DELE framework: an innovative sight on didactics for deaf people

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Deafness is a "hidden" problem, which is only partially considered in the design of interactive tools. The e-Learning Environment DELE proposes an answer by exploiting the mechanism of conceptual metaphor, in particular the "learning story". In this way DELE creates an environment for a "friendly" learning, which is strongly based on the visual channel, through the use of a structural iconicity of navigation.

1 Introduction

Nowadays, the problem of *literacy* acquisition by deaf people still remains poorly understood. As a consequence, the design of e-Learning environments is often deficient in addressing the needs of this group of users. In fact, because of their sensory deficit, deaf people develop serious difficulties in verbal language, both written and oral. These people are mainly "visual", and exploit a kind of organization and interpretation of the information by multilinear and global packets, albeit scanned sequentially in time. In Sign Languages (SLs) this characteristic has been recognized in certain components of linguistic production, defined as Structures of Great Iconicity. These are individual productions of signs in which meaning is encoded in a simultaneous and multilinear way (Pizzuto *et al.*, 2010). In this sense, a "literal translation" from / to a SL is a very difficult task: one cannot assign to each sign a textual "gloss", except for representing the standard form of the sign, which is often far from its variations in the real use.

The e-Learning environments could certainly represent a valuable resource for deaf users, as the use of these tools is based on the visual channel. In contrast, however, accessibility strategies currently exploited (such as those published by the W3C[1]) do not take into sufficient account the complexity of the problem of deaf users. They only require the inclusion of video in SL as an alternative to the text. On the other hand, there is the further problem that not all deaf people, who are born in hearing families, learn their national sign language in early childhood. They often undergo a long speech therapy, to educate them to lip reading and to vocal only production. Nonetheless, even this group of people develops similar difficulties with verbal languages. Therefore, these difficulties seem more related to deafness itself than to the use of sign languages.

Our studies have convinced us that the learning problems related to deafness, require to rethink the interactive strategies that are implemented in e-Learning. This work explains our approach in this regard.

2 Related works

Research on digital environments for teaching deaf people does not seem at a satisfactory level yet. In e-Learning, SL seems to be the main accessibility tool: Signed Stories[2] project, for example, deals with the dissemination of stories translated into BSL (British Sign Language) and enriched with interactive material as cartoons, images, etc.. In Italy, the DEAL-TOI[3] project has dealt

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[1] http://www.w3.org/WAI/intro.wcag.php

[2] http://www.signedstories.com

[3] http://toi.deal-leonardo.eu/

with the development of an on-line language course related to corporate communication, where videos in Italian Sign Language (LIS) are used as text facilitation tools, along with some animations. An interesting approach is adopted in the TERENCE[4] European project, aimed at creating a learning environment for children (7-11 years) based on the use of interactive stories implemented through educational videogames. Another aspect of the research deals with the formal specifications for the Sign Languages in order to create signing avatars (Cox *et al.*, 2002). The SiGML notation system is one example (Elliott *et al.*, 2004). As a further example of problems addressed by present research, the ATLAS[5] project, developed at Politecnico di Torino, aims at implementing a system for automatic translation from written Italian to LIS, performed by an animated avatar.

3 Searching a new approach

The work presented here has been developed in the context of the VISEL[6] project, during which we have thoroughly analyzed the state of the art of the research on e-Learning and deafness. The aim was to ensure that the approach would meet the real needs of the target group. In keeping with the findings, we abandoned some research lines (such as the implementation of signing avatars for automatic translation of texts in a SL), because they are still at a level that does not satisfy the needs of the deaf population. Deaf people require interactive tools that enhance their communication resources, encouraging a full use of them. For this reason, for example, deaf people do not consider as "interesting" present animations that attempt to reproduce the dynamic of the signed message, but which are not able to fully render the expressive wealth of SLs. Moreover, as already discussed, we cannot use SL as the only tool towards accessibility, due to the presence of the group of non-signing deaf users. Finally, there is an issue regarding the "foundation" of the frameworks that are normally adopted. Within them, the organization of information is fully textual, or has a table structure in which each element (links, maps, videos, etc.) is encoded primarily through the written language. In our view, this setting represents the first "wall" in front of deaf people that potentially hinders a real accessibility of e-Learning environments. In fact, if the virtual path itself becomes a barrier for the user to the use of the system, this is likely to burden the cognitive load even when just surfing the environment. This fact produces serious consequences for the motivation. These obviously also affect the moments when the difficulties which actually underlie the learning goal should arise, i.e. when the user is

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[4] http://www.terenceproject.eu

[5] www.atlas.polito.it

[6] http://visel.cnr.it

faced with the learning texts. The cited TERENCE project is the only one that seems to partially take this consideration into account, but it is designed only for children. In order to address such issue we investigated a coding model to represent information through channels which are primarily non-textual, while guaranteeing the integrity of the content.

4 Using the metaphor for teaching

In a previous work (Bottoni *et al.*, 2011b), we discussed of "sensorial criticality" to describe those contexts in which teaching lacks a concrete and bodily reference, either due to sensory disabilities (such as deafness), or because of "abstract" educational contents (in math, for example). On the other hand, such a reference is what would allow an easy representation of the contents by the students.

In order to overcome the problems that arise in these contexts our model uses the theory of the Embodied Cognition (EC) (Johnson, 2007) applied to the design and development of interactive digital tools for teaching. The body is seen as the original space by which, through environmental interaction, the subject forms knowledge, first in the form of pre-verbal "schemes" (called image-schemes) (such as the "containment", the "balance", etc.), and then as conceptual elements. The mechanism of **conceptual metaphor** is seen as a basis to move from the pre-verbal schema to the conceptual knowledge, allowing to perform a "translation" of a domain into another while retaining the semantic structure of the first one. This tool can be used in a twofold context. Firstly, to show how all the ideas and concepts can be reconstructed as metaphorical buildings, which start from the concrete, and reach the highest modes of the human mind. On the other hand, in the design of interactive tools, the conceptual metaphor enables the design of graphical representations and interaction paradigms that recreate a metaphorical context following the semantic structure of the reference domain. We provide below some details of the first aspect above, when the conceptual metaphor is used as a teaching approach, and then discuss the second in the presentation of our e-Learning environment, in which the metaphor was used in both structural level and content management.

5 The metaphorical construction of abstract concepts

We can just use mathematics to provide a convincing example of the educational use of metaphor. In (Bottoni *et al.*, 2011a) we discuss the problem of the teaching methods that are normally adopted for this topic. We show that there is an "inexplicable" gap between the abstract world of "formal" objects, which are used in the explanations, and some basic concepts of mathematics

(for example in the domain of arithmetics), which would seem easy to refer to concrete experience and, therefore, should be intuitive and easy to understand. In our analysis we will show how the disclosure of the metaphorical path which is the basis for the formulation and construction of the mathematical language can be a key moment in the design of an appropriate teaching strategy to bridge this gap.

As an example, let's take the "typical" first lesson of mathematics at school: we try to give a definition of natural and integer numbers. The "Progetto Matematica" ("Mathematics Project")[7] of Bologna University, gives an accurate description of this topic, using a well standardized formulation. One might think that in such context few problems should arise, since it is sufficiently immediate to relate the topic with real life. Nevertheless, we read: *"We will think of a set as a "collection" of objects […]. The first set that we will consider is the set of natural numbers. It is denoted by letter N and its elements are the positive integer numbers […]: N = {1, 2, 3, 4, …}. In general, it is preferred to indicate the set of natural numbers with N excluding 0."*

This last statement may leave the student already dumbfounded: the possible inclusion of the number 0 within the set of natural numbers, in fact, may seem an entirely arbitrary decision. Actually, it is based on a precise logic that is driven by the environment that sustains the metaphorical explanation. What is done first, is to offer the student a specific metaphor, that sees a set as a **collection**, or as a group of "objects" that can be considered "similar" for some reason. It is evident (Lakoff & Núñez, 2000) that this metaphor relies on the intuition (or, in terms of EC, on the *image-schema*) of the containment, i.e. on our immediate ability to imagine a container, an object that allows to define some elements that are "inside" and others that are "outside". In this context we can imagine any number *n* as a collection containing *n* objects and, by extension, we can in turn put together these numbers-collections in a collection that contains them: the set of natural numbers. At this point, the student considers a "number" as simply a group of objects. But how to deal with a "group" consisting of nothing? Intuition leads us to say, in fact, that such entity *is not* a group, because it lacks the fundamental characteristic to be defined as such, i.e. the objects that compose it. So here is where the problems of the "number" zero arise within this metaphor, so we prefer to exclude it.

Going forward, one soon comes to describing the basic operations of arithmetic, and comes across the following definition:

"*Given two natural numbers n,m ϵ N, we call n – m that natural number x,* **if it exists**, *that gives n if summed to m. In other words: n – m = x if and only if n = m + x.*"

[7] http://progettomatematica.dm.unibo.it

Following the above, the possibility that the subtraction operation might be *not defined* is consistent with the given metaphor, in which a number is seen as a collection of objects: to have a collection with a negative number of elements is something that lacks of significance and, in fact, the subtraction operation in this case would represent the act of extracting from a group of *n* elements a number of elements greater than n. But, leaving implicit the reference metaphor, this possibility seems to be attributed to a characteristic "owned" by the object one is dealing with (the set of natural numbers) and the student must become convinced that, quite simply, subtraction is not always defined on that object.

This "dogmatic" attitude which is imposed to the learner, and which is already a warning of something educationally dangerous, becomes more serious when one introduces new concepts that are based on those already defined, such as integers: "*The second set that we will examine is that of integers. It is denoted by the letter Z [...]. We can think of Z as obtained from N by "adding" it a "new copy" of the numbers 1,2,3,... which differs from the previous one for that "-" sign placed in front of them [...].*" The intention, apparently innocuous, to continue using the metaphor of the collections of objects leads to a set that seems "out of tune" with the concreteness of the former. This is because in this case it seems more difficult to create a concrete representation of the "negative" amounts (if seen as groups of objects). Students are required to "extend" the metaphor, in the same way as imagining a bigger container, and to put inside a on one side the elements with an immediate concrete reference, and on the other side a "copy" of them which seems destined to be disconnected from the reality. Actually, it is possible to give the student an alternative to this by simply *changing the metaphor*. Figure 1 shows a representation of a different metaphor where numbers are considered as points on a path.
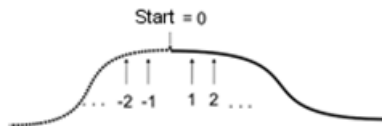

Fig. 1 - the metaphor of numbers as points on a path

This new model allows to accept in a natural way some concepts which are in contrast with the metaphor of the collections: zero, in this case, is simply the starting point of the "journey", and while going forward one meets the natural numbers, moving backwards means finding the negative integers. Interestingly, it is possible to establish a correspondence between this new metaphor, and one of the collections (by extending the latter through an operation of "meta-

phoric extension", as suggested by the above explanation), so it is possible to "translate" a model into another and to continue to use in a homogeneous way the context of the sets of objects also for integers.

6 DELE as a "learning story"

The main metaphor used in our system is one that allows to see a learning path like a **story**, or a sequence of events where the student is the protagonist. This is an educational application of the theory of **Storytelling**, where the user perceives itself in a process that can be "told" (Bruner, 1991; McDrury & Alterio, 2001).

Our Deaf-centered e-Learning Environment (DELE) is just an implementation of the metaphor of the "learning story" in an e-Learning environment. This metaphor allows to provide deaf people with a visual representation of the current learning path, to show them a clear common thread among the different educational experiences encountered. This is an important feature for our group of users since, because of their "visual" approach (and, therefore, naturally multilinear and parallel) to the mental organization of information, they may encounter difficulties in following the diachronic structure of the route. DELE was developed under the project VISEL, which is aimed at college-age deaf students in order to promote their ability to read-write. For this reason, the story that we decided to use as the general framework for the system deals with a university campus where the user is going through, being visualized in turn through a chosen avatar.

The metaphor allows to create a link between the concepts typical of e-Learning environments and the created metaphorical context: for example, the personal page of the student becomes his home in the campus, while the educational forum is the main square. Everything is rendered in an iconic way, while the text is presented only when it has an educational role. The iconic nature of the navigation system has been implemented through the use of two criteria:

1. Attention to the meaning that images are able to transmit, so to be able to use them even where the text is usually exploited (e.g., for the links)
2. Implementation of some image-schemes (containment, path) using animated graphics that make clear the relationship between the pages of the route: for example, a link can be represented by a container that "opens" showing the page it contains, or through a "linear shift" for pages one after the other (similar to browsing a book).

Our approach further shows how the adoption of a metaphor can imply a series of normal inferences, belonging to the current metaphorical context,

which can be used to enrich the source domain (the e-Learning environments). In our case, if one accepts that a learning course is represented as a story, it is immediate to imagine that a teacher should be able to "tell" the story. To this aim, the graphical editor **StoryEditor** was born (Figure 2).
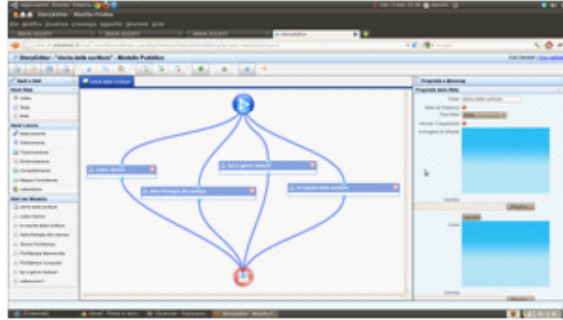

Fig. 2 - a screenshot from StoryEditor

In this editor, each page of the course is represented by a particular type of "node" that is placed along the path and connected to other nodes through graphic "cables". The nodes represent each type of element that can be inserted into a learning story (texts, videos, activities, etc.) and each node has its unique characteristics (title, content, an image that represents it in the path, etc.). For the publication of the path, the description of what was created (represented through a JSON string) is passed to a script that takes care of generating the code for the Web pages that make up the course. At the end, the course generated and running is shown the teacher (Figure 3).
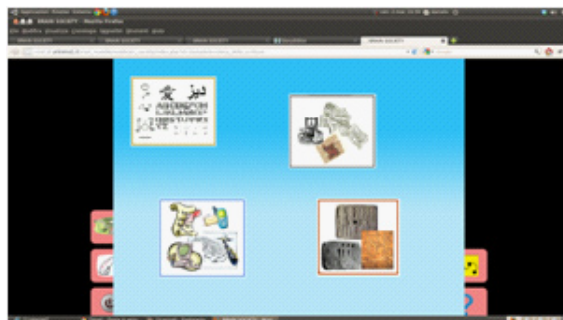

Fig. 3 - a screenshot of a course generated by StoryEditor

Figure 3 shows the output of the generation of the story defined by StoryE-

ditor and shown in Figure 2.

In literature, one can find other editors which are based on the model of "learning story", StoryTec[8] allows defining interactive applications which are based on the structure of a story. At present, it works only offline and does not allow collaborative story creation. As an alternative, YouTell[9] is an online system to create and modify through a bowser simple stories in "slide show" fashion. The StoryEditor in DELE is different from these examples because it is fully browser-based, and allows the collaborative creation of interactive educational paths with features which are strongly addressed to generate environments fro deaf students. To this aim, we performed a research activity with a group of experts in teaching to deaf people, in order to develop specific tools to facilitate the use of the paths and of learning contents. As an example, in order to provide an enrichment of texts and an aid for the most problematic points, we developed the "box" technique, by which it is possible to link pieces of text and images to an arbitrary set of additional resources (such as images, videos, ecc.)(Figure 4).

Fig. 4 - an example of educational "box"

As shown in Figure 4, the icon of a character wearing eyeglasses allows the student to see through "special lenses" which reveal the points to click to access additional material. If the user needs help about elements which are not present in the facilitation, it is possible to act on the text by inserting comments to ask for additional information. In this way, we implement the metaphor of an *object to manipulate*, on which it is possible to actively operate to discover hidden meanings.

The educational content included in the current prototype of DELE refers to four learning units on "The History of the Scriptures." The choice of the topic is due to the will to take deaf people near to the writing world, by showing them

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[8] http://www.storytec.de

[9] http://vermeer.informatik.rwth-aachen.de:9080/YouTell

an approach allowing a new and more effective interpretation of the material.

Conclusions

A first experimental phase has been performed on DELE, involving a group of four tutors and seven deaf students. A following phase is presently running, with twelve students. In the first phase the students were observed in the classroom, by writing down in real time the encountered difficulties and mainly focusing on the usage of the path and of interactive tools. In the second phase we are focusing on the use of synchronous (chat) and asynchronous (forum and messages) communication tools in DELE, giving the students the task to freely navigate from home. In the first phase, about 80% of students was able to complete the learning activities with very little difficulties (maximum two attempts), moving through the learning path without effort, as reported in the performed interviews. We can consider that some fundamental barriers of accessibility of e-Learning environments had being overcome, and that the co-textual insights are a resource are being used in a fruitful manner.

We plan, in the progress of the work, to extend the system so to include courses on other topics. Using the tool of conceptual metaphor, in fact, we believe we can extend this innovative approach to teaching in diverse fields of knowledge.

REFERENCES

Bottoni P., Capuano D., De Marsico M., Labella A., Levialdi S (2011a), *Il problema della "qualità" nell'insegnamento della matematica: una proposta metodologica*, in: XXIV Congr. Nazionale Associazione Italiana di Psicologia. (Genova, 19-21/09/2011).

Bottoni P., Capuano D., De Marsico M., Labella A., Levialdi S. (2011b), *DELE: a Deaf-centered E-Learning Environment*, in: Chiang Mai J. Sci. 38, 2011, 31-57

Bruner J.S. (1991), *The Narrative Construction of Reality*, Critical Inquiry, 18, 1-21, 1991

Cox *et al.* (2002), *TESSA, a system to aid communication with deaf people*, in: Proc. Fifth SIGCAPH., ACM, pp. 205–212

Lakoff G., Núñez R. E. (2000), *Where Mathematics comes from*, Basic Books Ed.

Johnson M. (2007), The meaning of the body, University of Chicago Press.

McDrury J., Alterio M. (2002), *Learning Through Storytelling in Higher Education: Using Reflection & Experience to Improve Learning*, Dunmore Press

Pizzuto A. *et al* (2010), *Language Resources and Visual Communication in a Deaf-Centered Multimodal E-Learning Environment: Issues to be Addressed*, in: Proc. of 7-th Int. Conf. on Language Resources and Evaluation (LREC 2010), 2010.