

Using Computational Resources on Bilingual Deaf Literacy: An Analysis of Benefits, Perspectives and Challenges

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Abstract. Various educational strategies have been explored on deaf literacy education. In bilingual deaf literacy, students learn two languages: first a sign language followed by a written language. This paper investigates the use of computational resources to improve bilingual deaf literacy. A study was performed in the context of the Literacy Project of the Baptist Church in Santana, Amapá, Brazil. It explored the use of technological resources in four activities with students from public schools. Results highlight the difficulties that arise from a lack of knowledge of written language. The article also presents design recommendations for Web projects that focus on learning activities and discusses perspectives and challenges.

Keywords: Accessibility · Computational resources · Deaf · Brazilian sign language

1 Introduction

Many people with hearing loss have serious difficulties learning a second language [1] due to teaching strategies that do not properly explore visual experiences to enhance learning. Some authors (e.g., [3] and [7]) emphasize the importance of taking into account cultural artifacts in studies of deaf education, in particular their visual experiences...

In the context of this work, we understand visual experiences as the use of vision (visual perception) instead of hearing (auditory perception) as a means of communication [6]. The deaf culture is based on visual experiences that influence their mode of being, expressing and experiencing the world. Usually, visual experiences are expressed by means of a sign language [2]. Consequently, it is necessary to provide

deaf learners with educational strategies that recognize linguistic differences in the way that deaf people access knowledge.

Bilingual (and bicultural) deaf literacy education is highly recommended because it promotes learning in two languages: a sign language (L1) as the first and highest proficiency language, and a written language as a second language (L2). For example, in the Brazilian context, the L1 is Libras (Brazilian Sign Language) and the L2 is Portuguese (written) language.

Studies in education point out that the use of pictures is a valuable pedagogical resource for both hearing and deaf students. Visual resources are even more important for deaf students by the fact that they require many images to learn their first language [4], and to understand the context of the world around them. Thus, professional training and teaching materials must be supported by images/pictures. They can serve as a direct reference to the meaning of words and concepts [7].

The hypothesis of this study is that by providing design solutions that are able to explore visual resources through interaction models, computers can effectively support deaf bilingual (and bicultural) literacy education. These solutions can also associate textual content with representative images. According to Marschark et al. [5], the combination of verbal/writing information with visual resources substantially improves learning and content retention.

In this context, we analyzed the importance of computational resources for supporting bilingual literacy education. This analysis included how the resources contributed to student learning performance, as well as teacher training. In particular, we focused on alternatives to encourage the autonomy of deaf students in the use of computational artifacts and to explore the Web as an educational resource. The paper also points out the difficulties raised during a set of activities performed with deaf students.

This study was performed in the context of the Literacy Project (*Projeto de Letramento*) of the Baptist Church in Santana, Amapá, Brazil. It used technological resources available in the computer labs of public schools in the state of Amapá-Brazil.

During the sessions, a researcher was responsible for assisting a teacher in the preparation of each activity. This researcher monitored the activities by observing the students' achievements and their main difficulties. The teacher reported on the students' performance during each activity, as well as the difficulties in accessing the Web and using the text editor.

This article also presents a tabulation of the researcher and the teacher observations according to key categories that identify the main student achievements, their difficulties, and the role of the computational resources employed during the performed tasks. The paper ends with a discussion about perspectives and challenges related to the use of computational resources for supporting deaf literacy courses and other disciplines.

This paper is structured as follows: the second section presents important facts about deafness and bilingualism in Brazil; the third section reports how the study was designed and executed; the fourth section discusses the results and challenges, and presents a set of design recommendations; and the fifth section concludes the paper.

2 Deafness and Bilingualism in Brazil

According to official statistics, there are approximately 350 thousand (totally) deaf citizens in Brazil.¹ However, even after the publication of the law 10.436/200,² Brazil is still a monolingual country regarding sign language [1]. This law recognizes Libras (Brazilian Sign Language) as a national language with the same status as Portuguese (the national oral language).

In recent years, deaf education in Brazil has been progressing from oral based education to bimodal bilingual education [1], where Libras is the L1 and Portuguese is the L2. Despite Libras' legal status, as well as its importance to deaf communities, there are still recurrent problems regarding deaf literacy in L2. These problems result in rudimentary skill acquisition in L2, so that bilingualism in Brazil is far from ideal. This situation is associated with many factors, one of which is the way both languages are presented to deaf students. Many educators argue that the bilingual learning process should occur at the proper age, presenting L1 and L2 at the same time [1].

In addition, current research highlights the importance of deaf students' contact with technology on all levels. In accordance with [8, 9], among other studies, we argue that information technology can be used to support the deaf students' learning process. The main contribution of our paper is to present an experimental study with deaf students that leads to a set of high level interface design recommendations.

3 Study Design and Execution

This section details how the study was planned and performed. Section 3.1 presents the context of study and the profile of the participants, and Sect. 3.2 describes the practices and activities performed with the students.

3.1 Context and Subjects

The activities with the students were performed during two months within the context of the Literacy Project, however the entire project took a year to complete. All the activities with the users were performed in groups: two groups of 8 students and one group of 7 students. The activities were assisted by a researcher and a teacher. The teacher selected the groups according to the education level of the participants in order to provide a better understanding of the students.

The activities were selected by the researcher in consonance with the teacher's lesson plans in order not to interfere with the pedagogic content. The teacher had the role of evaluator, taking into consideration the students' previous knowledge and adjusting the expectations accordingly. Table 1 presents the basic profile of the participants in the study.

¹ <http://www.ibge.gov.br/home/estatistica/populacao/censo2010/default.shtm>.

² http://www.planalto.gov.br/ccivil_03/LEIS/2002/L10436.htm.

Table 1. Participants of the study

No.	Name	Age	Education level	Leave of hearing loss	Use Libras	LIP reading
01	T. E. S. P.	27	Secondary	Profound	Yes	No
02	J. L. C. O.	19	Secondary	Profound	Yes	Yes
03	A. S. N.	29	Secondary	Profound	Yes	No
04	M. P. R.	13	Primary School Student	Profound	Yes	No
05	J. K. S. O.	15	Secondary	Profound	Yes	No
06	R. S. O.	14	Secondary	Profound	Yes	Yes
07	R. C. A. S.	18	Secondary	Profound	Yes	Yes
08	A. V. C. S.	12	Primary School Student	Profound	Yes	Yes
09	R. A. S.	16	Primary School Student	Profound	Yes	Yes
10	E. S.	15	Primary School Student	Profound	Yes	No
11	H. F. R.	18	Secondary	Profound	Yes	Yes
12	D. S.	27	Secondary	Profound	Yes	No
13	A. O. B.	29	Graduate	Profound	Yes	Yes
14	D. R. C.	29	Secondary	Profound	Yes	Yes
15	J. C. S. B.	21	Secondary	Profound	Yes	Yes
16	A. A. C.	20	Graduate	Profound	Yes	Yes
17	N. S. P.	17	Secondary	Profound	Yes	Yes
18	E. S. S.	20	Secondary	Profound	Yes	Yes
19	M. M. C.	29	Secondary	Profound	Yes	Yes
20	A. J. S. B.	29	Secondary	Profound	Yes	Yes
21	R. S. C.	30	Graduate	Listener	–	–
22	R. C.	29	Graduate	Listener	–	–
23	C.A.B	29	Graduate	Profound	Yes	Yes
24	T. A.G	19	Secondary	Profound	Yes	Yes
25	A. D. R	21	Secondary	Profound	Yes	Yes

A total of four literacy activities were performed with the users. During these activities the students answered questions written in the Portuguese language (L2) by searching the Web and using a text editor. Each lesson was based on activities that magnify language barriers, including: fill out a form, shop online, read a text and search for unknown words/concepts, interpret a text on a blog, and write a summary review.

The researcher provided support for the teacher during the execution of each group activity. The researcher also observed and reported on the students' major difficulties from both her own point of view and that of the teacher. The report included Web accessibility problems, problems using the text editor, and teacher *feedback* about the performance of the students during the development of the activities.

3.2 Execution of the Practices

This section briefly describes the four practices performed with the students including the main results and important remarks.

First Practice: syllabic separation.

The objective of this lesson was to explore the phonology of L2. This aspect of language is difficult for the majority of deaf people to understand. Phonology is the study of how words are formed, how the speech sounds are structured in L2, and how to classify the phonemes in units capable of distinguishing meaning.

This activity was performed using a web site for teaching Portuguese³ which includes interactive games. The rationale was to make use of existing Web resources that are not especially designed for the deaf, exploring visual aspects that facilitate the improvement of the deaf students' vocabulary and also as a way to present new words and concepts.

During this activity each task was presented and explained using Libras. Then, the students classified the words according to their own understanding. The software tool allowed three attempts based on multiple choice questions, after which the students were shown the right and wrong answers. The student's progress was presented at the end of the activity. Table 2 presents a summary of activity 1, including the context, answers and remarks.

Table 2. Summary of practice 1

Activity 1	Syllabic separation (Grammar)
Objective	To answer correctly the separation of syllables.
No. of participants	25
No. of sessions	Three (3) groups selected according to the education level (<i>c.f.</i> , Sect. 3.1) participated of three sessions with two activities each.
When	The sessions took place on different days.
Duration	One (1) minute for each word, when they went to the next participant.
Task to be performed	Each PARTICIPANT answered a word, but everyone observed the answers. It was carried out as a test format.
Qty. of right answers	9
Qty. of wrong ans.	14
Equipment usage	They answered on a computer and the others observed. The teacher had to explain the meaning of the words in Libras before they use the computer.

Important remarks: they made more mistakes in long words and in situations where they did not know the word beforehand.

Figure 1 presents an example of a Web application used during the first activity. In Fig. 1a students were asked to divide the word into syllables; Fig. 1b presents the feedback for a correct answer; and Fig. 1c presents the feedback for an incorrect answer. In this application the words were randomly selected. Some words were

³ <http://www.soportugues.com.br>.

simple, and others more complex. The teacher supplemented the learning activity by exploring visual resources available on the Web.

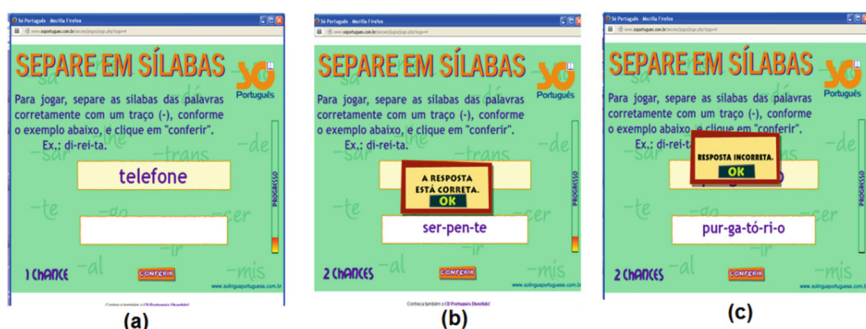


Fig. 1. Example of Web application used in the first practice (The entire set of tools can be accessed at: <http://www.soportugues.com.br/secoes/jogos.php>)

Second Practice: exploring writing

The second activity focused on exploring the Web using images to develop writing capabilities. During this task the participants searched for images and constructed phrases to describe them. The objective was to verify the deaf student's ability to compose sentences and to use the correct vocabulary. In this activity the participants had the support of a thesaurus integrated into the text editor. Table 3 presents a summary of activity 2, including the context, answers and remarks.

Figure 2 presents an example of student work during the second activity. Figure 2a⁴ presents a picture from the Web selected by a student, and Fig. 2b presents the phrase constructed by the student to describe the picture. This Figure shows a common problem in deaf literacy, which is the absence of connectives.

Third Practice: reading and interpretation

During the third activity the students elaborated a briefly summary of a text posted on a blog. First, the teacher explained how to correctly use connectives to give meaning to the sentences. Then, the students navigated on web blogs and wrote summaries of the posted texts. This task required knowledge about the grammar structure of L2. The teacher also emphasized the need to use and understand synonyms. Table 4 presents a summary of activity 3, including the context, answers and remarks.

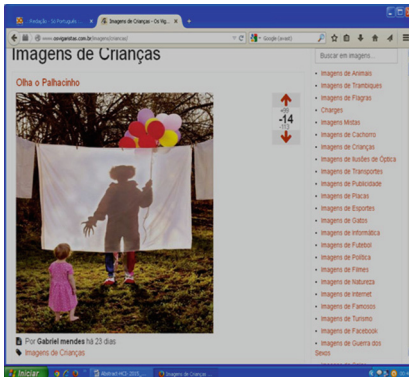
Figure 3 presents an example of text written by a student during the third activity. This Figure shows the common Portuguese expression "Pérolas Gramaticais"/ "Grammatical Pearls" used to denote inadequately used vocabulary in language constructions. The most common difficulties were related to the limited vocabulary and misunderstanding of the meaning of the words when grouped in phases.

⁴ This picture was recovered from: <http://www.osvigaristas.com.br/imagens/criancas/>.

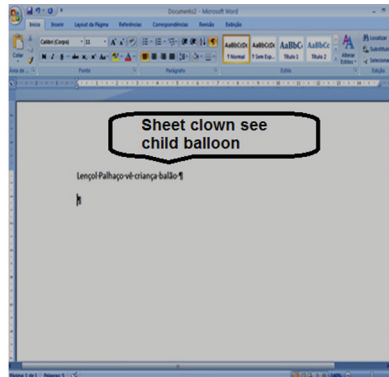
Table 3. Summary of practice 2

Activity 2	Exploring writing
Objective	Check writing and the use of connectives.
No. of participants	25
No. of sessions	Three (3) groups selected according to the education level (<i>c.f.</i> , Sect. 3.1) participated of three sessions, with two activities each.
When	The sessions took place on different days
Duration	There was no time restriction. Each participant performed the image search and then presented the phase and the image to others.
Task to be performed	Each PARTICIPANT did the web search individually, and then wrote up a phrase about the recovered ima-ges.
Qty. of right resp.	1
Qty. of wrong resp.	23
Equipment usage	Each participant used a computer, after that they shared the results with others.

Important remarks: the most frequent difficulty was the wrong application of the connectives. Only one student made the correct use of connectives in all sentences.



(a)



(b)

Fig. 2. Example of activity on the second practice

3.2.1 Fourth Activity: Writing and Understanding

In the fourth activity the students were asked to complete a register on the Web. Each participant searched a website and tried to fill in the required fields. The teacher explored the use of a dictionary integrated into a text editor and web search scenarios. Table 5 presents a summary of activity 4, including the context, answers and remarks.

The majority of the students managed to complete the register, however all of them had difficulties filling out the form. None of the students were able to complete the

Table 4. Summary of practice 3

Activity 3	Exploring the reading and interpretation
Objective	Check text understanding and writing skills.
No. of participants	25
No. of sessions	Three (3) groups selected according to the education level (<i>c.f.</i> , Sect. 3.1) participated of three sessions, with two activities each.
When	The sessions took place on different days.
Duration	There was no time restriction, everyone did the reading and wrote the text and then presented the activity to the others.
Task to be performed	Each PARTICIPANT navigated on a web blog. After that they drew up a short text. It was an individual task, however after each participant shared the result with the group.
Qty. of right resp.	1
Qty. of wrong resp.	23
Equipment usage	Each participant used a computer, after that they shared the results with others.

Important remarks: they had frequent difficulties in the words they did not know the meaning in Libras.

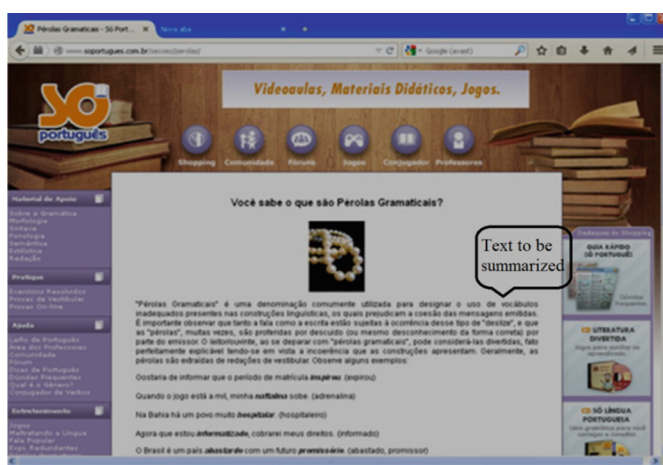


Fig. 3. Example of activity on the third practice (<http://www.soportugues.com.br/secoes/perolas/>)

entire process without teacher support. However, the researcher noticed that sites with easier questions and good field descriptions were easier for the participants. All the websites used in this practice were constructed according to accessibility principles.

Table 5. Summary of practice 4

Activity 4	Exploring writing and understanding
Objective	Verify understanding of words and text writing on web form fields.
No. of participants	25
No. of sessions	Three (3) groups selected according to the education level (<i>c.f.</i> , Sect. 3.1) participated of three sessions, with two activities each.
When	The sessions took place on different days
Duration	There was no time restriction, everyone did a search on a site of interest and then performed a registration with no time restrictions.
Task to be performed	Each PARTICIPANT explored sites of (s)he personal interests and then performed a registration.
Qty. of right resp.	16
Qty. of wrong resp.	8
Equipment usage	Each participant used a computer.

Important remarks: the most frequent difficulty was is related to the interpretation of polysemous words. The students usually knew only a single meaning for each word.

4 Discussions Over Results

As mentioned above, all the activities with the users were performed in groups, under the supervision of a teacher. According to our results and teacher remarks, the main difficulties were not related to the use of the technology itself. The difficulties were mostly related to poor understanding of L2 including: the difficulty to understand words that were not previously presented in Libras, and the difficulty to construct well structured phases.

Despite the observed difficulties related to literacy deficiencies, all the participants were able to perform all the activities using the proposed technological resources. Therefore, the study pointed out the possibility of using the Web to teach L2. Simple mechanisms and tools, which were not necessarily designed to support learning, provided valuable resources during the activities. These tools can be explored by the teachers by associating the L2 to images and visual representations.

This study is limited in terms of group size (24 students and 1 teacher), quantitative results, and number of activities performed. Consequently the results cannot be considered as conclusive. However, it presents evidence that leads to high level design recommendations for Web projects that focus on supporting learning activities in L2, as those presented in this work:

- Simple design with straightforward information;
- Minimalist design focused on the information need to solve a problem;
- Use images to contextualize the problems;
- Game-based tools can be explored to teach L2.

The recommendations aim to produce accessible interfaces for deaf users, where the technology can support and improve the attractiveness of L2 education. In addition, the teacher and researcher noticed that all the participants frequently use mobile technology to communicate using text messages in L2 (despite their limitations). Thus, mobile technology should be also explored in further applications.

This work contributed to verifying the potential of computational resources in support of bilingual deaf education. However, a challenge remains to design pedagogical studies to improve the use of these tools, for example, to contribute to teacher education, to encourage student autonomy, and to better explore the nature of WEB imagery as a teaching resource.

Visual literacy should also be explored more deeply as, unlike the hearing, the deaf first interprets the visual aspects of words and then associates meaning. Computational resources can be important tools in this process if explored at the “ideal age”. Tools specially designed for children learning at “ideal age” can potentially represent important advances in the deaf literacy rates. However this demands expressive efforts on both pedagogical and interaction design studies.

5 Conclusion

Proponents of deaf bilingual education advocate learning two languages simultaneously, a sign language as the first language and a written language as the second. As an additional learning tool, technological resources can potentially serve as an inductor of deaf bilingual education. In this paper, we explored the use of computational tools (including Web tools and text editors) in educational activities with deaf students. The activities explored syllabic separation, phrase construction/writing, reading and interpretation, and writing/understanding of L2.

Results highlighted that deaf students made good use of the technological resources during the execution of the activities. The results pointed out that the difficulties arose from lack of knowledge of L2, and, consequently, new learning processes as well as design strategies should be explored in future work. As next steps, we propose to conduct detailed studies to determine the influence of design issues on students’ performance, explore new pedagogical strategies using technological resources, produce a detailed design recommendation set, and construct and evaluate prototypes based on these recommendations.

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