IT Education Strategies for the Deaf
Assuring Employability

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Abstract: IT related jobs present a good opportunity for better paying positions for people with disabilities (PWD). Online training seems to be an interesting approach, due to its reach. Building and delivering online content for this population is challenging, especially for those who are deaf or hearing impaired (DHI). We face many problems in the process of teaching the DHI student. Initially we have language related issues, the vocabulary of the Brazilian Sign Language (Libras) is poor when it comes to specific content such as IT. Then, we confront the problem of having very few tutors versed in Libras. Content format, how can we present the information to the DHI considering visual aspects? Accessible learning objects, accessible programming environment, online collaboration between DHI and Non-DHI. Real word task analysis are all discussed in the current text. We present a series of studies our lab conducted and is conducting as we create and deliver IT online content for the PWD.

1 INTRODUCTION

Brazil has 45 million people with disability (PWD) and 9.7 of them are deaf or have hearing impairments (DHI) (Census, 2010). Government projects with the aim of promoting educational and social inclusion of this public, the educational process, the professional field and world knowledge are deficient (Santiago, 2011).

Software development market grows significantly in Brazil presenting opportunities for young programmers. The number of vacancies increased by 44.2% in 2015 and it is expected to increase 30% in 2016, despite current economic crisis (Zogbi, 2016). Jobs in technology present an opportunity to improve the lives of the DHI since there are many vacancies and training time is relatively short. IT courses are preferred 31% of young DHI (Santiago, 2011).

Distance education seems to be an interesting approach since the DHI (and PWD in general) are geographically distributed. However, implementing such online IT courses presents a series of hurdles such as:

1. making the learning management system (LMS) with the appropriate accommodations available;
2. implementing means of improving sign language lexicon, ensuring the existence of specific vocabulary in IT using Libras (the brazilian sign language);
3. creating content in the appropriate format so that it is accessible to PWD;
4. creating tools to access untreated data, process and make them accessible;
5. promoting collaboration between tutors who are not proficient in sign language and the DHI pupils; and
6. improving productivity in the workplace.

This paper succinctly describes our studies on each of the topics listed above, each one is dealt with in its respective section which appears in the order listed above.

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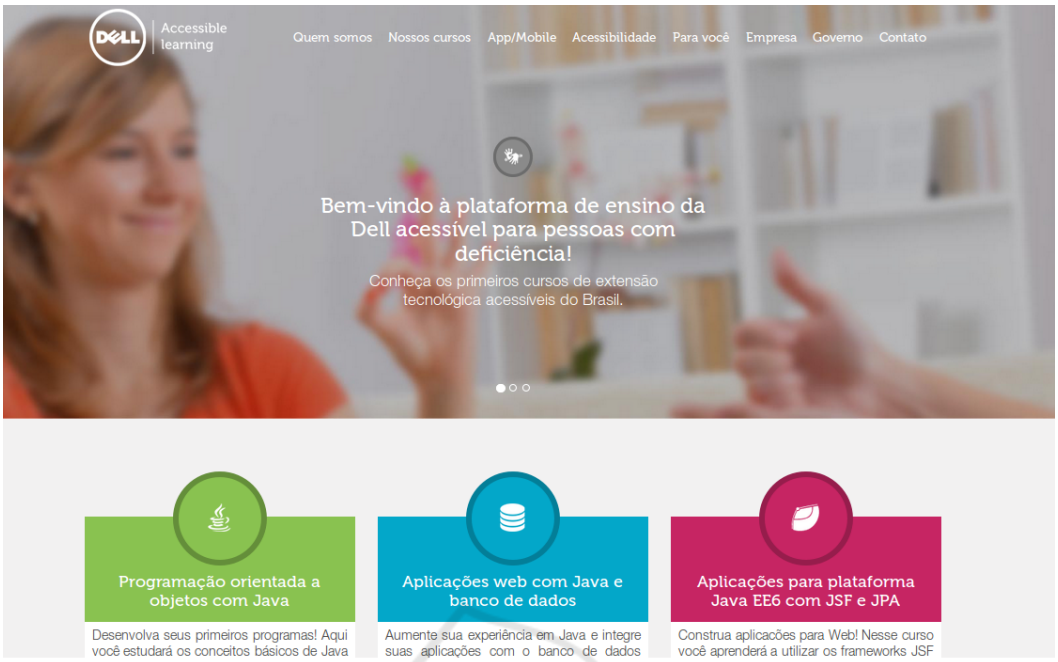

Figure 1: Our Accessible Learning Management System.

2 THE LEARNING MANAGEMENT SYSTEM (LMS)

Using a learning management system (LMS) is essential to provide e-learning. Some advantages of its use are:

1. it facilitates access to learning content;
2. it allows the support of classroom teaching; and
3. it gives a way of offering courses to a larger number of people.

Among the LMS available, two stand out: *Blackboard Learn* (Bradford et al., 2007), a virtual learning environment developed by Blackboard Inc; and *Moodle* (Dougiamas and Taylor, 2003), an open-source software learning management system written in PHP.

Since our target audience is the PWD, we needed a fully adapted and accessible tool, an LMS that meet the criteria of accessibility and usability since its inception.

Our laboratory designed our own accessible LMS, showed in Figure 1, and, through it, we create and offer seven IT related distance learning courses: Introduction to programming logic (70h), Object-oriented programming with java (120h), Developing applications for web platform with java and database (150h), Development of applications for java platform EE6 with JSF and JPA (140h), Mobile application development with Android (160h), Oracle database administration (120h) and Project management – preparation for PMP and CAPM certification (130h). Our online courses offers over 1,400 practical online activities.

Although this text is focused on DHI online IT learning, the LMS has accommodations for those with physical disabilities and people with low vision. Courses are also offered free of charge for those under social vulnerability (low income, living in areas of high crime rates) under a government supported program.

All the content is presented in portuguese and Libras. The system also has an ergonomic interface with shortcut for quick access, voice commands, text font adjustment and high contrast. All didactic materials and tools are validated and tested by a team of 50 software testers, all PWD or DHI before made available to the general public. Thus, the artifacts created are enhanced with a focus on the end user, so that the student receives a quality material, tailored to their learning needs. (Júnior et al., 2014)

3 IMPROVING SIGN LANGUAGE LEXICON

As Libras is a young language, its lexicon is relatively

short, notably in specific areas of knowledge such as mathematics and IT. The lack of signs to convey basic concepts like ”abstraction”, ”RAM memory”, for instance, must be overcome before any content creation.

Both in Brazil and in other countries, there are many collaborative web tools for the deaf. The Dicta-Sign Wiki (Efthimiou et al., 2012), funded by the European Union and developed with universities and research institutes, has the goal of making online communication more accessible for the deaf users. They work with the translation of terms in four sign languages: the British, German, French and Greek Sign Language. The Claws (Martins, 2012) is a collaborative tool to support interaction of deaf in web pages. Developed by the Polytechnic School of the University of São Paulo (USP) and installed as a complement to the web browser, it consists of several features that help the deaf user to understand words contained in the web pages. The ASL-Stem forum (Bigham et al., 2008; Cavender et al., 2010) is a web and collaborative tool for the purpose of disseminating terms and encouraging the growth and use of the American Sign Language (ASL).

The creation of signs from co-present discussions involving instructors, translators and the DHI can lead to regionalism, which might hinder their acceptance by members of other DHI communities throughout the country. A way to combat regionalism is through the asynchronous collaborative creation of signs, normally supported by web tools. But are the signs created through web discussions inferior in any way to those created via co-present discussions? We performed a comparative study on the acceptance of signs created by both methods showing that acceptable and legitimate signs can also be produced using web discussions and the users can not distinguish from which method they come from (Oliveira et al., 2015).

We selected some deaf participants with similar profile, they are all graduate and most of them had finished their graduate courses. The participants are students of the IT area and the majority of them code in Java. They were divided into three groups.

The first and second groups, A and B, performed tasks related to the creation of signs in a counterbalanced within-subject design. We worked with ten (10) terms, at the end of the creation, each term had two signs: one created in person and the other one using a web tool developed by our lab.

We also defined a third group C which performed a blind analysis of the signs created by Groups A and B. We asked Group C to vote which of the two signs they think it is better to represent the term. We

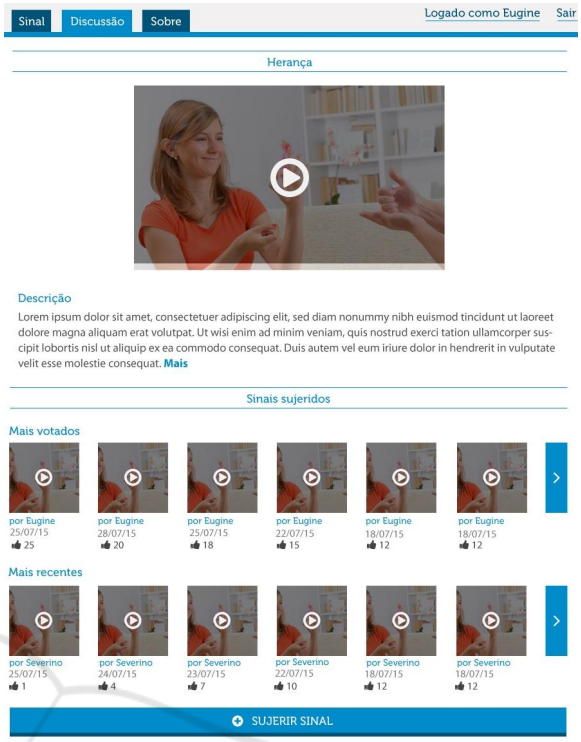

Figure 2: Description of the Term and Suggested Signs.

applied the results to the Student's T-Test, the two-tailed p-value obtained was 0.3009. Thus, we can conclude that the deaf can not distinguish the origin of the signs, and the two processes produce equally acceptable signs by the same community.

Figures 2 and 3 show the discussion page of our web tool for the creation of signs.

The participants can debate about what should be the best sign for a term. The tool has a wiki-like format and its layout and functionalities were validated and tested by a team formed by DHI and non-DHI.

First, in Figure 2, a description of the term is presented in Libras and Portuguese. Right below the suggested signs for the term are displayed. Any participant can propose a sign, and others users can vote in what they consider a good sign. The sign with more votes is elected the sign for that term.

There is also a discussion section, as we can see in Figure 3, where participants can send comments and exchange ideas, these comments can be sent in text or in video. Elected signs are cataloged into a technical glossary and used throughout course lessons.

The signs created integrate a glossary shown in Figure 4. These signs are also used in the process of creating signs.

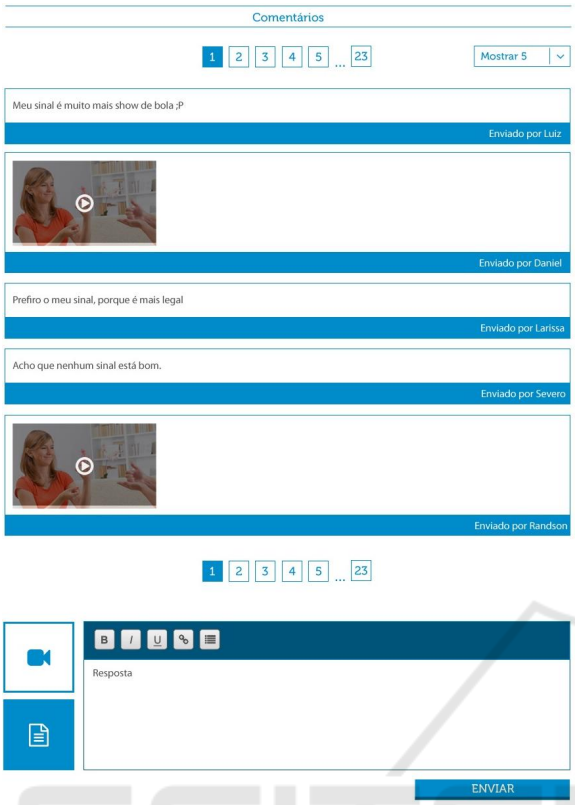

Figure 3: Discussion Section

4 CREATING CONTENT

The existence of educational material for DHI is also deficient. In this context, the creation of accessible content is essential to facilitate the learning process of this public.

A methodology for creating content involving a multidisciplinary team is a way to standardize and ensure the quality of the content.

Each of our seven courses is composed by a set of lessons comprised of:

1. a web lesson, disposed in HTML format;
2. a Learning Object (LO) to visual programming, also called Visual JO2 (da Silva Soares et al.,);
3. a practical activities workshop;
4. a video lesson; and
5. evaluative activities that make up the student's grade.

All activities on the LMS are accompanied by trained tutors in Libras and subject matter experts (Gonçalves et al., 2015).

The first phase involves planning and creation of the theoretical content of the lessons. Before content creation, pedagogues draw up an educational plan with various aspects of the teaching and learning of the DHI. After that, the teaching staff write the web lesson content. Then, the instructional design team review, revise and deliver it to each team responsible for each LO. This flow safeguards the content coherence between all generated LOs.

The second phase relates to the production of the material itself. In this phase, the first step of the video classes production process is the creation of the slides to be used in the recording video and its script to be followed during recording. A subject matter expert produces the first portuguese version of the lessons.

Then, a Libras translator inspects the artifacts and generates and produces a Libras version of the lesson. The instructional design team adjusts format and sequence and then designers create the appropriate images and animations to be inserted into the slides.

After the material to record the video is done, a subject matter specialist and the translator record the video class.

The instructional design staff analyze this new artifact and report to them some pedagogical improvements and amelioration to Libras translation and the lesson is deployed to the LMS for the review of our PWD team.

The video lesson accessible to the DHI is designed to prioritize the sign language communication.

The Figure 5 shows two sections of a video lesson, the opening at the top and the content at the bottom. The DHI students turn their attention during lessons to the sign language translator. The instructor appears in video only at the beginning and end of each lesson. Along lessons, content is displayed in the form of slides and code demonstrations in the development environment. The translator is the main actor and is shown along all video (Gonçalves et al., 2015).

5 CREATING TOOLS TO ACCESS UNTREATED DATA, PROCESS AND MAKE THEM ACCESSIBLE

In the last section, we've described the process of content creation. It is easy to understand that it is not a cheap one, although quality is assured. We investigated means to automatically translate texts in Portuguese and present them in an intermediary language, closer to Libras, but still in textual format, in gloss notation.

Figure 4: Glossary.

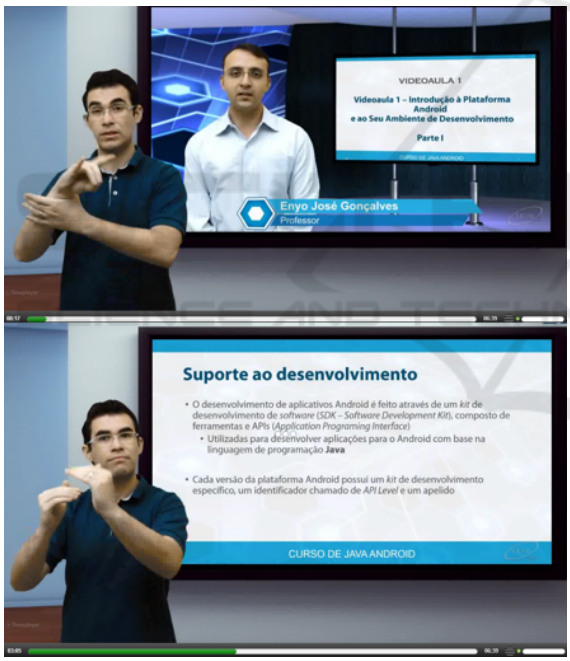

Figure 5: Sections of a video lesson (Gonçalves et al., 2015).

Among some related works we can mention the *PorSimples Project* (Aluísio and Gasperin, 2010) which offers a set of tools designed to perform text adaptations for low literacy readers. It has text simplification tools, such as: SIMPLIFICA, which helps authors to create simplified texts; FACILITA, which explores summarization tasks by simplifying web content. Another tool that translate texts in Portuguese to facilitate understanding of the deaf is the *LIBROL* (Carvalho et al., 2013). The software recognizes and discards the particularities in Portuguese that are not found in Libras.

We built the STAUT-Reader, a Rule-Based Machine Translation system to produce output texts in Gloss notation (De Oliveira et al., 2015). The STAUT-Reader consists of two modules: the translation and the reading module. The translation module is responsible for receiving input sentences written in Portuguese and translating them to Gloss notation. The reading module is responsible for displaying the translations to the users.

We performed a counterbalanced within-subjects design to evaluate the reading performance of DHI readers using our tool. The results showed to be promising, especially for non-oralized deaf. The experiment consisted of answering questions about texts. The participants were randomly assigned in two groups: A and B. For members from group A, the even-numbered texts were presented in gloss notation, and the odd-numbered texts were presented in Portuguese. The B group members had access to the same texts in the opposite version. Our participants also had different profiles: Non-Oralized and Oralized. The results indicates that the STAUT-Reader most benefits the Non-Oralized group.

The experiment was divided in three stages. In Stage 1, we evaluate the perceived difficulty of the texts using a 5-point Likert scale, all texts presented in gloss notation were better assessed than the versions in Portuguese. In Stage 2 and 3, we evaluated the number of correct answers. We ran one-way Anova at a 95% confidence interval on the data collected. Although there is not a significant statistical result in Stage 2 ($F_{3,40} = 0.2633, ns$) and Stage 3

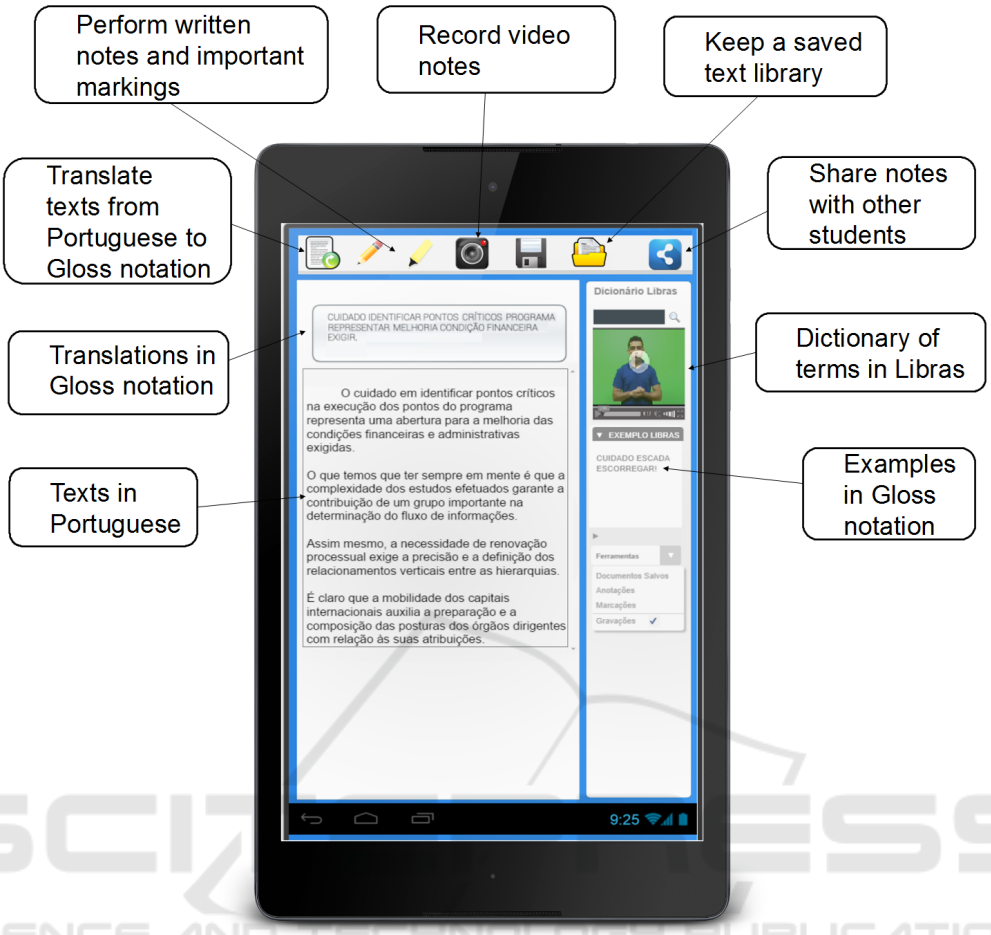

Figure 6: STAUT-Reader.

($F_{3,40} = 0.7869, ns$), there is a trend that might benefit non-oralized readers.

The tool evolved to became a mobile reader integrated to the LMS. Students can choose which format they prefer to access lessons content: Libras video, Portuguese Text, or Gloss notation. In this new version, students will able to collaborate, annotate and share their notes, and lesson writers will become aware of which lesson parts raise more doubts and improve them.

The Figure 6 shows the STAUT Reader screen in a tablet, still under construction. The superior toolbar contains seven buttons which allow users to: translate texts from portuguese to gloss notation, write short notes, highlight parts of text, record video notes, save the indexed notes, search and open a saved text library, and share notes with other students. Below the toolbar there are two columns. The left column shows at the top of the translated text to gloss notation and at the bottom, the original text in Portuguese. The right one has a Libras dictionary, an area to show examples in gloss notation and a toolbox to show or hide the user markings on text.

6 PROMOTING COLLABORATION BETWEEN TUTORS WHO ARE NOT PROFICIENT IN SIGN LANGUAGE AND THE DHI PUPILS

DHI dropout rates in online java programming course are staggering, especially during the course's first lessons. We developed the JLoad, an e-learning object designed to smooth the learning curve of a remote deaf Java learner.

There are some other works which aim to facilitate learning a programming language. *Hands* (Santos et al., 2011) is a computer program, similar to an integrated development environment (IDE) where pupils can learn programing logic. It was not intended

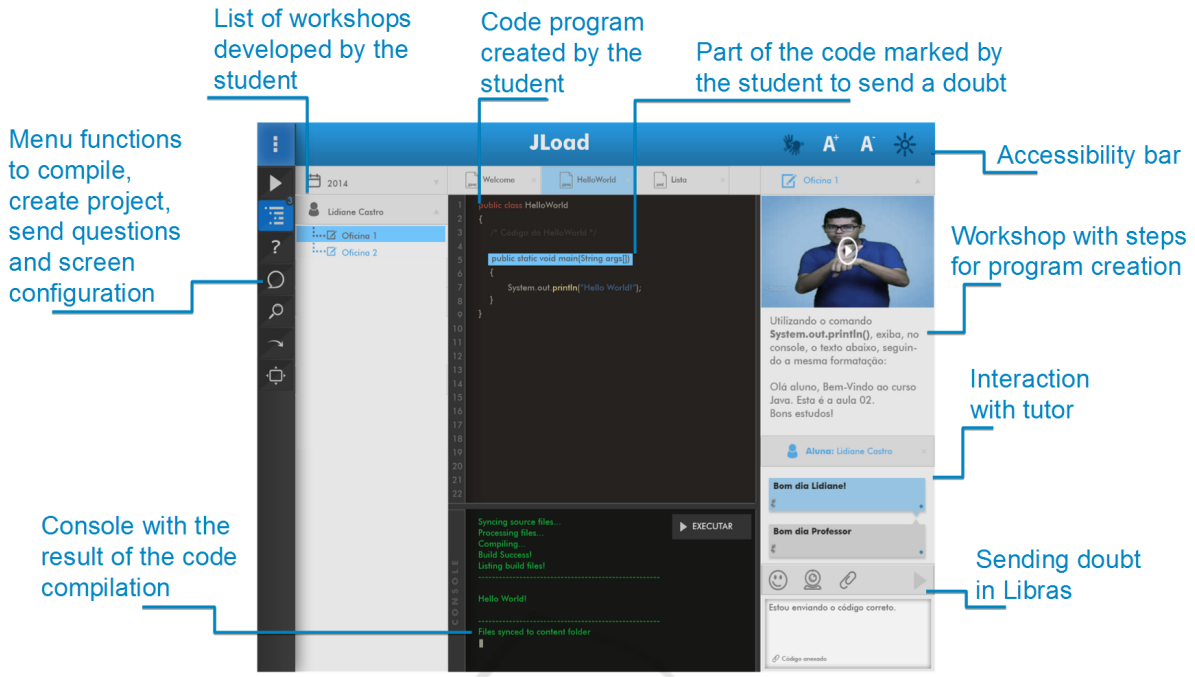

Figure 7: JLoad - Student View.

design for distant learning nor for asynchronous collaboration between pupils and tutors. Visual programming, as proposed by tools like *iVProg* (Brandao et al., 2012), has an interesting appeal for the deaf community, since they heavily rely on visual communication. *iVProg* has not been adapted for PWD.

The *Learning System* (LS) (Drigas et al., 2005) is a distance learning platform especially designed for the deaf. LS focuses on a bilingual education and, to our knowledge, has not been used for teaching a programming language to DHI.

JLoad has a simple IDE and collaboration tools to enable asynchronous and remote situated student monitoring and assistance. Such collaboration involves student, tutors and translators.

We presented JLoad's prototypes to a community of deaf programmers and tutor for early validation (Silva et al., 2014). From their suggestions we improved the prototypes and we created an all-in-one solution which prevents the learner to install and learn how to use an integrated development environment such as Eclipse before running her first program.

The JLoad was created supported by theoretical concepts: Using the theory of language acquisition, from Krashen (Krashen, 1982), we designed a LO to:

1. soften the learning curve;
2. offer the possibility of continuous monitoring;
3. increase student self-confidence and motivation; and
4. decrease the level of anxiety.

Situated learning concepts influenced the design of the situated tutor/pupil interaction where a shared workspace is also used. Armed with Csikszentmihalyi's flow theory (Csikszentmihalyi, 2008), we propose a LO together with the appropriate course syllabus to adjust course workshop demands to students skills for user experience maximization by keeping them in the flow zone.

With the original proposal at hand, we decided for the early involvement of the community of users for concept validation and acceptance assessment. Key-users not only confirmed the need for such intervention but also presented important contributions: all the participants agreed that the videos in sign language to describe the workshops' tasks are indispensable; all agreed that the proposed LO improves their experience in distance learning; they also asserted that the Eclipse IDE should have some of the features presented in the JLoad. Among the contributions, we have:

- Subtitles must be used whenever there is not a clear translation to sign language (e.g..: calculations and diagrams);
- Students might capture screen to submit along with inquires;
- Workshop steps written in text will have hyperlinks to the sign glossary (a glossary where terms

related to computing are described in sign language);

- To export JLoad's workshops to Eclipse IDE;
- Subjects also proposed many other widgets arrangements that were promptly incorporated to the tool.

The use of participatory design technique, involving members of the community proved to be extremely useful for early assessment of key concepts and validation of the main features of JLoad.

Figure 7 shows JLoad's chrome and highlights its main functions. It is now an integrated development environment embedded in our LMS that allows collaboration between tutors and pupils. Such collaboration may ou may not be mediated by Libras translators.

7 IMPROVING PRODUCTIVITY IN THE WORKPLACE

We've seen that it is not enough to train to secure a position in the workplace for the PWD. Our graduates still struggle to secure a position in IT industry. This is especially true for the DHI. There is the fear they will not match the performance levels of the hearing counterpart. Therefore the challenge extends to that of task analysis and design.

We are interested in empowering the DHI programmer in the daily tasks of a regular software engineer, such as software evolution, debugging. We have learned that DHI graduates from our courses had inferior performance in debugging tasks when compared to hearing counterparts who took the very same courses (do Nascimento et al., 2014). This first study consisted in finding and correcting one error in two Java classes. All the participants (non-DHI and DHI) used the Eclipse Debugger to perform same study tasks. The main idea of the experiment is to compare the way the two groups performed each task. Basically we measure the time spent to complete the task, the number of requests for assistance and if they successfully complete the task. The DHI had poorer performance and some were not even able to finish the tasks, despite the fact that no there was no time constraint.

As a response, we investigated the use visual debuggers and direct manipulation. Visual debuggers might represent hope for improving the performance of the DHI programmer.

There are some software which uses some visual concepts or some ideas of direct manipulation. *Jeliot 3* (Moreno and Joy, 2007) is a tool designed for pupils to learn procedural or object-oriented programming. Students can develop and see the visual representation of a running code. On the other hand, the tool has too many visual information presented at once and that might confuse the deaf student. *Jive* (Cattaneo et al., 2004) is a tool developed by the University of Buffalo. It allows debugging Java programs using views of object structure and interactions between methods. It uses the object diagram that demand prior knowledge, which can generate DHI greater cognitive effort. *JGrasp* (Cross et al., 2004) is an IDE developed to provide dynamic and illustrative views of Java data structures. These views are generated automatically and synchronized with the data structures in the source code. It uses the technique of direct manipulation of objects which made it stood out from the others.

In our second study (do Nascimento et al., 2015), we compare how a visual debugger (JGrasp) impacts the activities of a DHI programmer. Ten participants were recruited to debug code in Eclipse and JGrasp, in a between-subjects design. In that study, all subjects used industry-standard Eclipse programming environment.

Performance was measured by:

1. Time to complete the task (TCT);
2. Number of times the subject asked for external help assistance (HA) and
3. Number of tasks completed successfully (TCS).

Despite the fact that subjects were already familiar with Eclipse, the results, although not statistically significant, favor JGrasp as a more productive tool. The participants were able to finish more tasks demanding less time using JGrasp. A questionnaire based on the System Usability Scale (SUS) (Brooke, 1996) was also applied. The average SUS score for JGrasp was 72 and 50 for Eclipse. The *unpaired t-test* give us a *p-value* of 0.01, thus we can conclude that JGrasp has a better usability. Qualitative analysis indicates that JGrasp was more acceptable due to presenting visual appeal and better distribution of functionalities.

Debugging is just part of the many activities a software developer is involved. The findings reported here just encourage further investigation. There is lot to be done. One thing is sure: We have to intervene in the workspace to improve productivity of the DHI programmer. How far should we use vision is a tricky question. Vision is over special resource for the DHI and we should avoid overloading it. We will carefully design a visual debugger for the DHI, having that in mind.

8 CONCLUSIONS

Online IT courses present good opportunity for the PWD/DHI to gain access to better paying jobs. However, building content, delivering them to this special population impose significant challenges. For the adult DHI, language barriers are everywhere:

1. in the lack of signs;
2. in the lack of subject matter specialists versed on Libras;
3. in the fact that programming languages are languages in on themselves (normally derived from English), one more in this language cauldron and
4. in the lack of appropriate methods and materials which leads to poorer academic formation.

Beyond language barriers, tools are not appropriate: IDEs, debuggers, LMSs.

Throughout the sections above, we briefly showed how we tackled several of these issues and the impacts of our interventions. Each section described one research effort, each one in different stage, but all with clear and attainable goals. Our ultimate objective is twofold: 1) to prepare the PWD for the job market and 2) to convince employers to hire them. To achieve them, we are building tools that improve the learning experience and assure productivity in real-world tasks.

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