

## **Creating Learning Objects in Libras and written Portuguese**

**Cayley Guimarães\***

Dept. of Design, UTFPR,  
Rua Lourenço Pinto, 410/615  
80.010-160. Curitiba, Paraná, Brazil.

**Matheus Aquino**

Dept. of Design, UTFPR,  
Curitiba, Paraná, Brazil.

**Sueli F. Fernandes**

Dept. of Education, UFPR,  
Curitiba, Paraná, Brazil.

### **Abstract**

*Most Deaf<sup>1</sup> children are born to non-Deaf parents and have little to no contact with Sign Language (SL). SL is the natural language of the Deaf, necessary for intellectual development. They are a complete linguistic system, with grammar, syntax, semantics, etc. and they allow for the expression of abstract thoughts. SLs are used to create and disseminate information, science, and knowledge. They are vital for communication, identity, culture, and citizenship for the Deaf. There are very few studies to inform the design of Learning Objects (LO) for bilingual Deaf Education and Literacy. LO is system-based artifacts used to teach some subject. Bilingualism is the approach that values SL as a language of culture and education (L1) and the written form of the Oral Language (OL) as L2. This article presents the process educators could follow to create such LO to be used by the Deaf child her interlocutor.*

**Keywords:** Sign language; Deaf culture; Bilingual Education; Bilingual Learning Objects

### **1. Introduction**

The Deaf celebrate the birth of a Deaf child as a new member of their community. However, such is not the case for most of the non-Deaf parents, who can barely hide their deception of having giving birth to a child with some “deficiency.” Strobel (2008) presents several instances of shock, anguish, anger, and despair, of shattered dreams when the family first finds out the medical diagnosis of deafness. And thus starts the tortuous path: endless treatments and several peregrinations to doctors; medical procedures that are short of torture; phonological treatments in a fruitless effort to remove the deafness disease. Deaf children first embraced by the pathological paradigm (Perlin & Strobel, 2014). Only after years of unsuccessful attempts, and when the Deaf children are in their late teens, only then the Deaf will be acquainted with other Deaf persons who speak SL, and to seek information, socialization and what is

---

<sup>1</sup> This manuscript will use Deaf (capital letter) to refer to the social construction of the Deaf identity, according to Deaf Studies.

considered an adequate education (i.e. education in SL) according to Wrigley (1996). At least this has been the *status quo* in Brazil, in detriment of the intellectual and overall development of the Deaf. Perlin & Strobel (2014, p.26) tells us that in order for the “[...] Deaf to have access information, education, knowledge, and in order to establish their identity, it is essential that they are in contact with Deaf people”, within the Deaf community which uses SL (e.g., to serve as role model, and to teach the language, the culture, etc.).

Only a few numbers of Deaf children are born to Deaf parents – 10% at most. The other Deaf children are born to non-Deaf parents and thus raised within the oral community. Deaf children do not learn SL, their natural language, and they do not acquire Deaf references, and they have little to no contact with other Deaf people from which to create bonds, communication functions and the opportunity to learn SL (Hoffmeister, 1999). The lack of language acquisition brings serious communicational, behavioral, sociocultural and cognitive problems (Vygotsky, 1974). The linguistic barrier the Deaf children find in their own family (where the oral language is the language of choice) prevents the Deaf to acquire her natural language, the SL, for intellectual development (Sánchez, 1991).

Thus precluded from access to their natural language, Deaf children find themselves in dire situations (i.e. they are basically on their own, trying to make sense of everything): they are not able to develop, to exercise full citizenship, and all human possibilities, mainly intellectual development, communication, participation in the mandates of their own lives. The lack of these basic human characteristics directly affects the education of the Deaf: the linguistics and communication barrier caused by the lack of a shared language deepens the gap the Deaf have to face when they enter the official educational system. The call is clear for some political-pedagogical action regarding these problems (Fernandes, 2012).

The access to an education that contemplates the real needs of the Deaf should be in SL as a language of cultural and educational value. But that is not the case in most educational practices (Skliar, 1999). No Deaf graduated from a Brazilian Federal University, for 100 years (Fernandes & Moreira, 2014). This fact should not attribute to the ability of the Deaf to enter the educational system, but, rather, it is a reflection of how the education system has failed the Deaf. This fact is a clear and brutal reminder of the reality of lack of access of the Deaf into environments where SL not spoken. SL is still considered subaltern, carrying no prestige when compared to the majority language, the oral language. This way we characterize the exclusion and make explicit the lack of social, cultural, pedagogical and educational practices that consider the linguistic differences of the Deaf (Fernandes & Moreira, 2014).

It is no coincidence that for 100 years no Deaf graduated from the university. SL was deliberately and strongly oppressed, forbidden in schools and society in general, and their natural speakers – the Deaf people – have been subject to prejudices, persecutions and all sorts of oppressive practices: their hands were tied so that they could not sign; they told that SL was the language of monkeys (Strobel, 2008). A century is a long and precious time for the nurture of a cultural and social language, especially given that language is a social construct, experienced by the group of those who speak it. Each “voice” of the Deaf that silenced, also muted their language (Fernandes & Moreira, 2014).

The Deaf do not understand the oral language that imposed on them (if for one thing, because they cannot hear. Sometimes, saying the obvious reveals atrocious cruelties). Therefore, the Deaf present very low

levels of communication and comprehension when they come to school – compared to their non-Deaf peers (Marchesi, 1991), and they arrive with very few previous knowledge from which to start education (Lane, 1984). Most parents do not value, learn, use and teach the SL. The parents rarely seek Deaf schools and associations. The master narrative around the stigma of deafness creates a climate of shame and a sense that the parents should seek the “cure” (Perlin & Strobel, 2014). Those are the main reasons why the Deaf enter the school system with a gap filled with discrepancies: the gap between the Deaf community (where SL valued as a language of intellectual development) and the education of choice is bilingual literacy (SL as L1, and the written form of the oral language as L2), as proposed by Sánchez (1991), and the pathological paradigm that imposes the oral language.

Bilingual literacy for the Deaf and their parents and educators is the resulting process of appropriation and use of SL and its meaning. Bilingualism is the social movement that considers SL as the natural language of the Deaf, a language of identity valorization, and the written modality of the oral language as a second language (Fernandes, 2012). Deaf culture is the term used by the social movements that consider deafness to be another, different way to experience humanity (which includes the right to use SL) and regard the Deaf not by a deficiency, but as a person in her visual specificity. Strobel (2008) says that Deaf culture is the manner of the Deaf to understand the world, and to be able to act on it, to change it, using their visual abilities, their values, beliefs, and habits. Unfortunately, there is very few pedagogical basis from which to inform the design educational material for bilingual literacy (Campello & Rezende, 2014).

Pedagogical architectures (PA) are tools that have been shown to indicate a path to followed: they incorporate an understanding of the world, and a way to help the learners to modify their cognitive structures, a basilar function in Deaf children education. PA is learning structures that combine different elements, articulated in a pedagogical, technological and political approach. They have extensively used in different areas of education. They inform the design of Learning Objects for bilingual literacy. LO are digital artifacts, focused on stand-alone, interactive teaching and learning of a specific subject matter (Carvalho, Menezes & Nevado, 2007).

Several authors, such as Skliar (1999), Sánchez (1991), Campello e Rezende (2014), Pereira (2014) and many others are for bilingual literacy. This article exemplifies the use of PA to inform the creation of LO for bilingual literacy of the Deaf and their interlocutors (Schneider et al., 2012). The LO created is based on SL iconicity, used to utter the concrete elements so the children and their interlocutor can initiate a communicational learning process to elaborate superior mental functions (Vygotsky, 1974) in an educational environment. The learners can interact with the LO by selecting the element (e.g. in the context of a city park: a tree, clouds, grass, birds, etc.). After the interaction, an animation in SL shows the sign for that element, followed by a video in SL and written legend explaining some knowledge about the element – thus allowing for learning to occur. The remainder of the article talks about the Deaf people and their plight and exemplifies the LO created.

## **2. Deaf Studies**

The Federal Law 10.4366 of 2002 made the Brazilian Sign Language (Libras) an official language of the

country. If it is yet to be a *de facto* language of public service and education, this fact is nonetheless a victory for the Deaf movement. This conquest did not come easy and without mobilization (Perlin & Strobel, 2008), and has not fully implemented as a language of choice in educational policies. Fernandes (2012) tells us that bilingual literacy in Brazil is of the weak kind (i.e. the oral language is the prevailing language, even when bilingualism proposed). It is an educational model marked by assimilation processes – in which the educational system conducts the learning and teaching process mostly in the Portuguese (the oral language of the country), and Libras has not used as a language of education and communication. The majority oral language mandates the linguistic and cultural practices in the educational system. Bilingual education is still a matter of dispute between the two languages that are in “constant tension in the verbal interactions, given that they are languages in a power relation explicitly asymmetric in the educational arena” (Fernandes & Moreira, 2014, p. 60).

However, the advent of the law brought with it a discursive field, from where the debates regarding the Deaf conditions can occur – a possibility thus far negated and unacknowledged in the Brazilian political scenario. The movement can now argue for a Deaf identity, culture, interaction, education, and language. According to Hall (2004, p.77), Libras is a common ground, a trait of the union that allows the Deaf to identify other Deaf, create their community and identity, within a cultural acceptance of belonging to a community. The author goes on to say that more than the language, it was the Deaf community that still excluded; but now the Deaf can engage politically to the extent that “[...] within this cultural acceptance, there is also the rise of fights for political or conscious opposition by which the individual represents herself”, creating a new narrative outside of the homogenization of the defected body.

Lane (1984, p.377) says that there are a few pieces of evidence (e.g. a teacher here. A post over there. A school of Deaf that opens in a major city). Although the gains are few and far between, pinnacles of examples that are not generalized, the author says that there is hope towards changing the fact that “[...] nowhere the Deaf are capable of finishing basic education in substantial numbers”, and the author goes on to say that nowhere policies that guarantee the Deaf their right to self-realization as a citizen implemented.

Deaf Studies denominate the scientific and academic spaces that have incorporated the Deaf history, culture, language and ruptures. This field of study has protagonists from all areas of expertise: educators, scientists, Deaf and non-Deaf researchers aiming to problematize the hegemonic discourses about Deaf and deafness. The tone of the action of Deaf Studies has been that of rupture: to break away from the master narrative of medico-pathological deafness (i.e. deafness as a disease to removed) and from its prevalence in the special education territory (i.e. where there is a premise of learning the oral language as a priority). And to generate studies that place Deaf into the realm of a minority community, speakers of SL.

According to Wrigley (1996), Deaf Studies should clear the field for studies that are connected to knowledge, oppression, colonialism, power struggles, among others, problematizing the several discourses that were historically produced to oppress, stigmatize and subdue the Deaf as a subaltern, with an identity of audio and linguistic deficiency. This rupture brought about by Deaf Studies values the visual aspects of SL in opposition to the pathological models.

Ingrained in the epistemological cloth of the differences, now problematized in the cultural studies (Hall, 1997), the Deaf movement acts to reverse the dominant, hegemonic narrative of pathological deafness. E works at creating a discursive field of the language representing changes in the conceptions and practices. According to Fernandes & Moreira (2014, p. 54), the SL oppressed, and the Deaf culture decimated, causing “[...] a severe social set back that perpetuated the stereotype of deficiency and incapacity of the Deaf citizen, whose difference, up until the XIX century, was manifested primarily in linguistic terms”. The 90’s mark by the Deaf movements that claimed an identity, a representation of the Deaf as an individual, who capable of being an interlocutor in the social relations (Sawaia, 2001).

Fernandes & Moreira (2014) tells us that the Deaf movement and their quests put Libras at the center of discussions, as a discursive field of fights, signification, power and meaning production. Deaf Studies fight for bilingual education. The authors emphasize that it is not the language that is minor, but it is the discourse that minimizes the Deaf community: although the language is officially recognized, this fact does not reflect on the society and the educational system and policies: the Deaf community is still invisible in the context of educational policies for the Deaf.

## **2.1 Deaf issues**

The communicational gap between Deaf children and their non-Deaf families is the cause of a series of mental disorders that may appear in the Deaf’s life, with direct impact on quality of life and even surviving possibilities. Chomsky (1986) tells us that the abilities to understand, create and transform culture are a human characteristic that is language-dependent. Laborite (1994, p.59) reports poignant testimonies when he says that adults who deprive Deaf children of SL will never have the capacity to understand the mental anguish inside the Deaf’s head due to this: “There is loneliness, and resistance, and the quench for communication, and sometimes hate.” For the author, the exclusion that begins at home, and continues as an imposition at school, where everybody speaks the oral language, is a life of feeling disregarded, when everybody speaks, and the child does not understand. The child is constantly demanding for a shred of attention, a minimum bit of information to make sense of the world around her – a life lived in a silent movie without legends.

According to Brito (1993), the lack of SL acquisition diminishes the child’s capacities to perform shores, to develop intelligent actions, to plan, to participate in the family’s activities. The Deaf show more difficulties (compared to non-Deaf people) to control impulses, actions; to become independent of the visual, of the concrete; they have difficulties to create abstractions, to socialize.

Consequently, according to Finau (2006) members of the Deaf community are more prone to suffer: for the lack of meaning attribution; the lack of identity; the lack of social and cultural diversity. The Deaf fall behind in their intellectual development. They are not able to seek, obtain, create and disseminate information; they have difficulties going to a medical consultation, and to form effective ties, among others. Parents and educators encounter difficulties in teaching Deaf children.

Marschark, Lang & Albertini (2012) shows that the gap in education is almost insurmountable. Deaf people with the age of 18, when leaving high school, only achieve the equivalent of the 4<sup>th</sup> year, and of these, only 3% read at the same level of a non-Deaf reader of the same age. Svartholm (2014, p.41) points

out the importance of “[...] an environment that is interactive, communicational for the learning to occur.” And the author goes on to say that it is from the linguistic encounter, the understanding of information represented in various linguistic forms and its use that the development can occur. Deaf people are not defined by deafness, but by culture, and the use of SL to overcome such difficulties (Sklar, 1999).

## **2.2 Libras**

SL, such as Libras, are legitimate, complete linguistic systems, of visual modality, whose signs produced in the space and the body of the signer. Language is social constructions that reflect the identity of a certain group, and they served various functions and used for many different purposes, such as communication, modeling of the world, education, etc. (Stokoe, 2000). The author tells us that conventions fully describe SL, rules, grammar, lexicon, structure, etc. therefore, Libras is capable of providing the Deaf the tools with which to realize their full human and linguistic potential (Hoffmeister, 1999). Libras is not universal: there are different SL in each country. Libras is not dependent on Portuguese (the oral language of Brazil).

Sawaia (2001) tells us that the search for identity (even to construe it or to negate it) starts from a place of power struggles between inclusion and exclusion, and it occurs with the negation of rights for some, and the maintenance of privileges for others. Libras, therefore, on the one hand, is part of the inclusive discourse of the Deaf in the normality territory, in opposition to the stigma of deficiency. Libras is a link of the union of the common experience of the community whose members speak it, and, therefore, it is inclusive. However, when the community changes the master narrative to that of linguistic difference, this new narrative creates exclusion due to the sub-valorization of Libras, which has few users and social functions in formal spaces. In this regard, Fernandes & Moreira (2014, p. 67) say that inclusion should have as a premise the right to a “[...] transforming education mediated by linguistic, social and cultural experiences that are fully accessible to the learner”, in environments that value Libras and Portuguese as historical and cultural patrimonies of the country, giving real emancipation to the Deaf students (i.e. bilingual literacy).

## **2.3 Bilingual literacy**

Language is more than a tool for communication (Sánchez, 1991): they include thought regulation functions (Vygotsky, 1974). Bilingualism is the method of choice for Deaf education, the movement that calls for the use of both languages: Libras as the first language (L1) and the written Portuguese as the second language (L2). Libras should be accessible to the Deaf at an early age, for intellectual development. And the Deaf can achieve the domain of the written modality of the oral language because the development of the written system can treat as independent of the oral language – but this requires different pedagogical strategies of teaching and learning. The oral language and its written system are different systems, both in structure and in behavior (Vygotsky, 1974).

Libras is a language of visual signs, which implies in a visual signification of the world for those who speak it – different when compared to the significations that occur for the speakers of oral-auditive

languages. Deaf Culture, therefore, is visual in several aspects of its production: art, literature, humor, poetry and other activities of daily life. For the world to make sense to Deaf children, they must expose to SL, and they should be allowed to partake in their mental models of interactions that are visual. New, innovative pedagogical models are required to allow the Deaf children to grow linguistically and as a person.

Although Libras may have all its richness, the other language of the country is Portuguese, which used for social interactions with other groups within the country (i.e. family, friends, school, work, etc.). Therefore, the social use of Portuguese requires that the Deaf be also fluent in Portuguese, in its written form – the only modality that is naturally accessible to the Deaf (Sánchez, 1991).

Thus, we have bilingual literacy, best understood as the result of the social use of SL and the written form of Portuguese. The use of the written form of Portuguese required in most social interactions According to Fernandes (2012), bilingual literacy as an effective appropriation is pleasurable; it is leisure. It provides access to information and communication. It is, above all, a way to exercise full citizenship in different social practices.

Unfortunately, the reality of the Deaf happens in non-Deaf families, and they don't have access even to Libras to scaffold the teaching and learning of Portuguese. The Deaf usually does not appropriate the social and cultural references of the Deaf community, mostly because they don't have interlocutors with which to learn Libras. The lack of a shared language is a barrier that increases when the Deaf starts their process of formal education, given the current conditions of the school system: "[...] teachers, who are held responsible for a historical responsibility of inclusion of their students, who do not speak Libras" (Fernandes & Moreira, 2014, p. 59). There are very few interpreters, almost no pedagogical support, and their formation is precarious.

On top of that, Silva & Bolsanello (2014) points yet another issue regarding power struggles when it comes to teaching a writing system to the Deaf: one group that defends the use of Libras as a means to achieve the learning of written Portuguese; and another group that says that it is best to teach a special writing system for SL, of which SignWriting is an example (Sutton, 2006). And so, the necessary writing autonomy of the Deaf is still a challenge.

We know that the Deaf have been forced to try to communicate exclusively in the oral language for more than a 100 years. History shows plentiful methods that came short of torture (Sánchez, 1991), by forcing the Deaf to produce sounds they could not hear. For the most part, the Deaf were required to make sounds that made no sense because they were sounds to which the Deaf could not attribute meaning. Pereira (2014) tells us that until recently these procedures were predominant, and lead to a fragmented alphabetization. Geraldi (1996) points that the works of Vygotsky (1974) and Bakhtin (1998) brought some new perspectives for language, that becomes an activity, to occur in interactions – language is construed in social and linguistic activities. This approach focuses on the text and all its elements, and it considers that it is only the situation of use of language that allows its comprehension. The proposed LO has Libras as the first language and the written Portuguese as a legend on the video.

### **3. Related work**

The existing pedagogical architectures (PA), and their proposed LO are inadequate for bilingual literacy of the Deaf: they do not scaffold learning, they sometimes do not allow for collaboration, they not design for bilingual literacy, they based on the oral language among others (Behar, Bernardi & Silva, 2010). We present some works for comparison.

Elia & Sampaio (2001) present an interactive computational platform the offers LO of certain subjects, in instructional or activity format, with evaluation and bibliographical references, but they are in the oral language. Fagundes et al. (2006) present a non-computational project: it starts with a brainstorm to raise questions that are of interest for the group. These question then grouped, and a theme chosen. Then, the participants are invited to present any previous knowledge about the subject order to explore the theme – in a manner that is more based on uncertainties and temporary doubts. The closure of the collaborative process consists of the mediator providing information about the theme – it is not clear how the proposed method would allow for the learner independence. Serres & Basso (2009) present a PA of Virtual Diaries: they are no more than an asynchronous communication channel between the professor for monitoring and further explanations.

Some PA present as being in Libras. However, they have several inadequacies: Silva (2002) presents a web dictionary that is a one-to-one translator Portuguese/Libras – it may be useful for the Portuguese speaker to learn a sign, for example, but the dictionary fails to show proper sign movement. Secco & Silva (2009) present an environment in Libras, based on problem-solving strategies, to teach Libras: but it requires that the learner already know Libras (a strange contradiction). Tavares et al. (2009) present a glove with sensors that capture movements, send them to a system that tries to translate it to Libras. The use of a glove is highly undesirable (consider a voice recognition system that would require the speaker to wear a glove with sensors on her tongue).

As for general systems, there are several attempts, but they are not educational tools, and they are built based on wrong approaches (e.g. one-to-one translations; limited vocabulary; lack of usability, etc.). Coradine et al. (2002) shows a system that recognizes the voice and synthesizers in SL – it requires the oral language – it uses animation, but it is restricted by the lexicon already present on the system. BBC (2009) presented a system that proposes the use of an avatar – but it did not specify how the system worked. SignSmith (2009) presents a illustrated and animated dictionary – a one-to-one translator. Gloves are present in several artifacts, such as AcceleGlove (2009). Next, we present the proposed PA.

### **4. Pedagogical architecture for bilingual literacy**

PA are structures that articulate around pedagogical, technological and political dimensions to inform the design of LO of a certain subject matter. PA go beyond the mere teaching by providing an environment that is conducive to knowledge creation, where the learner models the world by communication, and the learners have the chance to attribute meaning during the course of the study using interactive activities: a continuous process based on the actions of learner on the world, and in the elaboration and execution of the proposed activities in a way that the learner may know and understand the world (Carvalho, Menezes



e Nevado, 2007). Learners derive meanings dynamically, as they engage in the LO interactive activities. PA promote dynamicity in three main forms: first, they have a strong pedagogical component (i.e. education to find real solutions to the real world; to transform information into knowledge; to create, to express, to communicate; to investigate and innovate; education that provides autonomy and collaboration opportunities among others). Then, PA is a methodological systematization of interactive cognitive activities (e.g. learning by doing; problem-solving strategies; simulated action, etc.). Finally, PA provides a virtual, stand-alone learning environment that gives independence to the learner. This article shows how to create LO for bilingual literacy (Libras and written Portuguese) for Deaf children and their interlocutor. It incorporates elements of interactive environments for teaching and learning, and a rich use of visual information, in complex situations of pedagogical development (Behar, Bernardi & Silva, 2010). Virtual collaborative systems are part of the LO: collaborative interactions are important for human historical and political formation of the individual (Arcoverde, 2010). The LO scaffolds the sharing of social languages, and provide an arena where emotional ties are formed between the Deaf and their interlocutor – a necessary step for the encounter of various “voices,” themes, points of view, thus creating a social interaction environment.

LO for bilingual literacy proposed base on an interactional pedagogical approach (i.e. a process of interactions and relations between actions and representations, where knowledge is something that creates in the interaction). Deaf children and their interlocutors are invited to create “spontaneous concepts” (i.e. those acquired by the concrete experience), and to elaborate from those to achieve the creation of meaningful “scientific concepts” (i.e. those acquired by reflection, explanation, elaboration, meaningful relations of a new concept and previous knowledge) thus developing superior mental functions (Vygotsky, 1974). The PA proposes the use of iconic signs from Libras to represent the spontaneous elements within the LO. That accomplished by an animation showing how the Libras sign nominates the element. Then, a video in Libras presents some knowledge related to the selected element, with a legend in written Portuguese.

#### **4.1 Bilingual literacy learning object**

To create the LO, educators should select the area of knowledge to be contemplated in the LO (e.d. bi-lingual literacy), the context in which the interactive activities for knowledge creation are going to occur (e.g. representations of daily activity, such as going to the supermarket). The educators make these definitions in brainstorm sessions. Figure 1 shows the research group creating the elements and their relations:



Figure 1. Selecting elements.

Deaf educators and researchers come together in brainstorm sessions to select teaching elements.

Figure 1 shows the work of educators and researchers: to create the LO, educators and other stakeholders (e.g. Deaf teachers, parents, etc.), should define the area of knowledge to inform the design of the interactions within the LO. All should use Libras as a language of education when choosing the area and the elements. The educators will choose elements from the knowledge area based on one of the most important and recognizable features of Libras: its iconicity (when compared with other, oral languages), in a way that the use of the language is closer to the object it is nominating (thus making it easier to understand the language). An animation in Libras will represent each element, superposing the element, to further implicate the iconic relationship. Figure 2 shows part of the creating process.



Figure 2. Selecting relations between elements.

Deaf educators and researchers select relations between the elements.

Figure 2 shows the discussion about the knowledge to inform the design of the LO. With this strategy, the PA will help educators create LO that incorporate the linguistic, cultural and social of the Deaf, geared

towards bilingual literacy, capable of providing communicational and educational environments, as preconized by the Dialogic/discursive perspective of Bakhtin (1988). The LO is thus a social and interactional environment where the elements in it are related, and they form discursive situations of the real world to motivate the Deaf and their interlocutor to exchange thoughts, ideas, communications to scaffold learning and knowledge creation.

#### **4.2 Creating a learning object**

In this phase of the PA, the educators have chosen the elements that can select within the LO. When activated, an animation will enunciate the element in Libras – a ludic way to use the iconicity. The, a video with some knowledge presented. These videos provide knowledge related to the element (e.g. relation to other elements, concepts, etc.). Later, the Dear and their interlocutors may select any element, in any order. So, to create the LO, the PA tells us to consider the following aspects:

- 1 – The general area of knowledge to be considered (e.g. health, hygiene, transportation system, etc.);
- 2 – The format of the LO (e.g. a digital book, a poem, game, etc.);
- 3 – A concrete representation, in the form of an illustration, a scenario of real interaction situations of daily life, part of the context of the Dear (e.g. a coffee break, a visit to the supermarket, etc.).
- 4 – The use of mental tools, such as sense making, the signification tool proposed by (Dervin, 1977) – a process in which the Deaf is invited to make sense of the experience. There is also the use of common sense, as proposed by (Anacleto et al. (2006) – shared common knowledge, related to life, customs, beliefs, situations, etc. The educators should use these mental tools to create the LO and incorporate them in the knowledge that will be part of the interaction activities proposed. The educators can create mental maps (Giombini, 2006) to keep track of the tasks that will enhance knowledge about the proposed theme (i.e. knowledge creation, information seeking and use, communicational interactions, comparisons, etc.).
- 5 – The educators should select elements that are part of the context and the chosen area of knowledge. The elements, videos, animation, actions, knowledge, relations and other aspects of the teaching and learning environment incorporate into the LO. Educators should consider strategies that favor the way knowledge is acquired, how things change over time, what actions are possible within the LO etc.
- 6 – The previous process (of creating the mental maps) will guide the nature of the LO, the selection of its components, the way information will impact and the manner in which knowledge will create.
- 7 – Educators should create a scenario for both the creation and the use of the LO. This way, they will create richer interactional environments (Carroll, 2003).
- 8 – Iconicity is used to represent the lexicon, and the concrete elements in Libras to form the spontaneous knowledge. The videos and their contents will aid the Deaf to engage in cognitive structures to create scientific concepts (Vygotsky, 1974)
- 9 – Narrative creation, according to Giombini (2006), and the pleasure of the narrative (usually acquired by non-Deaf children in their first infancy) requires the children to have intent, and that they have something to say, and also that they have the instrumental tools to say it (i.e. using Libras, in the case of Deaf children). The narrative created by the use of LO and the interactions with their interlocutors will aid the children to create links between a new information and pre-existing cognitive structures, from the

general (i.e. the element, represented by its iconicity in Libras via animation) to the most general, broad stories in order to achieve higher mental functions (Ausubel, Novak & Hanesian, 1980).

10 – The LO should make substantial use of ludic elements. According to Vygotsky (1974), game playing is a crucial process, one in which the individual understands ideas, develop linguistic, cognitive and other skills, get motivated and involved – a view also shared by Hoffmeister (1999).

### 4.3 Creation of mental maps

The decisions in the educators made in the previous phase should represent in a tool that is easy to understand and share: a mental map. According to Giombini (2006), mental maps are a network of conceptual representations of concrete objects and related information and knowledge. It is a tool used to help organize the elements and their relations and to represent the knowledge that will comprise the LO. According to the author, they are the most effective scientific tool to aid in the process of language acquisition (and the understanding of how learning acquisition happens).

Educators should start with representing the iconic elements (e.g. in an LO where the context is a city park, these iconic elements in Libras would be a tree, a bird, the grass, the clouds, etc.) as a node, and the links to other iconic elements or related knowledge (e.g. in the same context, the rain, the bird’s nest etc) and of other knowledge, such as a cause-effect relation between the elements (e.g. the sun burns the skin and the eyes; a sunglass should be used to protect the eyes). This will inform the design of an LO that is richer and will help keep track of the knowledge representation possibilities from which to choose when implementing the LO. Figure 3 shows the mapping of the elements and the relations among them, representing some knowledge to be used in the LO. It shows that the sun causes damage to the eyes and the skin. People should wear sunglasses or a hat to protect the eyes, and use sunscreen to protect the skin from sunburn.

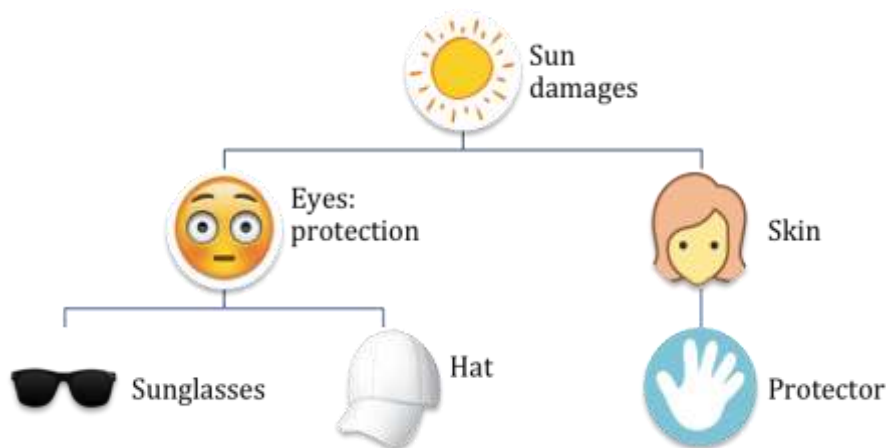


Figure 3 – Elements and their relations.

The sun damages the skin and the eyes. Children should wear sunglasses or the hat to protect the eye, and sunscreen to protect the skin.

All the elements and their relations, and all knowledge about the elements and their relations are mapped in maps as we see in Figure 3.

## **5. An evening at the park**

In this section, we present the use of the PA to create an LO. The research team comprised of Linguists, Deaf Psychologists, Deaf Educators, Computer Scientists, and Illustrators. The research team conducted weekly meetings, for several weeks. Each meeting was comprised of the same people and lasted for two hours. The meetings took place in a Deaf school located in the metropolitan region. Next, we exemplify some of the activities used to create the LO:

### **5.1 Defining the theme**

During two meetings, a brainstorm discussed the possible themes for the LO. The themes were chosen considering the possibilities to represent them as daily activities within the context of Deaf children lives. The researchers met for two sessions,

- I – Personal hygiene and food habits (e.g. shower; brush teeth; wash hands and fruits etc.);
- II – Social interaction within the family (e.g. corporal noises; behavior; cleaning habits; shared tasks; helping with chores etc.);
- III – Social interaction outside the family home (e.g. know the outside world; social interactions; friendship; sharing toys, etc.);
- IV – Child story (e.g. ludic environment; literature; fantasy world etc.).

### **5.2 Defining the elements and related knowledge**

The LO was to represent social interaction in a public space. The city in which the design took place surrounded by various parks and arborous squares, and people frequent those spaces for a lot of outdoors activities – jogging, walking, sunbathing, lunch breaks, meeting people, exercise, take pictures, picnics, etc.).

To inform the design of the LO and its posterior use, a scenario (Carroll, 2003) was created: “It was a nice, sunny day, with mostly clear, blue sky and only a few clouds. But, the city is known to have some occasional showers, which would last for just a few minutes, during this season. After lunch, the family allowed the kids to play in the park in the neighborhood, just outside the house, where they could meet their friends. During this walk at the park, the children were interested in their surroundings: they asked a lot of questions about the trees, the butterfly, etc. Their curiosity triggered interactions with their parents to find out more about them. The parents would then say some things about the elements”.

The above scenario was used to help the team focus on the elements and the knowledge about them, and to come up with the relations among them and the interactions that would be supported by the LO. Then, the research team met for three weeks, for two hours each time. In those meetings, 13 elements were chosen based on the theme and using the scenario. The Libras sign for the 13 elements are iconic, and this feature is important, because the illustration and animation of the sign, superposed with the element would be the first utterance in Libras in the LO. Tree, bush, grass, earthworm, sun, cloud, rain, bird, duck, bicycle, sunglasses, butterfly and fish were chosen to represent in the LO.

The researchers met again for two hours during the next four weeks to decide about the knowledge, the relations, the interactions that would comprise the interactional and educational part of the LO, to be

filmed and presented in the video. Next, we present some of the possible utterances. The knowledge exemplified in table 1 created in Libras. They were used to film the Libras videos for the LO.

The validation of the Libras videos took place in two meetings, of two hours each, where Deaf educators and researchers joined by 14 Deaf students from the school and five of their mothers, all fluent in Libras, ages 16 to 18 of both genders. These meetings allowed for the correction of the Libras. The participants were very creative, and some of the suggestions they made were very rich. For example, for the knowledge “the bird eats earthworm”, they did not use the sign for eat: they created what a classifier (i.e. they incorporated the character into the narrative) and the Libras showed the actual eating of the earthworm by the bird (i.e. the bird flying over the park, spotting the earthworm, diving towards it, and picking the earthworm with the beak, and then gulping the earthworm). The use of Libras as the language for creating and for validating the knowledge was important: the participants felt that the community was respect. They felt compelled to help to create the most correct and beautiful Libras.

Table 1 shows a few examples of the elements and some of the related knowledge:

Table 1. Elements and related knowledge.

<b>Elements</b>	<b>Knowledge</b>
Fish	<ul style="list-style-type: none"> <li>- The fish has scales;</li> <li>- The fish leaves in the water;</li> <li>- The fish eats the earthworm;</li> </ul>
Butterfly	<ul style="list-style-type: none"> <li>- The butterfly flies;</li> <li>- The Butterfly is colorful;</li> <li>- The Butterfly is beautiful;</li> </ul>
Bird	<ul style="list-style-type: none"> <li>- The bird is an animal that has colorful feathers;</li> <li>- The bird nests on the trees;</li> <li>- The bird eats earthworms;</li> </ul>
Duck	<ul style="list-style-type: none"> <li>- The duck has yellow feathers;</li> <li>- The duck is an animal that leaves on land and in water;</li> </ul>

An example of elements and related knowledge.

The pedagogical strategy for presenting Libras and Portuguese is to show an animation of the hands with the Libras utterance of the selected element. Then a video presents some knowledge.

### 5.3 The park

The LO consists of a digital book, with an illustration of an overall view of the park, containing the elements. The interactions occur when the child and her mother start to interact with the LO. This illustration is static, but the elements are dynamically animated (the river flows, the butterfly claps its wings, it rains, the duck moves its beak, the sun glows, the wind blows the leaves of the trees, etc.). This dynamicity of the elements was designed to make the LO appealing and had a second goal to show the child and her mother that the elements could be activated (like video games or other computer mediated

system the children may have seen).

Eventually, one of the elements would be selected (by touching it), and the LO would then show the animation of the sign in Libras for that element. Figure 4 shows this first instantiation of the LO, with the animation that shows the Libras sign for BUTTERFLY (BORBOLETA)<sup>2</sup>. The upper right side of the LO in Figure 4 shows the arms and hands showing the Libras sign for BUTTERFLY. As can be seen, the utterance of BUTTERFLY in Libras is very iconic, which is part of the language, and it is a feature that will be used in the LO to show Libras every time any of the elements chosen:



Figure 4 – A walk in the park.

The Libras sign for BUTTERFLY is shown by an animation of the arms and hands on the butterfly when it initiated.

After the animation, a video, with the Libras showing some knowledge of the element shown. The video has a legend in Portuguese. Figure 5 shows the video in Libras and Portuguese:



Figure 5 – Video in Libras and written Portuguese.

The Libras video presents some knowledge about the BUTTERFLY. The legend says: “The butterfly flies.

<sup>2</sup> Utterances in Libras will be written in capital letters.

Each time an element instantiated, the animation will show the utterance a Libras, and a new video will show. The videos will present increasingly complex knowledge, to allow for the interactions between the child and her mother to happen. Each instantiation is initiated outside from the LO (i.e. the child and her mother must interact with the LO for it to occur). During these in-between times, the LO will serve as a backdrop for further interaction to happen (e.g. some questions, some clarification, some other, different knowledge provided by the interlocutors, etc.). New interactions provide opportunities for learning both Libras and written Portuguese and some knowledge about the context. Any element appears to move, which gives a clue that it can instantiate at any time: this way, the LO encourages the interlocutors to explore, and create their interactions.

**5.4 Activities and definitions**

Table 2 summarizes the activities and the definitions of the process to create the LO:

Table 2. Creating the LO.

<b>Activities</b>	<b>Definitions</b>	
Define knowledge area	Social interaction behavior	
Define LO type	Interactive virtual environment	
Define Context	Real world	Visit a park
Define LO style	Model the real world. Exploration	
Create scenario	Concrete representation of use	
Define Libras signs	Candidate signs	Sign iconicity
Define knowledge in Libras	Define selection criteria	Cognition
		Context
		Teaching Goals
Define the LO	Select the best interaction representations	

Examples of some of the activities and definitions used to create the LO.

After developing the LO, the research team performed an internal validation.

**5.5 Internal validation**

The development and internal validation of the LO base on the approach of Dolz & Schneuwly (2004) of multi-disciplinary character. The researchers, Deaf Psychologists, Deaf Linguists, Deaf Educators, Deaf students and non-Deaf parents composed the validation team. The LO present a theoretical and methodological approach that is consistent with the effective interlocution with the literature in the area. The approach fulfills the criteria of social relevance and innovative approach in the context of Deaf education.

As a case study for proof of concept and training of Educators and mothers who would later use the LO, the research team conducted a workshop, that lasted for two hours. Five Deaf educators, twenty-five Deaf students, and three mothers participated in the workshop. The workshop previously announced to the Deaf school community (teachers, students, parents) and a date was scheduled. On the day of the



workshop, all participants gathered in the meeting room of the school. The participants sat around in U-shape format, looking at a screen that projected the LO installed at a computer in the back of the room. The research team briefed the participants about the LO, its purpose, and the purpose of the workshop. All participants either consented themselves (the adults) or had parental consent.

The researchers divided the students randomly in groups of five, and each group was invited to interact with a teacher and the LO. The interactions were free, and the other students were able to see them on the screen and could join in on the discussions. The children said that they loved the activities, and each group was waiting for their turn. It became a moment of leisure (i.e. the students didn't think of the activities as "school work." They were having fun. There were discussions on the knowledge that was not presented by the LO. For example, the LO said that the earthworm was brown, but the students questioned if it weren't gray. The video also said that the earthworm lived underground, but on the LO, it was on the grass. Also, they wanted to know how come the fish could make it the earthworm. The color of the butterfly not presented, but the students signed that it was purple.

After the workshop, the five teachers and the three mothers answered 15 item affirmatives, and they used a 5-point Likert scale (Cronbach  $\alpha = 0.92$ ). The questionnaire adapted from Behar, Schneider & Silva (2011). Next, we present the responses with the median and standard deviation in parenthesis.

The respondents agreed that the LO was easy to understand (4.2/0.8) and to use (4.8/1.1). There was unanimity as to their agreeing with the affirmation that the LO valued creativity (5), communication (5) and interaction (5). Regarding the concrete knowledge, the respondents agreed that the tool was helpful to teach them to the children (4.3/1.2). As for the affirmation that the LO helped the children interact to create abstract knowledge, the respondents agreed (4/0.9), but they expressed their concern that those concepts were still too complex.

The respondents were enthusiastic (4.5/0.9) about the fact that the LO incorporated social, cultural and linguistic specificities of Libras and the Deaf community, and that the LO would scaffold the bilingual literacy (4.3/1.2). The LO represented the real world for knowledge creation (4.8/1/3) and allowed for flexible interactions (3,8/1,2). The LO valued interlocution (5) and communication (5).

## **5.6 Creation of new LO**

The LO presented has been in use at the Deaf school in which it developed. The Deaf educators report that the mothers have been using it and that it has helped increase the mothers' fluency in Libras. The educators are conducting a longitudinal study to validate the effects in the long run of the use of the LO. The research team is creating new LO. The first one is almost complete: the theme selected was "Aquatic Sports," the setting is a swimming pool. The iconic items have chosen (e.g. the shower, the towel, the pull buoy, the bathing suits, the cap, the nose clip, the kicking board, the safety buoys). Figure 6 shows the preliminary draft of the LO environment; the chosen items have signs in Libras that are very iconic (a feature that will be used to represent the Libras sign as an animation superposing the elements). They depicted in bright red, for reference; it also shows the mother taking her son to swimming lessons, and on child using the buoy at the pool, and another one drying with the towel.



Figure 6. Aquatic Sports.

The initial draft of the next LO create. The iconic signs depicted in brighter red.

The research team has already defined the knowledge for the new LO. Deaf educators recorded the videos with the knowledge. The Deaf are now validating those videos with the Deaf community, and the videos will later incorporate into the LO. Figure 7 shows some of the knowledge in a format that the Deaf educators call “gloss”:

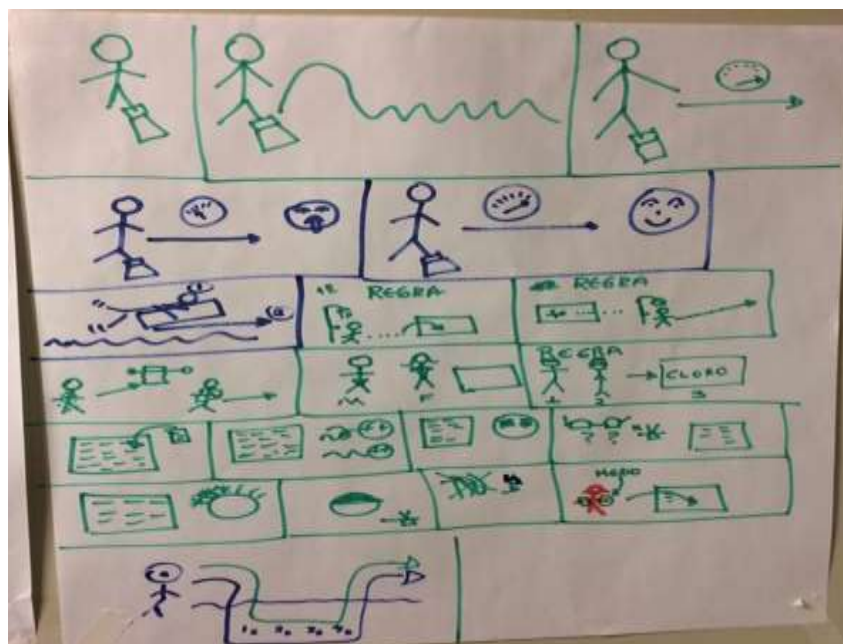


Figure 7. Knowledge for the Aquatic Sports LO.

Each frame on this figure shows a different knowledge (there are 20).

The researchers used only Libras during the creation of this new LO. Pictures of the actual items selected were used to represent the iconic elements. The Deaf educators discussed the knowledge that they wanted to show, and once they reached consensus, they would record that knowledge using the glossary.

## 6. Considerations

Deaf should have access to Libras, their natural language, for intellectual development. But most Deaf children are born to non-Deaf parents who don't use Libras. Thus deprived of a maternal language (because the parents, in most cases, do not speak Libras; and because they rarely socialize with other Deaf with whom to learn Libras) Deaf children lag behind when compared to other non-Deaf children. This gap widens when the Deaf initiates their formal educational process because the schools in Brazil are not prepared to offer effective bilingual literacy. The parents should learn Libras to create a channel of communication for the development of the Deaf child and to form families' ties.

The proposed PA and its related LO use the iconicity of Libras to scaffold the learning of the first signs in the language. Then, a video in Libras furthers the information provided (i.e. the LO is not only to learn Libras but to create knowledge as well). The videos contain information about the selected element and its relations to other elements in the LO and the world (e.g. characteristics such as color, shape, size, cause and consequence relations, etc.). This provides a basis from which the Deaf and her mother can learn together, and interact, opening new communicational channels. The case study showed a successful use of the LO. The Deaf and their mothers have been using the LO at the Deaf school.

It is our understanding that the PA proposed is of great value to inform the design of several LO, on several themes (e.g. science, life, poetry, etc.). It values Libras as a language of education, knowledge creation and communication. The PA allows for the creation of LO that represent daily situations (e.g. a medical appointment, a swim lesson, a visit to the supermarket, etc.). Libras is to be shared and used by members of the Deaf community.

The LO has widely distributed in the Deaf community. Readers interested in a copy can solicit one. The researchers are working on building a platform in which the LO will be made available, for easy access and sharing. The long-term effects of the LO will guide us into improving the PA.

## 7. References

Accele Glove. 2009. Available at <http://lges.iqm.unicamp.br> Accessed at 22/05/2012

J. Anacleto et al. "Can common sense uncover cultural differences in computer applications?" In: **Anais da IFIP World Conference (WCC)**, 2006. *Artificial Intelligence in theory and practice*. New York: Springer-Verlag.

R. D. L. Arcoverde, "Digital technologies: a new interactive space of social encounter in the written production of the Deaf." 2010. *Cad. CEDES*, Campinas, v. 26, n. 69, pp.1-10.

M. M. Bakhtin, *Questões de Literatura e Estética*, São Paulo: Hucitec. 1988.

BBC News, *Technique links words to signing*. 2009, available at <http://news.bbc.co.uk/1/hi/technology/6993326.stm> accessed in 05/22/2012.

P. A. Behar, K. Bernardi and K. A. Silva. “Arquiteturas Pedagógicas para a educação à distância.” 2010. available at <http://cinted.ufrgs.br> accessed in 05/22/2017.

P. A. Behar, D. Schneider and K. A. Silva, “As competências na EAD: dos objetos de aprendizagem ao mapeamento de competências.” 2011. Available at [http://lacloo2011.seciu.edu.uy/publication/laclo2011\\_submission\\_103.pdf](http://lacloo2011.seciu.edu.uy/publication/laclo2011_submission_103.pdf) Accessed in 22/05/2017.

L. F. Brito, *Social Integration and Deaf Education*, Rio de Janeiro: Babel, 1993.

A. R. Campelo and P. L. F. Rezende, “Em defesa da escola bilíngue para surdos: a história de lutas do movimento surdo brasileiro.”, *Educar em Revista. Ed. Esp.* N. 2, p. 71-92. 2014

J. M. Carroll et al. “Knowledge management support for teachers.”, *Educational technology and development.* 51(4). PP. 42-64. 2003

M. J. S. Carvalho, C. S. Menezes and C. S. Nevado, “Aprendizagem em rede na educação à distância.”, Porto Alegre: Ricardo Lenz, 2007.

N. Chomsky, *Knowledge of language: its nature, origin and use.* New York: Praeger Publishers, 1986.

L. C. Coradine et al. “FALIBRAS”, **Anais do III Ibero-american congress of informatics in special education, CIIEE.** Fortaleza, 2002.

B. Dervin, “Chaos, order and sense-making”. In: R. Jacobson, R. (Ed.). *Information Design.* Cambridge: MIT Press. 1977.

J. Dolz and B. Schneuwly, “Gêneros orais e escritos na escolar”, Campinas: Mercado de Letras, 2004.

F. F. Elia and F. Sampaio, “Plataforma interativa para a Internet”, **Anais da SBIE**, Vitoria, 2001, pp.1-10.

L. Fagundes et al., “Uma experiência mediada por ambientes telemáticos”, *Revista Brasileira de Informática na Educação.* 2006. V. 14, n.1

S. Fernandes, *Educação dos Surdos*, Curitiba:IBPEX, 2012.

S. Fernandes and L. C. Moreira, “Políticas de educação bilíngue para Surdos: o contexto brasileiro”, *Educar em Revista.* Ed. Especial n2. 2014. P. 51-70

R. Finau, “Possible encounters: Deaf culture, education and linguistic”, In: R. Quadros (Org.) Deaf Studies I. Petrópolis: Arara Azul, 2006.

J. W. Geraldi, Linguagem e ensino. Campinas, SP: Mercado de Letras. 1996.

L. Giombini, “Complex thought, conceptual maps and cmaptools”, In: concept maps: theory, methodology, technology, P. II. **Anais da International Conference on Conceptual Maps**, A.J. Cañas, J.D. Novak (Eds.), San José, Costa Rica, 2006.

S. Hall, A identidade cultural na pós-modernidade. Rio de Janeiro: DP&A. 2004.

R. Hoffmeister, “Families, Deaf children, the world of the Deaf and the professionals of audiology” 1999. In: C. Skliar (Org.) A atualidade da educação dos surdos v.2, Porto Alegre: Mediação, p. 113—130.

iSign 2009. Available at <http://idev2.com/iSign/iSign.html> Accessed at 30/05/12.

E. Laboritt, O vôo da gaivota, São Paulo: Best Seller. 1994.

H. Lane, When the mind hears: a history of the deaf, New York: Random House. 1984

M. Marschark, H. G. Lang and J. A. Albertini, Educating Deaf students, Oxford: Oxford University Press. 2012

A. Marchesi, El desarrollo cognitivo y lingüístico de los niños sordos. Madrid: Alianza Editorial. 1991

OMS available at <http://www.who.int/en/> Accessed in 05/05/2017.

M. C. C. Pereira, “O ensino de Português como segunda língua para os surdos: princípios teóricos e metodológicos”, *Educar em Revista. Ed. Esp.*, n. 2, p. 143-158. 2014.

G. Perlin and K. Strobel, “História cultural dos surdos”, *Educar em Revista. Ed. Esp.* N.2, p. 17-31. 2014

C. Sánchez, La educación de los sordos en um modelo bilíngüe. Mérida: Diakonia, 1991.

B. Sawaia, (Org.) As artimanhas da exclusão, 2ª ed. Petrópolis: Vozes, 2001.

B. Schneider et al., “An experimental toolbox for advanced interactive learning environments.” 2012.

available at <http://tecfa.unige.ch> accessed in 05/22/2017.

R. L. Secco and M. H. L. F. Silva, “Proposta de um ambiente interativo para aprendizagem em Libras gestual e escrita”, **Anais do XX SBIE**. Fortaleza, 2009, pp.30-40.

F. F. Serres and M. V. A. Basso, “Diários virtuais – uma ferramenta de comunicação social para a autoria e aprendizagem de matemática”, **Anais do XX SBIE**, Fortaleza, 2009,p.50-58.

T. S. A. Silva and M. A. Bolsanello, “Atribuição de significado à escrita, por crianças Surdas e usuárias de língua de sinais”, *Educar em Revista. Ed. Esp.* N.2, p. 129-142. 2014.

C. Skliar (Org.) The state of the art of bilingual education. 3rd ed., 2 vol., Porto Alegre: Ed. Mediação, 1999.

R. L. Silva, Ambiente Aprenda Libras Web. 2002. Dissertação de Mestrado. Federal University of Alagoas – UFAL, 2002.

SignSmith. 2009. VCom3D. Available at <http://www.vcom3d.com> Accessed in 22/05/2012.

W. C. Stokoe, “Models, Signs, and Universal Rules”, *Sign Language Studies*. v.1, n.1, 2000, pp.10-16, Gallaudet University Press DOI 10.1353/sls.2000.0006

K. Strobel, As imagens do outro sobre a cultura surda”, Florianópolis: Editora da UFSC. 2008.

V. Sutton, “Lessons in SignWriting”, La Jolla, CA. 2006. Available at: <http://www.signwriting.org> Accessed in 10/05/2017.

K. Svartholm, “35 anos de educação bilíngue de surdos – e então?”, *Educar em Revista. Ed. Esp.* N. 2, p. 33-50. 2014

J. E. R. Tavares et al. “Uma aplicação para o ensino de Língua Portuguesa para Surdos usando o SensorLibras”, **Anais do XX SBIE**. Fortaleza, 2009, pp.78-90.

L. S. Vygotsky, *Mind in society: the development of higher psychological processes*. MA: Harvard University Press, 1974.

O. Wrigley, *Deaf policies*, Washington: Gallaudet University Press. 1996.

**Copyright Disclaimer**

Copyright for this article is retained by the author(s), with first publication rights granted to the journal. This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).