing inclusive digital linguistic resources for sign languages.

The findings highlight a general appreciation for the innovation of the platform, particularly in the sign search feature, which utilises phonological parameters. Users described this feature as "pioneering" and "bold", confirming the perception of the feature as valuable in being able to navigate a sign language dictionary through linguistic components rather than through written Portuguese. However, users also encountered some significant usability challenges, including difficulties in isolating specific parameters, visual indistinction in selection highlights, and a lack of clarity regarding how the parameters operate. This feedback highlights a need for improved visual communication in our user interface and its design.

The text-based search engine was seen as easier and more functional, but still exhibited limitations related to spelling, accent sensitivity, and semantic filtering. These evaluations suggest that while phonological search represents an important linguistic innovation, the text-based interface provides a more immediate result and usability. Future development might benefit from a refinement in parameter search.

One of the most significant outcomes of the deployment is the strong endorsement of the participatory nature of the Dictionary. Our participants expressed enthusiasm for the possibility of proposing, voting and commenting on new sign proposals, indicating a recognition of the platform as a collaborative linguistic space. From this participatory nature of the Dictionary came recurrent concerns regarding quality control, moderation and management of user submissions. Some participants inquired whether proposals should become visible immediately or require preliminary review, raising tension between openness and curation.

Technical issues, such as recurring "Error 500" messages, inconsistent video playback, and submission errors, might have significantly hindered the user experience. These issues, while common in deployments, can carry specific implications for accessibility. For DHH community members, where their interaction depends heavily on video content, playback reliability is a fundamental usability requirement.

Our participants also expressed some confusion regarding the overall organisation of the Dictionary, with a focus on the coexistence of the general and first-cycle dictionaries. There was a lack of clear boundaries between these components, which suggests a need for a more transparent architecture.

Despite these limitations, the participants strongly emphasised the cultural, educational, and societal

potential of the platform. Participants' comments portrayed the Dictionary as not only a technological resource but also a symbolic and practical tool for community empowerment and linguistic preservation.

Multiple dimensions were highlighted regarding the value of the platform, serving as a pedagogical aid for students and interpreters across various degrees of learning, from first-cycle to Bachelor's. It was also valued as a repository for rare and extinct signs, as well as a means of fostering inclusion between the Deaf and hearing communities. This multi-layered potential positions the platform at an intersection of education, linguistics and accessibility, making it a tool for both research and an infrastructure for linguistic documentation.

The positive sentiment towards the Dictionary Platform suggests a strong alignment with the project's goals within the community. However, the limited participation and incomplete form submissions also reveal the difficulties of sustained engagement in early-stage participatory deployments. Factors such as time availability and technological proficiency likely influenced participation.

6.3 Refinement

Over the given feedback, which includes the challenges we identified and the improvement suggestions we noted, we made iterations over the following issues:

- **Too subtle of a selection highlight; Improve Visibility of selected elements** - We have made the selection border/highlight thicker, in order to appear less subtle to users.
- **Parameters accumulate across searches; Make it easier to clear parameter selections between searches;** - While we support the functionality of unselecting the parameters, this might not be as evident as initially thought. We have added a "Clear" button to remove all the selected parameters for a new query.
- **Addition of Introductory Texts Explaining how Parameter Selection Works; No clear starting point or introductory text explaining where to begin** - We have added a tutorial section into the platform to explain to users how to utilise the features of the dictionary, including the sign search engine and the crowdsourcing module.
- **Requires exact Portuguese spelling including accents** - For our textual search, we have refined the query request to accept unaccented words and get from the database accented entries.
- **Accept both uppercase and lowercase text** - While this feature is already implemented, we have added a suggestion to the placeholder text in the textual-search bar to let users know both cases are permitted.

- **Sort video results alphabetically** - While this feature is already implemented, we have added a section in the tutorial module of the platform in order to further specify to users that sign-search-based queries are returned in order of most similarity, and text-based queries are returned alphabetically.
- **Confusion in first proposal. "Name" field confused for the name of the user, instead of the name for the sign entry** - Changed the name in the form to "Proposal Entry Name"
- **Cannot go back to correct mistakes** - Added a warning popover before submission of the sign for user confirmation of details.
- **Could not find voting functionality in some cases** - We have added some highlights to the voting section in order for it to stand out to the user.
- **Cannot find the comment feature** - As the comment section is at the bottom of the page, and might be hidden depending on screen size, we have added a side button where users are scrolled down to the comment section.
- **Error 500: "Error fetching signs, please try again later"** - We have conducted several internal tests on the dictionaries and crowdsourcing modules, testing queries in combinations with filterings and sortings in order to refine our implementation, and avoid these errors.
- **Video playback failures, which prevented users from opening certain videos; Some users could not view their own submitted videos; An inconsistent ability to view different users' videos** - While our team could visualise all submitted videos, we made sure to refine our uploading process in order to accept more video formats, including .mp4 and .mkv.

7

Conclusion

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7.1 Achievements

We have achieved a community platform harboring a total of 2,790 sign entries across 186 themes, of which 777 sign entries covering 59 distinct themes belong to first-cycle teaching subjects. In the Dictionary are present signs used throughout Portugal, as well as regional variants from the Açores, Madeira, and Porto, therefore allowing the community to store lesser known regional variants, in a repository made by its community. There have also been proposed, thus far, 19 distinct sign entries, allowing our users to utilise the platform in an autonomous manner.

We also achieved rigorous work in engineering and implementation, with the help of LGP linguists, Professors, and students, in a setting of a study conducted in schools, further allowing their representation on the platform, and the creation of a solution tailored to the community's needs.

The development and usability test evaluation of the crowdsourcing module for the Dictionary Platform has yielded significant results, demonstrating technical feasibility and the community value of participatory engagement approaches to sign language documentation.

This research has created what our participants recognise as a "revolutionary" platform for the Portuguese DHH community. One participant mentioned that it has a pioneer effort in Portugal: "In Portugal, there is nothing like it. It is the first step, the first time being done.". This achievement extends beyond a mere technical implementation to establish a new paradigm for community engagement in dictionary construction; it converts from traditional top-down approaches to a collaborative, community-driven language documentation.

Aimed across various user groups, including the Portuguese DHH community, bilingual individuals, the Portuguese-speaking community, linguists and researchers, this multi-stakeholder approach demonstrates the potential of the platform to serve as a bridge between academic research and community needs, easing knowledge exchange across multiple and different domains.

The successful implementation of our parameter-based search engine, the Sign Search Engine, and annotation systems, represents a significant technical achievement. These features serve immediate dictionary needs and provide unprecedented research infrastructure for sign language studies. The participants recognised the dual dictionaries system and comprehensive search engines as "excellent" and that they were advancing the field of digital sign language resources.

Our thematic analysis successfully identified four primary themes, characterising user experiences, and providing valuable insights into the design requirements for sign language platforms, contributing to a broader understanding of how digital tools can effectively serve visual-spatial language communities.

According to our users, the platform has also successfully fostered a sense of community and language ownership over the language documentation processes. Valued by the participants are the platform's potential for linguistic standardisation, centralisation and quality control, recognising the space for proposal discussion and limiting scattered, unregulated discourse across several social media platforms.

We also developed a technical architecture and framework of a sign language platform for documentation, with crowdsourcing capabilities, easy implementation of other modules such as didactic games, and easy adaptation to other sign languages.

We have resolved most usability issues present in our formative study to discover usability issues and bugs.

This is a Project that remains deployed and ready to be used, and currently in use by the community, even after our studies concluded. We have created an infrastructure that allows the continuous use of a platform for the LGP DHH community. The platform can be visited at: [Dicionário LGP](#).

7.2 Limitations

While our research achieved significant milestones, several limitations were discovered and acknowledged, further enhancing the current state and areas requiring further development.

A limitation concerns our single-session approach, that provided a brief and straightforward snapshot into the user experience rather than a longitudinal study and insights into how users might adapt to the platform over a larger period. Therefore, extended use could reveal different interaction patterns and assessments as users might become familiar with the platform's functionalities.

The fact that both participants were already familiar with the platform introduces a potential bias in our usability testing results, as it may have skewed our results towards more positive assessments, due to masking challenges that novice users might encounter. Additionally, the translation arrangement between participants during data collection may have introduced cross-contamination effects, such as the second participant having been influenced by observing the session of the first participant.

Our analysis revealed usability issues representing a critical barrier to broader community adoption. While one of our participants found the platform easy and intuitive, another user struggled with basic navigation tasks, including locating the crowdsourcing module itself. This gap suggests the current design may inadvertently exclude potential community members and participants, who could provide valuable contributions and feedback, to the dictionary and its development process.

Actual novice users were absent in our user sample, which is particularly significant given that one of our primary findings was this usability gap. Without adequate representation and variability in our user sample of inexperienced users, we cannot fully assess the platform's accessibility to the broader community it is meant for.

Visual design emerged as a critical usability barrier that affects current users, regardless of their expertise level. Participants consistently identified issues with visual contrast, describing the interface as "too white" and lacking elements that would stand out effectively. Even though we have implemented a "Dark Mode", this also proved challenging to find. Hidden interactive elements, such as the three-dot

moderation function, were consistently difficult to find across both studies, increasing the overall task completion time.

The commercial appearance of the platform and lack of culturally appropriate visual design elements suggest traditional and current web design principles might be insufficient for sign language communities, whose linguistic modality is inherently visual and spatial.

Our evaluation focused explicitly on the newest crowdsourcing module, rather than conducting a comprehensive platform assessment. The targeted approach was appropriate for our research objectives; however, this implies our findings may not represent a broader platform usability or user satisfaction with the complete system.

While valuable for capturing immediate user reactions, our think-aloud protocol may have influenced natural interaction patterns due to their awareness of being observed and recorded, which might have influenced their behaviour and willingness to express negative feedback, potentially masking usability issues.

7.3 Future Work

The results of our study indicate several areas for future development and research that could continue to make the platform more effective and have wider community adoption.

As indicated by our results, future work must address closing the usability issues. This could involve, for example, creating various interface modes or progressive disclosure systems that allow the user to access progressively more advanced functionality as they become more advanced on the platform or basic operations. Offering tutorials or onboarding sequences designed explicitly for sign language users may allow new users to use the platform better. Comparing these interfaces can result in a technical solution that pleases expert researchers and community members on the same platform. This would include longitudinal studies to understand how user needs evolve with familiarity with a platform.

There is also a need for culturally appropriate visual design, a vast field for future research. This would include participatory design sessions with DHH community members, to develop visual interfaces and solutions that resonate with the community and its communication style and identity. Specifically, a contrast amplification is required throughout the interface to make interactive controls more noticeable, with the addition of LGP logos and culturally relevant imagery. More research must be conducted to understand how the sign language community's visual-spatial communication can be translated to design more effective interface guidelines.

Future research must address the methodological shortcomings we had during our research through larger-scale usability testing involving heterogeneous user groups. This would encompass longitudinal studies of user adaptation and learning over the longer term of platform usage. Enrolling participants

with a broad range of expertise, over the entire spectrum of experience levels, from novice to expert users, will yield a better picture of platform usability and accessibility problems. Various sessions could present feedback and demonstrate how users' perceptions and capabilities change over time and with increased usage and acquaintance with the platform.

The future should explore how the platform can serve as a model for other minority and dying sign languages to be digitally documented. In the same way, the educational value reported by the participants offers possibilities for developing specialised features for the learning context of languages.

The technical infrastructure of the platform should be enhanced so that it can support more sophisticated interaction models. This includes optimisation of the parameter-based search engine and development of more sophisticated annotation systems with larger numbers of parameters for both.

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Main Algorithms of the Dictionary

The Dictionary comes with many algorithms. However, of most notability, comes the Hamming Distance algorithm, which makes the Sign Search Engine algorithm possible.

A.1 Hamming Distance Algorithm

```
1 DECLARE
2   distance INTEGER := 0;
3 BEGIN
4   IF cardinality(array1) != cardinality(array2) THEN
5     RAISE EXCEPTION 'Arrays must be of the same length';
6   END IF;
7
8   FOR i IN 1..cardinality(array1) LOOP
9     IF array1[i] != array2[i] THEN
10      distance := distance + 1;
11    END IF;
12  END LOOP;
13
14  RETURN distance;
15 END;
```

Listing A.1: Hamming Distance Algorithm

A.2 First Cycle Dictionary Filtering

Listing A.2: First Cycle Dictionary Filtering Algorithm

```
1 async function getSigns(): Promise<Sign[]> {
2   let query = event.locals.supabase
3     .from('signs')
4     .select('*', { count: 'exact' })
5     .eq('is_annotated', 2)
6     .or(`theme_flattened.ilike.%1 CEB %`, theme_flattened.ilike.%DACTILOLOGIA%`)
7     .range((page - 1) * perPage, page * perPage - 1);
8
9   // ...
```

```

10
11     return signs as Sign[];
12 }

```

A.3 Sign Search Engine Algorithm

```

1 BEGIN
2
3 RETURN QUERY
4 SELECT
5     *
6 FROM signs
7 WHERE CAST(signs.is_annotated AS INTEGER) = 2
8 ORDER BY
9     -- Primary: hamming distance (0 = exact match comes first automatically)
10    hamming_distance(signs.annotation_array, query_array),
11    -- Secondary: count matching positions (more matches = higher priority)
12    (
13        SELECT COUNT(*)
14        FROM generate_series(1, LEAST(array_length(query_array, 1), array_length(signs.
15             ↪ annotation_array, 1))) AS i
16        WHERE query_array[i] = 1 AND signs.annotation_array[i] = 1
17    ) DESC,
18    -- Tertiary: find the minimum position where both query and sign have value 1
19    (
20        SELECT MIN(i)
21        FROM generate_series(1, LEAST(array_length(query_array, 1), array_length(signs.
22             ↪ annotation_array, 1))) AS i
23        WHERE query_array[i] = 1 AND signs.annotation_array[i] = 1
24    ) NULLS LAST,
25    -- Final: prefer signs with earlier 1s overall
26    array_position(signs.annotation_array, 1)
27 LIMIT limit_count offset offset_count;
28 END;

```

Listing A.3: Code for the Sign Search Engine

B

Study documents

In this appendix we will showcase the various documents used for the studies to shape the Project.

Fases	Contribuição/Proposta	
Passos da Jornada	Adicionar um novo gesto	Submeter contribuições
Ações do Utilizador		
Necessidades do Utilizador		
Ganhos e Perdas / Positivos e Negativos		

Figure B.1: Proposal section

Fases	Discussão/Deliberação	
Passos da Jornada	Iniciar discussão	Finalizar discussão
Ações do Utilizador		
Necessidades do Utilizador		
Ganhos e Perdas / Positivos e Negativos		

Figure B.2: Deliberation section

Fases	Aceitação	
Passos da Jornada	Visualizar Resultados	
Ações do Utilizador		
Necessidades do Utilizador		
Ganhos e Perdas / Positivos e Negativos		

Figure B.3: Acceptance section

Figure B.4: Journey Map sections for the Workshop



GUIÃO PARA O ESTUDO DO USO DO MÓDULO DE CROWDSOURCE

Cenário 1: Contribuir com uma Variante de Gesto

Suponha que está a aprender Língua Gestual Portuguesa e reparou que o gesto para "pássaro" que aprendeu com o seu amigo surdo é ligeiramente diferente do que vê nos dicionários online. Quer partilhar essa versão do gesto com a comunidade para ajudar a tornar o recurso de língua gestual mais completo e representativo de diferentes formas de gestuar.

A sua tarefa: Encontre uma forma de contribuir com a sua versão do gesto para "pássaro" na plataforma.

Cenário 2: Interagir com Conteúdo da Comunidade

Acabou de submeter uma variante de gesto e quer ver como a comunidade responde a contribuições como a sua. Também tem curiosidade sobre como outras pessoas gestuam de forma diferente e quer mostrar o seu apoio a boas contribuições.

A sua tarefa: Explore como a comunidade interage com as submissões de gestos e participe na discussão sobre variantes de gestos.

Cenário 3: Gerir as Suas Contribuições Pessoais

Tem contribuído para a plataforma de língua gestual há algum tempo e quer acompanhar o que submeteu. Está particularmente interessado em ver quais das suas contribuições foram aceites pela comunidade.

A sua tarefa: Reveja o seu histórico de contribuições e veja o estado atual das suas submissões.

Cenário 4: Moderar Conteúdo da Comunidade

É um membro de confiança da comunidade que recebeu privilégios de moderação. Quer ajudar a rever novas submissões de gestos para garantir que cumprem os padrões da comunidade.

A sua tarefa: Reveja e tome decisões sobre submissões de gestos pendentes de outros membros da comunidade.



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TAREFAS PARA A UTILIZAÇÃO DO DICIONÁRIO

- ☐ Registe-se na plataforma.
- ☐ Procurar a entrada do gesto PÁSSARO, no motor de pesquisa, pela seguinte



configuração

- ☐ Procure, pelo menos, mais 5 gestos no motor de pesquisa, por configuração, localização, orientação, movimento, expressão facial.

a. Quais os gestos que procurou?

i. Nome do gesto: (por exemplo: PÁSSARO)

1. Parâmetros fonológicos utilizados:

- a. Configuração ☒
- b. Localização ☐
- c. Orientação ☒
- d. Movimento ☒
- e. Expressão Facial ☐

ii. Nome do gesto: (escreva aqui o nome do gesto)

1. Parâmetros fonológicos utilizados:

- a. Configuração ☐
- b. Localização ☐
- c. Orientação ☐
- d. Movimento ☐
- e. Expressão Facial ☐

iii. Nome do gesto: (escreva aqui o nome do gesto)

1. Parâmetros fonológicos utilizados:

- a. Configuração ☐
- b. Localização ☐
- c. Orientação ☐
- d. Movimento ☐
- e. Expressão Facial ☐



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iv. Nome do gesto: *(escreva aqui o nome do gesto)*

1. Parâmetros fonológicos utilizados:

- a. Configuração ☐
- b. Localização ☐
- c. Orientação ☐
- d. Movimento ☐
- e. Expressão Facial ☐

v. Nome do gesto: *(escreva aqui o nome do gesto)*

1. Parâmetros fonológicos utilizados:

- a. Configuração ☐
- b. Localização ☐
- c. Orientação ☐
- d. Movimento ☐
- e. Expressão Facial ☐

vi. Nome do gesto: *(escreva aqui o nome do gesto)*

1. Parâmetros fonológicos utilizados:

- a. Configuração ☐
- b. Localização ☐
- c. Orientação ☐
- d. Movimento ☐
- e. Expressão Facial ☐

b. Relativamente à procura por gesto, por favor partilhe a sua opinião.

Pontos positivos, pontos negativos, melhorias.



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☐ Procurar a entrada do gesto PÁSSARO, no motor de pesquisa, por texto.

☐ Procure, pelo menos, mais 5 gestos no motor de pesquisa, por texto.

a. Quais os gestos que procurou?

- i. Nome do gesto: *(por exemplo: PÁSSARO)*
- ii. Nome do gesto: _____
- iii. Nome do gesto: _____
- iv. Nome do gesto: _____
- v. Nome do gesto: _____
- vi. Nome do gesto: _____

b. Relativamente à procura por texto, por favor partilhe a sua opinião.

Pontos positivos, pontos negativos, melhorias. Por favor, substitua este texto com a sua opinião.

☐ Proponha, pelo menos, 3 entradas de gesto para o dicionário.

a. Quais os gestos que propôs?

- i. Nome do gesto: *(por exemplo: PÁSSARO)*
- ii. Nome do gesto: _____
- iii. Nome do gesto: _____
- iv. Nome do gesto: _____

b. Relativamente ao processo de proposta de novos gestos, por favor partilhe a sua opinião.

Pontos positivos, pontos negativos, melhorias.



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☐ Vote, pelo menos, 3 vezes em diferentes propostas de gestos.

a. Em que gestos votou? Votou positivamente, ou negativamente?

i. Nome da proposta e voto: *(por exemplo: PÁSSARO e voto positivo)*

ii. Nome da proposta e voto: _____

iii. Nome da proposta e voto: _____

iv. Nome da proposta e voto: _____

b. Relativamente ao processo de votos de propostas de gestos, por favor partilhe a sua opinião.

Pontos positivos, pontos negativos, melhorias.

☐ Comente, pelo menos, 5 vezes numa proposta de gesto, via texto ou vídeo.

a. Em que gestos comentou? E de que forma?

i. Nome da proposta e tipo de comentário: *(por exemplo: PÁSSARO e via vídeo)*

ii. Nome da proposta e voto: _____

iii. Nome da proposta e voto: _____

iv. Nome da proposta e voto: _____

v. Nome da proposta e voto: _____

vi. Nome da proposta e voto: _____



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- b. Relativamente ao processo de comentários de propostas de gestos, por favor partilhe a sua opinião.

Pontos positivos, pontos negativos, melhorias.

QUESTIONÁRIO APÓS COMPLETUDE DAS TAREFAS

- 1) Como vê a utilização da plataforma no seu no dia a dia?

Por favor escreva aqui a sua resposta. Pode escrever as linhas que quiser.



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- 2) Relativamente à sua ocupação e posição na Comunidade Surda Portuguesa, que tipo de potencial consegue ver do dicionário?

Por favor escreva aqui a sua resposta. Pode escrever as linhas que quiser.
