Evaluation of potential communication breakdowns in the interaction of the deaf in corporate information systems on the web

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Abstract

The translation of web content into Libras (Lingua Brasileira de Sinais – Brazilian Sign Language), although adequate, cannot always be implemented, due to its high cost. Thus, the present study aims to identify and propose solutions for the potential communication breakdowns in the interaction of bilingual deaf users in corporate systems on the web. The analysis of the interaction took place at the Oswaldo Cruz (Fiocruz) Foundation, with the utilization of the Communication Evaluation Method (CEM) of Semiotic Engineering. The results showed that the population in the study, although having experience in the web, had difficulties using the corporate system.

Keywords: Observation of users; Accessibility; Usability; Deaf; Human-computer interfaces.

1. Introduction

Usability, an important feature in information systems does not ensure full access to all users [1], [2]. It is necessary that these systems also take accessibility in consideration [3],[4],[5].

The development of sites aimed at usability, in conformance with the accessibility guidelines, does not ensure access to pre-linguistic deaf users, i.e., those who became deaf before they learned how to speak. Many pre-linguistic Deaf communicate only through sign language, do not know Portuguese, and may find it hard to perform simple tasks, due to the predominance of text information on the Web [6]. It is necessary to translate the content into sign language, in the Brazilian case, Libras (Brazilian Sign Language).

Since in Brazil, there are approximately 5.7 million citizens with hearing deficiency, about 3.38% of the population [7], it is essential to recognize the specificities of these users' interaction with information systems, in order to minimize the barrier that might compromise or prevent the use of corporate systems on the web.

The translation of content to sign language through the utilization of videos with interpreters, although quite fitting, increases the cost of implementation, maintenance and storage of content, making the project more difficult [8].

As few studies dealing with accessibility issues for deaf users were found in the literature, this study aimed to identify potential communication breakdowns in the interaction of bilingual deaf users in Corporate Information

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Systems on the Web.

The observations were done at the Oswaldo Cruz Foundation (Fiocruz), one of the main research institutions in the health area in Brazil. This foundation has an agreement with the National Federation of Education and Integration of the Deaf (FENEIS), employing 150 deaf workers [9]. The evaluations followed the Communicability Evaluation Method (CEM) of Semiotic Engineering (EngSem), which tries to maximize the developer's knowledge about the users' difficulties, based on the results of the metacommunication analysis [10].

2. Web Accessibility and Deafness

Web plays an essential role in the advance that the Internet represents in the day-to-day life of persons with handicaps, such as blindness, deafness, cerebral palsy among others. The Web has totally changed life for these users, by giving them a freedom never before imagined [11]. Therefore it is essential to recognize the differences among individuals, so as to offer them the means of accessing any content available on the web [12].

For deaf people in Brazil, the process whereby words have meaning is achieved by the translation of sign language, the natural language of the deaf, into the Portuguese written language [13],[14]. This fact limits the reading and interpretation by deaf users, since a significant part of the Portuguese language words does not exist in sign language, making it hard for this group of users to interact with the web [15],[16],[6].

Libras does not consider a structure based on articles, prepositions and conjunctions, having a verb conjugation different from the Portuguese language. The concept of "word" or "lexical item" in Portuguese is called "sign" in Libras, being made up of the combination of five parameters: configuration, movement, direction, the point of articulation of the hand and facial expression.

The philosophy as an educational model enables the flexibility of using the two languages according to need. Sign language does not have its own written language system. The deaf are supposed to use the written form of Portuguese in their reading and writing activities [17].

Besides words and its own grammar, sign language reflects cultural traits of the community that uses it. The language utilized by a community has a much more comprehensive responsibility than just allowing communication between individuals. It contributes to the transformation of social and cultural relationships and of experiences, which are the base for the construction of cultures and identity [18].

The existence of a culture of the deaf has been considered in studies, such as Moura [19], who defends its existence. Supported by the concept of multiculturalism and not only ethnicity, nation or nationality, this culture stands apart from others due to its linguistic aspect, where social and cultural relationships are impacted due to the need of using sign language as a communication instrument [20],[15].

Since the deaf live in an environment where most persons communicate only orally through speech, they often times feel they don't fit in this environment, which makes their social interaction difficult, making them feel isolated and socially excluded, often within their own family environment [21].

Deaf people struggle to have their citizenship rights respected, since their culture has its own linguistic aspects, its own way of living and of learning values, its own behavior, and its own social and interaction traditions [21]. As an example is the recognition by the Brazilian Legislation of the Brazilian Sign Language (Libras) as a legal means of communication and expression, with its own linguistic system including its own grammatical structure, set forth in Law No. 10.436/2002, which will not substitute the written mode of the Portuguese language [22].

3. Interface Evaluation under the perspective of Semiotic Engineering

Interface evaluation consists of a systematic way of data collection with the purpose of analyzing how the system is utilized in performing tasks [23], allowing the detection of communication breakdowns (usability and accessibility

problems) of the systems. Some evaluation methods are based on the Theory of Semiotic Engineering (EngSem), such as the CEM, used in this research [24].

In Semiotic Engineering a system interface is seen as a way of communication. The user understands the message in the process of interacting with the interface. This communication is referred as *metacommunication* and its message is the *metamessage* [10].

3.1. Communicability Evaluation Method (CEM)

The Communicability Evaluation Method (CEM) is executed sequentially in three steps: tagging, interpretation and creation of the semiotic profile, starting on previous observations (tests) of the users' interaction [24], [6], [25].

Communication faults (breakdowns) occur when the users are not able to interpret the message sent by the designer, either when executing a given action or in response to the system after some action, whereby these faults may or may not be realized by the users. Complete faults occur when the users do not understand the message. Partial faults occur when the users understand only a part of the message. On the other hand, temporary faults occur when at first the users do not understand the message, but later on detect the message's intent and try to execute the action correctly.

In the first evaluation step, tagging, the researchers analyze the evidences of communication breakdown, through the interaction videos, associating the problem according to a set of thirteen expressions of communicability (tags) proposed by the CEM, whereby these tags represent the researcher's interpretation of how the user behaved vis-a-vis the interaction context [10 p.127], [25], [24 p.37]. Table 1 shows the complete set of the thirteen possible expressions of communicability (tags).

Table 1. Tags, Meanings and Communication Failures - adapted from [10 p.138].

Tag	The user's behavior demonstrates that he ...	Category
"I give up."	didn't care about the outcome.	Complete failures
"Looks fine to me."	didn't realize he/she had failed and completed the task as he/she saw fit	Complete failures
"Thanks, but no, thanks."	understood the designer's solution, but preferred to interact in another way	Partial failures
"I can do otherwise."	did not understand the designer's solution and preferred to interact in another way	Partial failures
"Where is it?"	knows what has to be done, but is not able to find out how	Temporary failures
"What happened?"	did not realize or understand what the interface was telling him/her	Temporary failures
"What now?"	doesn't know what to do at the moment	Temporary failures
"Where am I?"	performs an action that does not fit the context	Temporary failures
"Oops!"	realized he/she performed a wrong operation and redoes the operation correctly	Temporary failures
"I can´t doit this way"	after a long interaction, realizes he/she took the wrong path	Temporary failures

Tag	The user's behavior demonstrates that he ...	Category
"What´s this?"	tried to understand the interface element through tips displayed on same	Temporary failures
"Help!"	resorted to help systems or asks for help from other persons	Temporary failures
"Why doesn´t it?"	Tried to understand what went wrong and repeated the operation	Temporary failures

In the second stage, interpretation, the researchers base themselves on the mapping and tabulation of the expressions of communicability. In this phase the researchers interpret the meaning of the set of tags [24].
Lastly, on the third stage, the creation of the semiotic profile, the analysis process is completed with a characterization of the receipt of the metacommunication messages, which consists of the interpretation of the data identified in the previous step, by trying to reconstruct the metamessage that the designer wished to transmit through the interface [10 p.126],[23],[25]. In order to reconstruct the metamessage, the interpretations done in the tagging stage allowed the evaluator to assume the designer's role and to answer the following questions: *"Who are the users of the systems?"; "What do the users need or have to do?"; "How do they like to do it, and why?"; "How can or should they use it?"; "What's my vision of design?".* The Construction of the designer's metamessage for the user should be done through the following template: *"This is my interpretation of who you are, what I've learned you want or need to do, in which preferred ways, and why. This is the system that I have therefore designed for you, and this is the way you can or should use it in order to fulfill a range of purposes that fall within this vision."* [10 p.25].

3.2 Related works

Some of the works show evidence of the difficulties of web interaction by deaf users. The study by Oliveira pointed to the CEM as one of the most efficient methods in the evaluation of accessibility for deaf users [6]. Corradi's work reinforces the inclusive participation of the bilingual deaf in the Information Society, starting with the planning of information architecture in digital environments [16]. Abreu's work presents a set of recommendations of accessibility for Information and Communication Technology projects that allow the literacy of deaf children [14].

With respect to the works that point to the linguistic difficulties of bilingual deaf people, Goldfeld's research deals with the difficulties of understanding the Portuguese language because of the process of meaning of words [15]. Kowlowski's work reinforces the notion that sign language does not have its own writing system, forcing deaf individuals to use the written form of the Portuguese language when reading and writing as their second language [18].

The present study presents some recommendations to solve the breakdowns, thereby helping designers in the development of organizational Information Systems more accessible to the deaf users' profile, trying to include them in the organizational environment.

4. Research Method

The present study, of an exploratory nature, is based on the qualitative method of data collection, made up of three stages: (a) preparation of the test environment; (b) observation of the users' interaction; (c) analysis of the results through the CEM and Development of the list of potential communication breakdowns in the interaction of pre-linguistic bilingual deaf user in corporate systems on the web. The last stages will be detailed in sections 5 and 6

respectively.

(a) Preparation of the test environment

The users taking part in the research were invited during an interview of the FENEIS at Fiocruz according to the following characteristics: pre-linguistic deafness, bilingual literacy, more than three years of computer use and educational level from elementary school (so as to make the knowledge of Portuguese homogeneous). In order to ensure the anonymity of participants, they were coded as U-1, U-2, U-3, U-4, U-5, U-6, U-7, U-8.

It was defined that the tests would take place at Fiocruz, in a controlled environment, specifically created to conduct the research. The observations were done by two evaluators, where one would help the users in the test and another would observe and record the interactions, which were stored on video for later analysis and tagging.

The option of analysis through the Fiocruz Intranet, was due to the fact that this institution employed close to 150 deaf workers, therefore allowing an ample source of human resources to develop the research.

(b) Observation of the users' interaction

The objectives of the research were presented and the procedures were explained by the interpreter at this stage. The contents of the test scenario and the term of consent were translated into Libras, for later reading and signature.

Two interviews were performed. The pre-test interview was intended to collect information about the users' experience in the utilization of computers and in access to the Internet, while the post-test interview tried to clear doubts that could influence the tagging stage and solve general impressions of the participant about the system.

The video recording of facial expressions and of the gestures, allowed the identification of difficulties in interaction, helping the data interpretation stage. There was no time deadline to complete the tasks.

The test scenario was set up so that the users performed the activities sequentially, allowing the spotting of faults in the interpretation of the system's information. The chosen tasks were ones frequently performed by the organization's staff in the research environment, through informal interviews with professionals of the human resources sector. This resulted in two tasks shown in tables 2 and 3. Table 4 shows the shortest path to be traversed by the users in the task that consisted in placing a call to the technical support team.

There was no time limit for the performance of the test, allowing each user to interact as long as necessary.

Table 2: First task selected for analysis.

Task	Task description	Objective
1	You must update your personal and professional data.	To fill out 46 input fields in a form

Table 3: Second task selected for analysis

Task	Task description	Objective
2	You must open a call to the technical support team about the change of a broken mouse.	Information search and messaging

Table 4: Shortest path to be traversed by the user to complete the task of calling for help from the technical support team

Task	Shortest path
1. Access the internet	https://intranet.fiocruz.br/intranet/index.php
2. Log on to the page providing CPF (Taxpayer Id) and password	https://intranet.fiocruz.br/intranet/index.php ?fez_login=sim
3. Select the ICICT work unit	https://intranet.fiocruz.br/intranet/index.php ?muda_unidade=sim&nova_unidade=2
4. On the side menu, select "support and systems"	https://intranet.fiocruz.br/intranet/index.php ?muda_unidade=sim&nova_unidade=2
5. Select IT support	
6. Click on "open call"	http://intranet.fiocruz.br/sasds/index/inside/ bemvindo.icict
7. In the "type of request" option, select "change mouse and/or keyboard"	http://intranet.fiocruz.br/sasds/index/inside/ chamados/cadastro.icict
8. Click on "Send"	

5 Analysis of Result Through the CEM

After making the observations of the users, the next step was the CEM application, whose phases are described below:

Tagging: This step consisted in the identification of communication faults of the interface and relating them to the set of thirteen communicability expressions (tags) proposed by the CEM. It was divided into two sub steps: the analysis of 206 minutes of video recording of the interaction and the review of the notes taken by the researchers during the observation of the users.

The task which consisted in the updating of personal data and of requesting technical support lasted 27 minutes on average by user, with the exception of the U-7 user, who completed the activities in thirteen minutes and was the only one to successfully complete the technical support request task. All the other users gave up on this task.

In analyzing the interaction of participant U-1 in the updating of personal data task, it became clear that during the filling out of the "Degree of Deafness" field, said user tried to infer the meaning of the word "Degree" by associating it to the word "Pregnancy". Consequently, the question "Degree of Deafness" was interpreted as "Are deaf since birth?" In doubt about the reasoning, the interpreter was asked to help. These two breakdowns were associated to two tags: "I can't do it this way" and "Help", which could only be attributed based on the association of the recorded

interaction and the participant's facial expressions and gestures.

Participant U-1 did a more detailed search on the interface with the intention of locating resources that would help in performing the task. This action was noticed as the user placed the fingers over the computer screen, trying to contextualize the information in the areas of personal data, professional data, etc, delimited in the interface by rectangles.

Still on this task, participant U-2 also did a detailed search in the interface. As an example, this user, not understanding the sentence "entity issuing the identification", analyzed his own ID card, answering the question as "Male". This type of behavior was tagged as "Looks fine to me". Actually, this user did not realize the mistake, completing the task erroneously. This behavior was frequent by most of the users during the personal data updating task.

Another example related to the "Looks fine to me" tag happened when the "Person responsible for the sector" field was filled out, where two thirds of participants answered the name of the unit where they worked, since they did not understand the word "Responsible".

With respect to the five questions about Leisure in the personal data updating task: "What do you like to do on your vacations?", "Do you practice any sport?", "Do you practice any other cultural, family activity?", "Would you like to know other subjects", "Do you have any suggestion for the social project?", only participant U-7 answered all the questions correctly. Of the other users, only participants U-2 and U-4 answered the first question "What do you like to do on your vacations?" correctly. The other participants did not understand the questions, leaving the five questions in the Leisure topic blank.

User U-5 had trouble in identifying the context of the word "address", asking the researcher for help, on whether that word referred to the course's or his own address.

Another frequent doubt among users was when the same word occurred more than once in the page, such as the word "name", which was present in the personal data area as well as in the dependents' area.

In post-test interviews it became clear that the users are aware that they don't know a great number of words present in the interface, but at the same time they tried through association, to infer the meaning of unknown words, resulting in wrong answers.

In the technical support request task, the first element utilized by participant U-2, was the search option, by keying the expression "technical support". Since the search results were not understood, said user repeated the operation, which was tagged as "Why doesn´t it?" In the second attempt, getting the same result, the participant asked for the researcher's help, which was tagged as "Help!" After some frustrated attempts in trying to complete the task correctly, whereby this behavior was tagged as "Where is it?", the user gave up on the task which was tagged as "I give up".

Still on this task, participant U-3 was the one who did most of the exploration in the interface in trying to complete the task correctly. This attitude made the participant a very good candidate of having tags assigned to him, earning fourteen of them in the communicability item. As an example, the frequent use of the "Where is it?" tag is mentioned. The participant began the task of asking for support marking the words "technical support" in the test scenario form, looking for these words in the interface later on, thereby trying to compete the task through representative words. However, these words were not present in the first level of the main menu of the interface, appearing only on the second level, causing a great number of breakdowns by this user, to which the "Where is it?" tag was assigned. After locating the sentence, U-3 did not manage to successfully complete the task, since he did not know the other words.

The highest number of help requests for the researcher to explain unknown words, came from participant U-6 even though she knew that the answers could not be supplied.

In the post-test interview this participant informed that she had several doubts about the meaning of the words, feeling that she needed help in conceptualizing the words. Participant U-4 also informed in the post-test interview that

he had a lot of trouble in performing the task since he did not know a great number of the words utilized in the interface.

Participant U-7 was the only one who was able to execute the technical support request, also showing less difficulty in the personal data updating task. In the post-test interview, this user reported that in his first interaction with the system, he had trouble since he did not know some words, but in the future his interaction would be easier, since he knew the path to the technical support request task. With respect to the difficulty in the understanding of words, the participant reported that the verbs in Portuguese are very difficult, and when having trouble, he asks for help to a non-deaf friend or looks up the word in the Internet.

Interpretation: in this phase the communicability problems and their origins were revealed. The most common tags in the personal data updating task were "*Help!*", 54 times, classified in the category of temporary faults and "*Looks fine to me*", 34 times, classified in the category of complete faults, making up 55% and 35% of the occurrences respectively. The temporary faults point to issues related to the difficulty of the bilingual deaf in dealing with words that don't figure in their first language's dictionary. The "*Help!*" tag is used when the user asks for help in an outright way, which is what happened to all participants. The "*Looks fine to me*" is utilized when the user believes having completed the task successfully.

The post-test interviews revealed some relevant aspects, for example, the difficulty in recognizing the change in the context of information: Two thirds of users filled out their own name in two fields with the same heading, but different functions. One of them referred to the interviewee's name, the other one to the dependent's name. Another noticed aspect was the habit of users in asking the meaning of words to a non-deaf person, and in the absence of same, looking for help in the Web.

The task of requesting support evaluated the system's use and functionality, showing the "*I give up!*" tag as the most frequent, with seven occurrences. This tag is classified as a complete fault, pointing to issues related to the interpretation of language expressions in the interface. During navigation, before giving up, many users resorted to the "*Where is it?*" tag, followed by "*Help!*", with nineteen and eighteen occurrences respectively, which added together accounted for 60% of occurrences. The data showed that in some occasions it was not possible to find the elements necessary to complete the task in a satisfactory manner, due to incompatibility of the semantic definitions utilized.

The post-test interviews point to the wish of looking up for explanation in the first language due to the number of unknown words in Portuguese.

Creation of the semiotic profile: The metamessage of the organizational system is: "In my interpretation, you are a Fiocruz user employee with enough experience in interacting with computers and fluent in Portuguese. Therefore, this is the system that I designed for you. I understood that you like to use the Intranet to access news about Fiocruz and also specific news about the unit to which you are assigned. I also understood that you use the Intranet to solve occasional problems such as requesting technical support, update your personal data and have access to memos, ordinances and documents in a practical and quick way".

6. Development of the list of potential communication breakdowns in the interaction

After the observations of the eight users and the recordings were analyzed, it was possible to develop a list of potential communication breakdowns of the pre-linguistic bilingual deaf, synthesizing the accessibility and usability problems, which were revealed based on the observations with the CEM. The problems were grouped into five main topics: significant information, ; use of acronyms; linguistic differences; user-context-information; and interface customization, where each topic is made up of three elements: problem, possible solutions and benefits, which when applied, try to solve specific problems.

Significant information

The Problem: Difficulties in recognizing words that are not part of the Libras vocabulary, such as organizational terms.
Possible solutions: (1) Utilization of words common to both languages; (2) utilization of examples and explanatory texts in Portuguese, respecting the grammatical specificities of Libras.
Benefits: Help in understanding during navigation, helping in data entry tasks, for example, fields in forms and in data recording and updating.

Use of Acronyms
The Problem: Difficulty in understanding acronyms.
Possible solutions: (1) Utilization of the "title" attribute together with the "acronym" tag, showing each one of the words making up the acronym; (2) utilization of the "title" attribute in the links, with a brief description about said link's objective.
Benefits: Allows inferring the significance of words, increasing the chances of the deaf user in locating the desired information.

Linguistic Differences
The Problem: Difficulty in understanding inflected verbs, including those contained in user's first language.
Possible solution: Use of verbs in the infinitive and objective texts.
Benefits: To facilitate the deduction of the meaning of words, promoting the knowledge of new vocabulary in the Portuguese language, meeting the interest shown by the evaluated group in interpreting the information.

User-Context-Information:
The Problem: Difficulties in identifying changes in the context of information. During the interaction, deaf users tend to focus attention on small portions of information and not on the page as a whole.
Possible Solution: Use of visual aids such as the use of colors and/or icons.
Benefits: To facilitate the identification of context change, assisting in the correct understanding of the information.

Customization of Interfaces
The Problem: Difficulty navigating with the elements available in the interface.
Possible solution: Customization of the interface, using technologies such as CSS.
Benefits: Creation of a custom layout, customizing the user interface elements according to the users' needs.

7. Final Considerations

The study tried to elucidate relevant aspects of the interaction of users with hearing deficiencies in corporate information systems on the Web. The active participation of this public in corporate environments implies in the need of detailed studies that take the interaction specificities of this group in consideration, with the aim of identifying possible barriers that might compromise or prevent the use of corporate information systems on the Web.

The study included an evaluation of the interface of a corporate system from Fiocruz based on the Communicability Evaluation Method of Semiotic Engineering. The evaluation's objective was to evaluate faults in the user interface communication. Eight users executing two tasks were observed. Based on the characterization of the metamessage, it became clear that the project was not developed with the accessibility of pre-linguistic deaf people in mind.

The deaf, even those with experience in the use of computers and the Internet, have trouble in understanding linguistic terms present in the interface of organizational systems, which prevents them from executing simple tasks.

In the execution of the personal data updating task, it became clear that terms commonly used in the organizational environment are unknown by the deaf such as: "person responsible for the sector", or "work journey", making it hard for participants to interact. In addition to the linguistic issue, the study also revealed difficulties with regard to the proper identification of the context of information present in the interface. The questions related to the leisure activities demonstrated the deaf person's difficulty in interpreting sentences in Portuguese. Even though three participants

answered the questions correctly, only one understood the question right away. The other ones did not understand the questions and left them blank.

The technical support request task focusing on navigation counted for the highest number of participants giving up, with only one participant completing the task correctly. This task had a large number of textual information, making it hard for users to correctly select the topics.

The post-test interviews showed that the participants would like to look for explanations about how to fill out the fields in their first language, since the number of unknown words in Portuguese makes it hard to interact with the information system. The participants also reported that they would like to have resources that would facilitate the identification of the words' context, making it easy to make the correct inference of same.

Even though the research method does not provide for the recording of users during the interaction, this recording was done, showing its efficiency in the analysis stage. This resource allowed the identification of doubts during the interaction through the users' facial expression and gestures.

It should be highlighted that the research allowed the analysis of the points of communication breakdown between the interface and the deaf user in the organizational context, pointing to possible solutions to the interaction problems that were revealed, contributing to the improvement in the development process of interfaces in IHC that take in account the deaf user's experience in the interactions of organizational information systems, reducing the gap between the deaf user and the interface.

Based on the evidence, it stands out that even for bilingual deaf person deafness is the key factor in the difficulty of accessing text information on the interface. Since most words in Portuguese do not exist in sign language, the deaf have trouble interpreting texts in Portuguese, unlike other oral auditive languages.

The creation of protocols for the analysis of Web accessibility, specific to deaf users, is suggested for future studies. This would help researchers in accessibility tests, respecting the specificities of the profile of these users.

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