# AN INTERNET-BASED TOOL FOR KNOCKING DOWN DEAF CHILDREN BARRIERS TO LEARNING

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## Abstract

Learning to read and write is extremely difficult for deaf children because these two activities are based on verbal language. The hearing impairment prevents deaf children from being exposed to oral language, so that they are unable to acquire the verbal language through a natural process like hearing peers. Moreover, the educational intervention they are exposed to, seems to not help the development of global comprehension ability. Considering that deaf children have specific needs and that they are visual learners, we have developed an innovative Internet tool which should improve their reading comprehension skills.

*Keywords -* literacy and deaf children, games for learning.

## 1 INTRODUCTION

### 1.1 Literacy and deaf children

The word literacy refers to the ability to read and write at a level that lets one understand and communicate ideas in a literate society, in order to be part of that same society.

Literacy skills are fundamental both for academic success and for future achievements in the professional world. Moreover, it is claimed that reading and writing skills do influence the functional organization of the adult human brain [1].

Learning to read and write is extremely difficult for deaf children because these two activities are based on verbal language, which is definitely not deaf people's natural/first language [2]. As their hearing function is severely or even completely compromised, they cannot acquire the oral/verbal language in their first years of life in a natural way as hearing children do and this causes a considerable delay (3 - 5 years) in their language/literacy developmental patterns as compared to hearing peers [3]. If we consider that nine out of every ten deaf children are born from hearing parents who do not know sign language and who have no experience or knowledge of the deaf community, it is obvious that the linguistic experience of such children is, in most cases, extremely poor and sketchy. They lack that naturalistic, frequent and consistent exposure to language that is the fundamental requirement for language development. The results of this pitiful situation can be clearly seen in the many difficulties deaf children have in writing and even in reading. At a lexical and inferential level, they dispose indeed of a limited vocabulary which is strongly connected to their everyday context. This has two consequences: on one side, the way in which concepts are interconnected in deaf children's long-term memory could be very different and even "wrong" as compared to the conceptual maps of hearing children [4]. On the other side, deaf children are less able in categorization and generalization tasks [4, 5]. Much obviously, they also have difficulties in understanding idiomatic expressions, metaphors and allegories [6].

Some studies further affirm that, while reading a text, deaf pupils tend to focus on the comprehension of isolated words or single sentences, thus loosing the global view of the text [7, 8]. They often reason on isolated words or chunks rather than trying to relate (distant) concepts in written texts. This attitude partly depends on the kind of "literacy interventions addressed to deaf children" which prefer to "focus

on single sentences and the grammatical aspects of text production" [9]. As a matter of fact, deaf pupils' educators often propose writing and reading tasks based on single words and sentences, but this procedure risks to compromise the development of global and inferential comprehension ability [8, 10, 11, 12].

Besides all these aspects, which mainly pertain to vocabulary and basic linguistic knowledge, another cause of unfruitful reading can be traced back to the difficulty of deaf readers to apply their linguistic knowledge with sufficient automaticity to quickly retrieve the meanings of printed words from their mental lexicon. Experiments on deaf readers have indeed suggested that "low automaticity is an explanation for limited comprehension in this population" [13].

## 1.2   Some literacy tools for deaf children

The big challenge for those who are involved in deaf children's education is to understand their specific needs and, above all, to exploit their abilities as *visual learners.* Understanding that deaf pupils are not the same as hearing ones just not only because of their disability, but because of their different (linguistic) experiences and because of the differences in the content and in the organization of their conceptual knowledge [4] is fundamental. From this point of view, information technology (IT) techniques can help teachers "maximize opportunities" for deaf pupils "to use their ability to see in developing their literacy skills" [14] and to make reading practice stimulating. High memory capacity, visualization abilities, hyperlinks techniques as well as sophisticated artificial intelligence techniques can be used to build new effective educational tools able to improve deaf pupils' abilities.

Hereby, we briefly review some literacy tools for children based on story-telling. Some of them are specifically designed for deaf children.

In order to facilitate the integration of a deaf girl into an Italian primary school, her teachers and peers created *Fabulis* [15], a collection of famous fables for children narrated through text and images. These stories are also told in Italian Sign Language (LIS).

A more ambitious project is *Tell me a Dictionary* [16], which purpose is to offer both deaf and hearing children an interactive and enjoyable instrument, enabling them to discover and compare Italian with LIS.

Among non-Italian projects, it is worth mentioning *CornerStones* [17], a project developed at the Carl and Ruth Shapiro Family National Center for Accessible Media (NCAM). *CornerStones* is based on a technology-infused approach to literacy development for early primary children who are deaf or hard of hearing. One of its essential elements is a story taken from the PBS's literacy series Between the Lions, integrated with versions of the same story in American Sign Language and other visual-spatial systems for communicating with deaf children.

Another interesting project aiming at improving students' literacy is the Foundations to Literacy (FtL) project [18, 19], developed at the Center for Spoken Language Research (CSLR, University of Colorado) in collaboration with other research centres. FtL has not been developed specifically for deaf or hard of hearing children, nevertheless this group of users has also been taken into account. FtL consists of three integrated components: a Managed Learning Environment (MLE) that tracks and displays student progress and manages an individual study plan for each student; Foundational Skills Reading Exercises, which teach and practice basic reading skills, such as alphabet knowledge and word decoding, providing the foundation for fluent reading; Interactive Books, which represents the state of the art in the field of integration of human language and animation technologies to enable conversational interaction with a Virtual Tutor that teaches fluent reading and text comprehension. The final evaluation of FtL produced significant learning gains in letter and word recognition for kindergarten pupils. Among the cited projects, this is the only one using Artificial Intelligence techniques.

## 2.   DESIGNING A TOOL FOR DEAF CHILDREN

Designing a tool for deaf children is a most difficult task as deaf subjects have unique and highly variable linguistic biographies and characteristics [20]. The different degrees of deafness, the role and mother tongue of the family (cfr. the massive migrants' flows), the competence (or not) in sign language, the type of educational intervention, etc. prevent to identify a sort of "prototypical user", neither from a linguistic nor from a technical point of view. Nevertheless, we tried to single out some general features and guidelines that should help creating a useful literacy support tool for deaf children.

As already stated before, deaf children are reading disabled ones, they have some special educational needs but are also excellent visual learners. In order to ameliorate their status of poor readers, they need to practice reading, as practice is the critical ingredient in automation [21]. Nevertheless, the material on which to practice must have some specific features. 1) Texts must be written in a clear and simplified form, 2) they must not be too long, 3) they must have a pleasure or interest component (i.e. children's stories and or stories with which the child can identify himself). Moreover, in order to capture and sustain the child's interest, the recourse to ICT technologies, drawings and short game exercises seems to be the best solution.

## 2.1 LODE (Logic-based e-tool for DEaf children)

The development of LODE (Logic-based e-tool for DEaf children) started as a PhD project at the Free University of Bolzano-Bozen (FUB) [22]. The idea is now carried on by a consortium which involves the Fondazione Bruno Kessler (FBK) [23], the European Academy of Bolzano (EURAC) [24], the Abbattimento Barriere della Comunicazione (ABC) and FUB. It was born with the purpose to realize an Internet tool for improving deaf children's reading comprehension and, in particular, the comprehension of the temporal relations between the different events of a story.

LODE presents two groups of stories – one for children from 8 to 10 years old and one for children from 10 to 12 - the child can choose between. The stories are enriched with explicit temporal relations so as to draw the attention of the child to temporal events and relations. Each story, whose length varies between 150 and 250 words, is presented split across different pages as a storybook for young children. The syntactic structure has been simplified: we preferred main clauses and direct discourse; the subject has been made explicit in every sentence. The vocabulary has been compared to a frequency lexicon [25], in order to avoid unusual words. However, we also selected a list of words from the stories that, in our opinion, could be of difficult comprehension for deaf children and we will include them in an online dictionary linked to LODE so us to guarantee the highest level of comprehensibility. Although we had to simplify the texts, we tried to maintain certain fluidity so that the children won't be too much bewildered when facing a "normal" text. In order to stimulate the reader's attention we will provide some drawings which should also help to further characterize the characters of the stories. Moreover, we chose different kind of stories: the ones for younger children are animal tales while the ones for older children have children as main characters. Our purpose, in proposing different stories, is to arouse the interest of two groups of children who could be very near in terms of language skills, but who are rather distant in terms of interests and stimuli.

In order to verify if the child has understood what he/she has just read, we developed a few practice exercises disguised as games whose main aim is that of stimulating the child to reason on the story in its entirety and on the temporal relations in the text.

For a technical description of LODE, see [26, 27].

## 2.2 LODE's Games

LODE's exercises/games follow a progressive logic. As deaf children are first of all visual learners, the system proposes to them a first game based on drawings which illustrate the crucial events of the story: the child is required to put the drawings in the right temporal order. This task should help him/her to verify if they have correctly understood the story's development and to approach the textual games which follow.

In the comprehension exercises, the child has to build the correct sentence that reconstructs a temporal event of the story, choosing among three different adverbs or conjunctions (i.e. *the duck sits on its eggs* (AND) THEN/WHILE/BEFORE *four yellow ducklings are born*.). This should implicitly ameliorate both the child's temporal reasoning ability and his/her comprehension and mastery of the linguistic means that transmit temporal concepts.

When the child gives the correct answer, the system provides a positive feedback (Fig.1 on the left), whereas when the child gives a wrong answer, the system invites her/him to retry (Fig. 1 on the right). We paid great attention to create a positive, enjoyable atmosphere, as we are perfectly aware of the difficulties LODE's users have and of the danger of frustrating them. We therefore tried to follow Csikszentmihalyi's lesson [13] in providing clear goals, in giving immediate feedback to one's actions and in balancing the challenge of the task with the children's skills, so that they won't fear mistakes.

Fig. 1. LODE: comprehension exercises.

As a further challenge, we also planned the implementation of some production exercises (see Fig. 2) based on temporal relations. The system proposes a set of three or six events independent from the stories of the LODE's database, that the child can relate to one another, using adverbs or conjunctions he/she has learnt reading the stories and playing the comprehension games and invent his/her own e-stories. This should help the child fixing the acquisition of temporal concepts through practice.
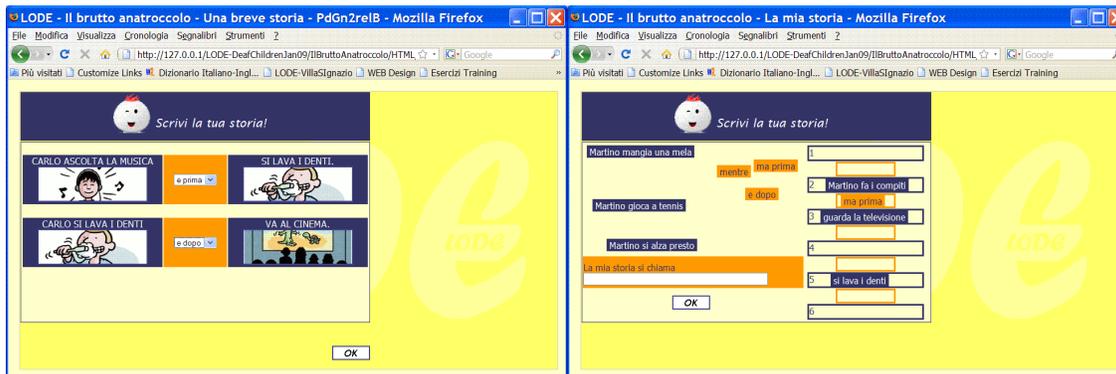

Fig. 2. LODE: production exercises.

## 3. FUTURE WORK

As already said, the impossibility of determining a prototypical user – who does not exist – exposes us to the risk of proposing contents and exercises/games which could be too easy or, on the contrary, too difficult for our audience. Meeting with educators and experts and testing LODE with deaf children are the only ways to refine the instrument. A prototype of LODE has already been evaluated with hearing and deaf children [28]. These tests highlighted some questions related to the behaviour children adopt while playing the comprehension games, which are currently based on the 'multiple choice' paradigm. We observed that the children tend to choose casually the right answer to give, without really referring to the read story. In order to avoid this casual-answer-pattern, we are actually reflecting on developing new games, not based on the multiple choices paradigm, but with dynamic – changing components (i.e. images and/or parts of text) which should prevent the child selecting the same answer. Dynamicity and scoring techniques should help capture the child's attention and stimulate him/her to reason before giving the answer. As future work, we are going to check the pedagogical effectiveness of the last LODE's version with deaf children in order to realize a tool which really helps knocking down the existing barriers to learning Italian.

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