# The Use of a New Visual Language as a Supporting Resource for People with Intellectual Disabilities

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**Abstract.** Our society is radically changing at an astonishing rate essentially, due to the fact that Information and Communication Technologies (ICT) are becoming an ever greater part of our lives. The frenetic rhythm at which the technology has evolved in recent years, has caused a significant separation between individuals who use communication technologies and those who don't. There is a technological gap, and most of the time it's because of the inadequacy both of the hardware and the software currently present for people with different levels of disability. This article discusses the use of a new visual language, known as VILA (VIsual LAnguage), to resolve the accessibility problems that people with certain types of disabilities have when they use ICTs to access to information and knowledge society and to communicate with other people under equal terms. We also present a first evaluation of a software prototype performed by a group of trainers specialized in children with Down syndrome to demonstrate their utility and the application fields of the language, as well as its advantages.

**Keywords:** Educational media/multimedia · Personalization and adaptation in learning technologies · Accessibility · Functional diversity · Intellectual disability · Visual language

## 1 Introduction

In recent years, Information and Communication Technologies (hereinafter ICT) have transformed the way in which we work, live and interact with others. There are many terms that have been coined in an attempt to identify and understand the scope of these changes. At the World Summit on the Information Society (held in a first phase in Geneva in 2003 and in a second phase in Tunis in 2005) two terms stood out among the rest: information society and knowledge society. And although the first of the two was used primarily at the meeting, the second currently seems to make more sense. In fact, the term has begun to be used in the plural form (knowledge societies) to reflect the different social, ethical and political dimensions; thus, rejecting the idea of a single model that does not reflect the cultural and linguistic diversity present in any modern society today [1].


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However, from the beginning of time, knowledge control has often led to a significant series of inequalities, exclusions and gaps which increase the existing differences between the rich and poor, industrialized and developing countries and even between the citizens of the same country. It is precisely the use of new technologies that has generated what is known as a "digital divide" which can be defined as the separation that exists between the people (communities, states, countries, etc.) that use ICTs as a routine part of their daily lives and those that do not have access to them or those that have access, but do not know how to use them [2].

As a matter of fact, the group of people in our society that is most susceptible to these kinds of inequalities is made up of individuals who suffer from certain types of disabilities or functional diversity which often times prevents them from accessing and using the information under the same terms as the rest of society.

Perhaps the discrimination that most affects this group is their lack of access to the various environments, products and services; and for this reason, terms such as "breaking down barriers", "design for all" or "accessibility" have come to be commonly used in reports, rules, technical standards, etc.

But, the concept of accessibility has evolved in parallel to the progress made integrating people with disabilities. At first, these people were treated as a group requiring protection and a distinct environment (an approach known as the "medical model"). Today, this approach has changed. Now, the trend is towards their normalized inclusion without discrimination (the "social model" approach and the principle of "equal opportunities") [3].

Therefore, a need to classify accessibility arises so as to approach the study and problems that appear in each individual case. This classification could be as follows:

- Architectural and urban planning accessibility.
- Transport accessibility.
- Information and communication accessibility.

For this research work, we will focus on the latter precisely because of the importance of information in today's society as mentioned at the beginning of the article.

When analyzing the problems that people with certain types of disabilities encounter when accessing ICTs, we run into two new terms: "e-accessibility" and "e-inclusion".

The concept of "e-accessibility" may be defined as the removal of barriers that older people and/or people with disabilities encounter when they try to access ICT products, services and applications.

The concept of "e-inclusion", which is broader and includes the other, is defined on the European Knowledge Society's website [4] as the strategy aimed at ensuring that disadvantaged people are not excluded from this society due to their lack of digital literacy or Internet access. This term also involves being able to make use of the advantages offered by the new opportunities generated by new technologies in the interest of the social inclusion of disadvantaged people and underprivileged areas.

On the other hand, it is important to acknowledge that the information society can provide more independence and opportunities to people with disabilities although they can also become even more excluded from access to information and participation in society than is currently the case if a series of fundamental rights such as the right to information is not respected.

The solutions to guarantee this access to information using ICTs for people with disabilities include very diverse resources which range from software adaptations (voice recognition, graphic and non-graphic interfaces, sign language translators, etc.) to hardware adaptations (switches, adapted keyboards, pointing devices, amplifiers for sound reception, etc.). These solutions are known as technical aids or support products; and United Nations Convention 61/106 on the Rights of Persons with Disabilities, which was approved in December 2006, establishes a general obligation for the signatory States to promote research and development, the availability and use of mobility aids, technical devices and assistive technologies that are suitable for people with disabilities.

This article is organized in the following way. The second section outlines the theoretical framework by explaining the accessibility problems of people with disabilities when using ICTs and describing VILA visual language. The third section describes the methodology used to do the research and describes the software prototype developed with the research. The experiment and results section analyzes some of the advantages of using VILA language with these types of systems that make it possible to improve communication and language use for people affected by certain types of disabilities. Finally, some of the problems that arose while carrying out the research are described and their solutions are provided in the discussion section. The article ends with some conclusions on the questions and objectives set forth at the beginning of the research work.

## 2 Theoretical Framework

### 2.1 Accessibility Problems for People with Disabilities

The use of new technologies also involves disadvantages for people with some type of functional disability for whom it is more difficult to access the information and knowledge society. The new information and communication technologies must be adapted to the individual needs of all groups of people with disabilities. Just as all citizens, these people have different needs and interests and the information and knowledge society can also provide different types of information, communications, knowledge and network creation for these groups. Thus, considering people with disabilities as a homogeneous group is discriminatory and does not take into account the capacities and possibilities of some individuals who, in some cases, simply need tools that are adapted to their needs.

Moreover, producing support products so that people with disabilities may access information requires technical and functional requirements in order for the final result to be effective. These requirements must include the official authorization and standardization of suitable technologies which must be based on knowledge, experience and technological development. All of the parties must be involved in their creation: the industry, users, professionals, etc. For this reason, in order to guarantee the participation of end users in the research and development of technological products and applications, this must be done by either including people with disabilities in the process of developing the new products or in the analysis of the users' real needs and the adaptation of the existing products as people with disabilities are the ones who best know what requirements these products must meet.

Therefore, if we wanted to classify the accessibility technologies available on the market, we would have to follow standard UNE-EN ISO 9999:2007 (Assistive products for persons with disability. Classification and terminology), which offers this classification in accordance with their function and consists of three hierarchical levels (classes, subclasses and divisions). However, we believe that this may be confusing for users as this standard frequently uses cross references meaning that the interested party is constantly directed to sections that are found in various parts of the document which can make it difficult to quickly and accurately locate a desired product.

For the particular case of people who suffer from some type of intellectual disability, we believe the classification based on promoting and stimulating intellectual capacities offered in the 2008 Study on Accessibility Technologies in Spain, published by the National Accessibility Technologies Center [5] is more appropriate. It includes four types of technological solutions or support systems; namely: memory development and training systems, reading and writing learning and support systems, sensory stimulation enhancement systems and language and communication development and training systems. The four types are related to cognitive skills learning, development and training.

For this research work, we focus on systems that enable improved communication and the use of language with accessibility technologies for people affected by intellectual disabilities. All of these systems are based on the use of symbols, graphics and images that are used to support natural language. Our objective is to improve these systems by using a new two-dimensional visual language instead of natural language which will help eliminate some specific barriers encountered by people with intellectual disabilities such as a difficulty understanding complex communication structures and accessing abstract concepts or a difficulty appropriately interpreting the symbolic language used on the Internet.

In this research we have focused on children with Down syndrome and their problems to use and learn natural language. Reading is a very effective way to help these children learn the language. The ability to read opens many doors to any child, but in children with Down syndrome the advantages are even greater. Reading helps them learn the concepts of language through their visual channel, thus avoiding other difficulties. Sue Buckley of Down Syndrome Education International has discovered that learning to read has positive effects on the tasks of spoken language, receptive vocabulary and memory. It advocates the use of visual processing and visual memory skills to support all learning [6].

Some children with Down syndrome begin using spoken words at the age of two, and some use speech before that age, but many will not begin to speak until they are seven or eight years old. In addition, a small percentage will never come to use speech as the main communication system. In these cases, it is necessary to use alternative communication systems, such as communication boards, so that children can communicate with each other.

## 2.2 New Visual Language: VILA

The research described in this article came out of a project developed by a research group which has been working in the Knowledge Engineering field for several years. A new visual language called VILA (VIsual LAnguage) was created within the context of this project.

The basic objective of Knowledge Engineering is to represent knowledge in a way that it can be automatically processed with a computer. But, knowledge is generated in natural language by human beings and in order to be able to automate it on computers, this knowledge must be represented in formalized structures. Transforming knowledge expressed in natural language to formalized structures requires a translation process. And the problem lies precisely with this translation process. In order to formalize knowledge, the translator (normally an expert or specialist in the field of knowledge that is to be formalized) needs to eliminate the ambiguities inherent in natural language, its lack of precision, the various meanings of the terms and its structural “vagueness”. There are no standards for this task. Each translator applies his/her own criteria and this leads to very subjective results. The structures formalized by one translator are not usually compatible with those completed by another [7].

After several years of reflection, we have reached the conclusion that it is necessary to eliminate the translation process that causes the aforementioned ills. Our proposal consists of generating knowledge directly in a formalized language - a language that is common to man and machine. And this represents a change in paradigm. The structure of this new language must resolve the problems of ambiguity and “vagueness” inherent in natural language. Let’s see how this objective is achieved.

VILA language grammar is based on the concept of linguistic expression. There are many types of linguistic expression, but all of them are constructed by grouping together the three basic types. These are: linguistic expressions of identification, linguistic expressions to describe characteristics and linguistic expressions to describe actions. Each linguistic expression is represented inside a rectangle. The rectangles are grouped into pages and these into documents [8].

For linguistic expressions of identification, it must be kept in mind that when the words of any given language are used to identify a concept or an object, only one form of this word - the most common - is used. Plurals are not used and there is no difference between masculine and feminine; this is only done when referring to living things that are differentiated by sex (i.e.: cow, ox, etc.), but gender is not assigned to objects or concepts. There may also be cases where the concept to be represented is comprised of several words although the identifier is considered to be unique. The words are then joined with an underscore. (i.e.: tooth_brush).

The second type of basic linguistic expressions is comprised of those used to describe characteristics. These are the expressions associated in natural language to the verbs “to be”, “to have” and a few others. There are many special features and major differences in these verbs between some languages and others. Verbs are not used in VILA to express the characteristics of something. Characteristics are always applied to one or more already identified elements using the corresponding linguistic expression (see Fig. 1). Characteristics are distributed into one of the following groups: adjective, value, relationship, space, time and adverb.

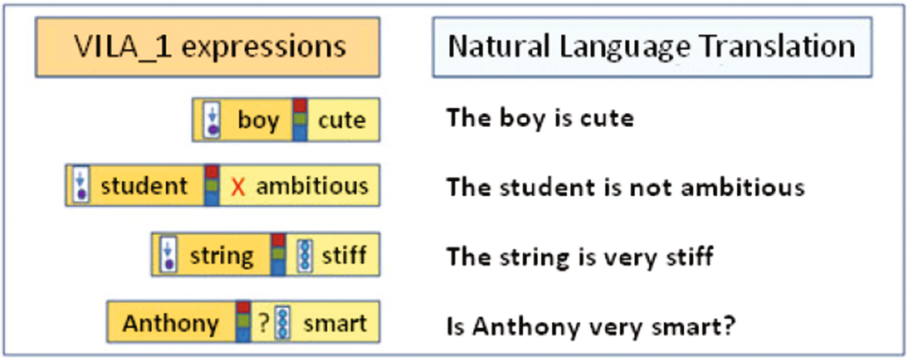


**Fig. 1.** Example of VILA language expressions and their translation to natural language.

The third group of basic linguistic expressions is comprised of those used to describe actions. They are expressions which are used to describe changes in the characteristics of a concept or entity. The main element of these types of expressions is the verb. The corresponding action is described with it. The verb is always expressed in the infinitive.

Both linguistic expressions that describe characteristics as well as those used to describe actions can be used to identify elements. Linguistic expressions of the same type can also be grouped together using "and" and "or" operators. This way we can easily communicate without the linguistic barriers that can be found in the use of natural language.

Furthermore, and given that the immense majority of man/machine knowledge transactions are via an electronic screen, the language must have a clear visual orientation. It is precisely this characteristic that makes this new language appropriate to be used as a support resource by people with intellectual disabilities, facilitating access to information by these types of users through the new information and communication technologies.

## 3 Methodological Framework

To corroborate this hypothesis, we have developed and evaluated a software prototype by adapting the linguistic structures of this new visual language to the picture communication symbols (PCS) that are often used in assistive products and are known as alternative communication systems. They have already been commercialized and tested by users with this type of functional diversity.

For the development of the prototype we have taken into account the recommendations of software engineering in terms of accessibility of computer applications for people with disabilities, especially when designing the interface. We have also taken into account the regulations concerning software adaptations that people with disabilities should use (see Table 1).

**Table 1.** Regulations on software adaptations for use by persons with disabilities.

| Standard | Title |
|---|---|
| AEN/CTN 139/SC 8 | Information and communication technologies for health. Systems and devices for later age and disability |
| UNE 1399801:2003 | Computer applications for people with disabilities. Computer accessibility requirements. Hardware |
| UNE 1399802:2003 | Computer applications for people with disabilities. Computer accessibility requirements. Software |
| UNE 1399803:2004 | Computer applications for people with disabilities. Accessibility requirements for content on the web |
| ISO/IEC TR 19766:2007 | Information technology. Guidelines for the design of icons and symbols accessible to all users, including the elderly and persons with disabilities |

In the application development process, we used the methodology known as "user centered design" [9], because as indicated above, users with disabilities are the ones who best know which requirements these types of assistive products must meet. We also took into consideration the principles of quality, usability and functionality in the software design and development process as we believe that the quality of software products is an ever greater concern in the field of information technologies and that this can make a major difference in a market with similar products. But, in order to be able to offer a quality software product, the focus must be on the entire lifecycle of the product and not just on the latter part. Thus, the process must begin with a thorough compilation of the customer's requirements and then final tests and finally, acceptance of the final product by the users once the software has been developed.

Two important terms must be kept in mind when ensuring the quality of the product throughout its entire lifecycle: verification and validation [10]. Verification checks that the product meets the requirements established by the user and helps ensure that the product is being developed correctly. Validation evaluates the product based on the user's needs making sure that the product fulfills the use for which it was created. In order to achieve these two objectives, tests, analyses and inspections have been carried out always with the collaboration of the end user - which in this case were people with Down syndrome (children between the ages of 7–10).

## 4 Experiment and Results

In this paper, we have tried to design a prototype digital communication board that will serve, as Basil and Puig [11] point out, to cover the full range of communicative functions in people with some kind of disability, allowing him to communicate with all kinds of interlocutors.

To achieve this goal, we have consulted with several educational psychologists and professionals who work with people with some type of disability and who have problems communicating with normality. We have also evaluated different software available in the market and that allow the development of communication boards, such as, Boardmadker, Plafoons, Sicla II and TPWIN. Apart from the high cost in most cases, they are usually proprietary programs and do not allow the export or use of some modules to other systems. All this, has led us to the need to create our own software with the advantages and disadvantages that this decision supposes.

The software is still a communicator prototype where, after choosing the language (Spanish or English) and the level of language (see Fig. 2), the user goes to the main panel where he/she can choose between the different pictograms and easily communicate.


**Fig. 2.** Prototype software home screen.

This main screen is divided into 4 areas (see Fig. 3). The first, which is on the left side of the screen, shows the seven categories into which we have grouped the different symbols. Each one of them is represented by a color. The first five and their respective colors correspond to the standards used in augmentative and alternative communication [12]. A new category called "Social Expressions" was added which groups together a series of commonly used expressions from a pragmatic perspective of language and includes salutations and farewells, asking about wishes and basic needs, requests for attention, expressing emotions and feelings, requests for information, etc. Also was added is a new category called "Nexus" in which are grouped the symbols corresponding to those elements that serve as union between words or phrases.

The area corresponding to the sentence the user goes about building by choosing the pictograms from the corresponding category is found at the top right (zone 5 and 6 in the Fig. 3). The pictograms appear in a third central area (zone 2) on successive screens each with a maximum of 24 pictograms.

The area corresponding to the actions the user can take, which are represented by buttons, is found at zone 4.

### 4.1 Evaluation of Software Prototype

Although we have worked with different professionals specialized in the training and treatment of people with disabilities, we have discarded the test phase with users with


**Fig. 3.** Main screen of the software prototype. (Color figure online)

intellectual disability (more specifically with Down syndrome) for two main reasons. First, the assessment instruments required by these tests (Stanford-Binet intelligence scale, Wechsler intelligence scale for children, visual perception development test, auditory and phonological discrimination evaluation and psychomotricity test) and suggested by the specialists themselves, escape our scientific knowledge. The same happens with the analysis of the results of the same. Second, the tests require the written consent of the parents of users with Down syndrome, prior information about the characteristics and content of each test.

Therefore, in the test phase the evaluation of the prototype has been carried out by the educational psychologists and teachers of the AmiDown Association[1]. The test involved three teachers and two educational psychologists with extensive experience (5–15 years).

One of the ways to measure the usability of a software application is to perform these measurements using specially designed questionnaires for that purpose. The main reason for these questionnaires is that it is possible to obtain concrete answers by providing verifiable data, for example, statistical studies. The most relevant questionnaires in this area are: QUIS (Questionnaire for User Interface Satisfaction), SUMI

[1] Down León Amidown, founded in 1995 by parents and professionals, is a non-profit organization whose purpose and object is the search and achievement of the full social integration of people with Down syndrome, guaranteeing the safeguard of their Rights in all Aspects of life (training, psychological, legal, labor, recreational, sports, etc.), helping these people and their families and raising awareness of society. http://www.amidown.org/.

(Software Usability Measurement Inventory), WAMMI (Web Site Analysis and MeasureMent Inventory) and MUMMS (Measuring the Usability of Multi-Media Systems).

In this paper we have decided use and a SUMI questionnaire, adapted and modified according to our needs. For this, we have defined several hypotheses to validate the software prototype. Each hypothesis is accompanied by a series of statements, which users evaluate according to the Linkert Scale (Strongly Agree, Agree, Undecided, Disagree, Strongly Disagree). Let's look at these hypotheses in more detail:

**Hypothesis 1: The Software has an Appropriate Level of Difficulty of Use**
This hypothesis aims to identify if users have the ability to use the software, and that does not have a level of complexity that prevents its use. For this, the following statements are made:

- I had no great difficulty working with the main interface of the application.
- I had no major difficulties performing the basic operations to open, save, print and exit the application.
- Going through the different categories of pictograms and choosing each one was easy for me.
- I had no major problems creating and modifying the sentences with the application.
- Sometimes I do not understand what I have to do.
- Overall, the app was easy for me.
- The application works correctly.

**Hypothesis 2: The Software Allows Functions that do not Allow Other Programs**
It indicates if the user has found that the software is useful and better than others already existing, and that allows him to perform operations that he had not achieved with other applications. The following statements are made:

- When it comes to creating reading and writing exercises for my students, I prefer this tool over others.
- To develop communication boards for my students, I prefer this tool over others.
- When I used the application I managed to perform tasks I had not been able to accomplish with other tools.

**Hypothesis 3: The Prototype Interface is Appropriate to this Type of Application**
Indicates whether the interface designed for the application is useful and usable.

- The interface is visually appealing.
- The user interface is intuitive.
- The interface responds quickly.
- It is difficult to find some options.
- The user interface is very static and not very customizable.
- The interface needs to be improved.

Once the hypotheses and the objectives of each of them have been defined, we proceed to carry out the questionnaires with the people chosen for the test. For this, a questionnaire was designed in which the hypotheses raised previously were collected. Sixteen closed questions were defined on a five-level Likert scale and a comment was included at the end of the questionnaire.

In this research, we performed a qualitative analysis instead of a quantitative one, since the number of people who participated in the study is not enough to perform the first one. Users found it easy to manage the software. However, it was shown that at the beginning of its use, the goal was not very clear and what was the first step to be taken.

Another point to keep in mind is that there are users who were not clear using any of the buttons. However, by working more with the application, they recognized its usefulness. Therefore, the first hypothesis is met, since users could work with the software.

As for the second hypothesis, the users also find it valid, since they had not worked with other similar programs. This hypothesis is also fulfilled, since the first one is satisfied (could use it), and has not used other similar software.

The last hypothesis is also completely valid although it is perhaps the one that has generated the majority of the comments or observations.

### 4.2 Advantages of Using VILA

From the results obtained in the test it is deduced that the use of an alternative communication system, enable improved the learning capacity, the communication and the use of language on children with Down syndrome by replacing natural language with the use of symbols, graphics and images as support, have already been mentioned in Sect. 2.1.

Some of the advantages of using VILA language in these types of systems are based on simplifying the syntactic structures of this new language, which eliminate the ambiguity inherent to natural language.

Another of the advantages is that the new language enables expressing just one idea per sentence, thereby avoiding technical terms and abstract concepts. These are very important aspects when it comes to information access by people who have problems related to their capacity to understand and communicate either because they suffer from some type of disability or functional diversity or have limited cultural training, use a language that is not their maternal language or because they are elderly and have serious problems using new technologies to access information. These advantages are common to the European directives for generating easy-to-read information as promoted by the International League of Societies for Persons with Mental Handicap (ILSMH) [13].

## 5 Discussion

Using pictographic communication systems favors the visual memory process and relating words to concepts. Moreover, special motivation has been observed in children in general when using pictograms, not just those who suffer from some type of functional diversity. But, the meaning of some pictograms is complicated for them and this involves a specific sentence syntax learning process, especially for those who suffer from Down syndrome. In an attempt to solve this, we have enabled an option that allows the user to customize the symbols or graphics used by replacing the pictograms with images of real objects that the person using it is familiar with which facilitates their identification. This option has improved the functionality of the software and arose as a proposal by the users and educational psychologists themselves during the testing phase we conducted (see Fig. 4).


**Fig. 4.** Prototype file editing and customization box.

We also observed that, at first, the use of the verbs confuse children as there are no verb tenses since the pictograms do not vary for each grammatical change. The same occurs with the lack of distinction between gender and plurals in the definition of the concepts; however, they are used to using these types of communicators. In any case, the final objective, which is to achieve simple communication between people who have difficulties expressing themselves, is fulfilled quite satisfactorily.

## 6 Conclusions

The role of the new information and communication technologies in today's society is ever more decisive. Paradoxically, the use of these new technologies has, in some cases, generated risks of exclusion for groups such as people with certain types of disabilities or those who, because of their cultural level or advanced age, have serious problems when using ICTs to access information. This paper proposes the use of a new visual language known as VILA to resolve the accessibility problems people with certain types of disabilities have when using ICTs to access the information and knowledge society and communicate with other people under equal terms.

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