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# New perspectives for inclusion: special education meets 1-to-1 computing

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# Contents

# Acknowledgements

This thesis tells a story: it is the story of a fieldwork experience, which was preceded by a period spent reflecting upon the usage of Assistive Technology in educational contexts. But it is also the story of a student who met with a social and educational environment that was very different from where he had grown up. A different place, with different past, present and future.

When the possibility to go to Uruguay and to do research on the local One Laptop Per Child deployment was offered to me, I did not know the majority of the things which compose this work. The world I was about to explore was so wide – with its 400.000 computers in the hands of every single children, its internal economical differences, its peculiar social structure – that I could barely understand what this meant for them, for special education, and for me.

I would like to acknowledge all those people who, with their presence, made all this possible. This mainly includes my partner in life, Laura, my parents, Rosa and Pietro, and my sister Laura with her husband Stefano for always supporting me; Professor Paolo Ferri for supervising my work; Professor Antonio Battro for warmly welcoming me in the OLPC project, together with Mónica Báez who made it real; Francesca Scenini and Fabio Serenelli, for sharing part of the time I spent in Uruguay, living and working together; the teachers, children and parents I met in Uruguay; the OLPC and free software volunteers, especially those from CEIBAL Jam. Thanks also to the LISP lab staff at the University of Milan Bicocca for offering me logistical

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# Chapter 1

# Introduction

> If you want truly to understand
> something, try to change it.
>
> Kurt Lewin

The main subjects of this work are the concepts of integration and inclusion of disabled children at school, in a particular environment - the Uruguayan special schools - which is currently living a real revolution - the "One Laptop per Child" project - together with the rest of the primary schools of Uruguay. *Integration* and *inclusion* are the possible positive results of special education interventions at school. The two terms, often considered synonyms, are here used adopting two specific meanings: *integration* is seen as the result of an intervention directed towards the empowerment of an impaired individual, as in rehabilitation, while *inclusion* is what is obtained by the means of a change in the potentials of the environment.

This work describes an Action Research project conducted in the contest of Uruguayan special schools during a particularly interesting period: the deployment of the CEIBAL plan. CEIBAL, which stands for "Educational Connectivity of Basic Computer Science for Online Learning", is the local

implementation of One Laptop Per Child (OLPC), a project aiming to the diffusion of wifi connected laptops in primary school classes. OLPC targets the children of all countries, putting particular attention towards those of developing countries.

The main idea guiding this thesis is that giving a laptop to every child can change the established structure of relationships which connects the disabled children to the able bodied. In fact, they cease to be the only ones using technology at school, and a new environment is created where the computer is no longer a possibility, but a matter of fact. The traditional technological means which support a pupil's integration process become an existing part of the environment and they are no longer an objective to aim for.

The research follows a mixed experimental design, including various data collection techniques. The initial part of it adopts an ethnographic approach, describing the environment studied: this is paired with the description of the solutions adopted in order to solve technical problems together with the local actors. The research to this point is mainly based on interviews and direct observation, plus a cycle of development and testing of new accessibility solutions. A reflection on the local meanings of integration and inclusion is also proposed, to set the basis for the second part of the research. After the initial explorative study, four case studies are analyzed in order to deepen in the comprehension of the relational processes which are fostered by the introduction of technology at school. A methodology is proposed, based on both qualitative and quantitative techniques, in order to study the integration and inclusion processes of disabled children in ordinary schools. Observation of children and interviews are paired with level tests and sociograms, in order to verify if the teachers' views on their children are confirmed in practice by the pupils.

This research does not try to find a general, abstract theory: the knowledge generated here is based on direct experience, tested on the the field and reported in the form of a grounded theory. The final objective is double:

exploring the present conditions of the environment studied and defining guidelines for planning future work.

This work is organized as follows: in chapters 2 and 3 is described the background in which this work is settled, with particular references to the discourse on disability and to the social and technological context. Chapter 4 describes the guiding ideas and the strategy adopted during the field research, reporting detailed information about the baseline assessment of the first year. In chapter 5 four case studies are exposed, setting the basis for a grounded theory, while in the final chapter 6 the reflection about the lessons learned gives space to a (re)discussion of the general concepts of accessibility, integration and inclusion. Some further research ideas are also presented there.

# Chapter 2

# The theoretical background

This chapter introduces the main topics which form the theoretical background of this work, which addresses *the inclusion of disabled digital natives in a Constructivism-inspired environment.*

The chapter starts from a conflictual situation, describing the debate which is currently running in the fields of disability, special education and human rights. The main focus is on the opposition between two disability models: the traditional Medical Model against the more recently proposed Social Model of disability. The main ideas of Disability Studies, a current endorsing the Social Model, are introduced and explained as a foundational basis leading the whole reflection.

As the research project took place in a setting which is a unique novelty in the field of education for its broadness and for the efforts put in it by many actors, analogies with other, broader pedagogical theories are also traced, particularly with the emancipatory learning theories proposed by Constructionism and Constructivism. The One Laptop Per Child Project, which will be described in detail in chapter 3, took inspiration from the former theory and is an attempt to lower digital divide and to fight social exclusion, empowering education by the means of technology.

Finally, the children involved in the research can be defined *Digital Natives*: this particular denomination deserves a whole section in this chapter, where the most important theories about the topic will be exposed.

## 2.1 The debate on disability, integration and inclusion

The discourse about disability, integration and inclusion is huge and articulate. The scientific debate about those topics is also wide and vivid: its panorama was dominated for decades by the so-called Medical Model of Disability. One of the mayor oppositions to such a model was introduced when supporters of the Disability Studies started criticizing the dominant Medical and Rehabilitation perspective. Such debate is mainly about *models*, defined by Oliver as *"ways of translating ideas into practice"* ([122], page 43). Different models attribute different meaning to the same terminology and offer distinct epistemological perspectives.

As will be extensively explained in the following paragraphs, a variety of models has been applied to disability in the past centuries, with the predominance of the Medical one. This position assumes that disability is the condition of people lacking part of their bodies or of their cognitive potential and the way of acting towards this disadvantaged condition is mainly based on the *completion* of those lacking parts, by the means of prostheses, of special education interventions or of rehabilitation. The influence of this way of considering the problem has evidently influenced the way in which technology has developed in order to provide disabled people with aid for their everyday activities.

For Disability Studies supporters, the best possible model to be applied in the field of disability is what they call the *social model*: people who have some forms of impairment live segregated in a *disabling society*. Disability is then

a consequence of living with a particular impairment in a society where said impairment is not treated as *normality*. They suggest that social research and social work on the topic of disability should not address disabled people's personal problems, but should concentrate on improving the quality of their lives by changing the way their social context considers them. The approach of Disability Studies is hence emancipatory and critical against bad politics and segregation.

The debate is focused on a set of terms, which includes *impairment* and *disability*, but also *integration* and *inclusion*. The latter couple of terms are often considered synonyms but their etymology can easily clarify the differences in meaning that in this debate are attributed to them:

"Integration" comes from the Latin word *"*integratio*, noun of action from integrare: to render (something) whole, from integer, whole"*. On the other hand, "inclusion" also comes from Latin, but derives from includere (*includaudere*), *"shut in, confine, enclose, imprison, but also fig. to include, enclose, insert, embrace, comprehend"*. These two last meanings are the most relevant for this work. The word "integration" has been heavily criticized by the movement for Independent Living for its closeness to the concept of *paternalism* [47]. On the other side, "inclusion" is a way of welcoming difference by creating or modifying environments in order to take it into account.

Michael Oliver, one of the most important upholder of Disability Studies, in [121] brought the discourse on an educational plan. In his opinion, "Inclusion" seems to be the best perspective in which *education for all* can be achieved. Among the Italian supporters of this view, Medeghini sustained that inclusive education should provide *"an adequate background for the different abilities in learning and relationship environments"* [110].

In the field of special education, integration has traditionally been a point of discussion for teachers of children with special needs. Technology has already proven to be very useful for interventions of this kind and, as will be discussed later, in the chapters of this thesis which are dedicated to field re-

search, most educators seems to think to technology as the basis for powerful *prostheses*.

Prostheses are necessary, and they help disabled people overcome the difficulties imposed by their particular situation and achieve an higher standard of living. Without prostheses, a person with any kind of special needs often stands alone in environments which were designed for the able-bodied. This happens because the Assistive Technology they use is something very specific, sometimes it cannot be moved from one place to another, and especially because who designed a particular space did not care about anything else than the commonly accepted "normality".

The massive introduction of technology in schools creates new opportunities for social inclusion. While in the past the idea of exclusion was mostly related to poverty and low income, nowadays digital skills and access to digital resources assume a primary role. As M. Warschauer notes, *"the concept of social inclusion does not ignore the role of class, but recognizes that a broad array of other variables help shape how class forces interact"* [167]. In this perspective, the availability of equal educational opportunities means that a person needs to acquire a complete repertoire of cognitive skills in order to learn and succeed in a complex learning environment.

### 2.1.1 Medical Model versus Social Model: the rising of Disability Studies

Mainstream explanations of disability have traditionally considered on impairment as both the cause of our experiences and disadvantage, and the focus of intervention. In a Medical perspective, disability is a permanent biological impediment and is seen as a personal, physical, psychological, cognitive and sensorial tragedy.

In the Medical Model of Disability people are defined and characterized not only basing on their diagnostics, but also on their degree of difficulty in

reaching a normal development as human beings. This puts a strong focus on functioning as the most desirable of human conditions. Under this model, disabled people's inability to join in society is seen as a direct result of having an impairment and not as the result of features of our society which can be changed.

This mainstream view of disability was strongly criticized when the Disability Studies emerged: this field is of relatively recent origin but it rapidly reached the position of legitimate sociological and multidisciplinary debate. It focuses on people with disabilities but explicitly rejects the traditional views of disability and the idea that disability is an individual's "problem": this definition is attributed to the industry of caring professionals, which used it in order to maintain its power. Disability Studies derive from the Disability Rights Movement, which has among its main objectives the raising of a collective consciousness of the lack of rights that disabled people have and experiment in their everyday life.

Disability Studies proposed what is known as the Social Model: through the terminological distinction between *impairment* and *disability* they defined the former as a personal trait and the latter as a consequence of the relationship between the subject and society (see [3], [120]).

The scope of Disability Studies differs in different countries. In the UK, for instance, it is seen as the province of disabled people, whereas in the USA a much wider range of professions concerned with disabilities and disabled people is involved. All Disability Studies movements have a multidisciplinary orientation: the study of disability crosses academic classifications and includes philosophy, psychology, sociology and history. One of the major points of debate is the relationship between disability, social justice and political understanding. Disability Studies often take as a starting point the fact that the lack of rights recognition typically experienced by those who are disabled reflects primarily the way society defines and responds to certain types of "difference". These ideals of difference are reflected by almost every cultural

artifact produced by the human populations throughout history: laws, literature, social policy, architecture and many other disciplines show the marks of the society which produced them and carry out a particular point of view on what is "normal", what is "different" and what is "disabled".

The above cited Medical Model did not dominate the discourse on disability since the beginning of it and a common definition of disability did not form through history. Disability Studies hence pursue the ultimate objective of finding an equalitarian, universally acceptable definition. In order to build such a definition, they criticize the dominant views of disability, which are perpetrated by laws, medical institutions and social constructs.

We can take the current legal definition of disability for the United Kingdom as an example of practical application of the Medical Model. It is included in the "Disability Discrimination Act" of 1995 [38], which states:

> a person has a disability if he has a physical or mental impairment which has a substantial long term adverse effect on his ability to carry out normal day to day activities.

This kind of view, besides carrying a certain degree of ambiguity, immediately associates the idea of disability to the concept of loss of functioning and does not attribute any responsibility for discrimination to the rest of the society. Disability is here caused by the individual's loss or impairment and is linked to the concept of chronic illness, in a hierarchical cause-effect order. This is in accordance with the International Classification of Functioning, Disability and Health (ICF) devised by the World Health Organization (WHO) [173], which introduces a distinction between the terms *impairment*, *disability* and *handicap*. Impairment is referred to as any medical damage or malfunction of a part of the body. Disability is subsequently

> any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being.

A handicap is then the social consequence of an impairment and its resultant disability, *thus cognitive or hearing impairments may lead to communication problems, which in turn result in isolation or dependency* (See Gilman in [64], page 271). Cultural, social and environmental variables also form part of the social model of disability, which will be examined later.

Disability Studies aim to reconstruct the language of disability, just like any other academic discipline creates its own specific language and imagery. The metaphors which dominated the discourse on disability before Disability Studies began their terminological reflection were prevalently oppressive and negative. This language was mainly influenced by how different disciplines represented disability through models. Those disciplines are described by Corbett [33] as a layered hierarchy, where the Medical language is the base and other disciplines stay on the top of each other. Every discipline adapted its own special language to meet the needs of marginalised groups. The shaping of Disability Studies as a critical discipline is reflected in the terminologies of these different disciplines. The hierarchy is shown in figure 2.1:


**Figure 2.1:** The languages hierarchy of disability

These disciplines maintain an independent view of disability: their language choices are hardly influencing one another and have many differences among

them. Disability studies try to go beyond this *disablist vocabulary* and, as Johnostone says, *to reflect the more inclusive voice of a new social movement* [86]. The hierarchical model is hence criticized and a new one is proposed, with different explanatory power: this newer model does not grant any privileged role to any particular language and there is neither oppressive nor negative metaphor. As noted in [86], *the notions of disability as loss and restriction are removed*. This model tends to the construction of an inclusive language and to the creation of new alliances with other marginalized groups.

The first formulation of the principles of the Social Model of Disability date back to 1976, when the Union of the Physically Impaired Against Segregation (UPIAS) gave their definitions of disability, based on their direct experiences ([159] and [54]). The group interpreted physical disability as a form of oppression deriving from a *disabling society*, not from an individual's medical conditions. They defined it in terms of environmental and social oppression, and they did not accept the causal connection identified in the above mentioned WHO classifications. Their definitions of disability and impairment are:

> **Disability**: emphasising the disadvantage or restriction of activity caused by a contemporary social organisation which takes no or little account of people who have physical impairments and thus excludes them from the mainstream of social activities.
>
> **Impairment**: emphasising the lack of all or part of a limb; or having a defective limb, organ or body mechanism. In other words it tends to emphasise the individual.

Those definitions were rewritten some years later by Disabled People's International (DPI), moving the focus even more towards the impositions and barriers erected by society on people with impairments. Their definition of disability is *the loss or limitation of opportunities to take part in the normal life of the community on an equal level with others due to physical and so-*

*cial barriers* [41]. The DPI places causality within the schema of community living.

This shift in the definition of disability coming from disabled groups is the sign of an emerging disability pride, which comes together with a disability culture and exposes the limitations imposed by the notions of normality. But both the WHO and UPIAS views seem to tend towards a process of rehabilitation to the normality, but this disposition is also criticized by Disability Studies authors. Oliver in [120] explains that the definitions of disability and impairment are not just a matter of semantics: he believes that the real objective of disabled people movements must be that of *rejecting the normalising society.*

### 2.1.2 Disability and (Computer) Technology

Technology, and especially the branch of it which is commonly referred to as Assistive Technology, has historically played a fundamental role in supporting and expanding possibilities for disabled people. With particular reference to the discourse on disability and to the above described debate between the Medical and the Social Model, technology has represented the evolving possibility of creating better prostheses. The association with the Medical perspective is quite obvious: throughout history, many people with different kinds of impairments have enjoyed the possibilities offered by technological aids of various level and potential. Nowadays, computers and other technological devices allow people with different degrees of impairment to live an independent life, but the discourse about technology is very wide and is developed in a dedicated chapter, starting from page 27. In Flippo, Inge and Barcus opinion, technology will be the equalizer of the 21st century for disabled people [56]. Assistive Technology is a basic tool in the educational process for any individual who may experience a disability [26].

The introduction of computers at school to support children with various

kinds of impairments is not something new. In many cases, computers allow children to perform actions which would normally require a huge effort, such as writing or speaking. During the last decades, the adoption of technology in classrooms was mainly addressed to such a function. Battro and Denham in [10] describe this use of computers at school *'the forbidden experiment'*: children with no disability are not normally encouraged to learn how to use a computer, spending their time in learning analogical techniques. On the other side, children with impairments can enjoy the benefits of such an instrument during that period of their lives when their brains still have the possibility to adapt to and to interiorize such a competence. This creates a trade-off in the classroom, by the fact that children with no impairment learn less about technology than their impaired peers. At the same time, technology can act as a mark of difference: the need for a computer aid is peculiar of those who have some kind of 'problem' (see Lupton and Seymour in [100]).

One of the key topics of this whole work is the relationship between Technology and the Social Model, studied in a specific learning environment: the Uruguayan schools involved in the CEIBAL plan. Such an environment is *permeated* by technology: computers are everywhere, as well as connectivity infrastructure. This allows the implementation of distributed solutions, where people do not consider the machines as separated from the reality where they live, but as an important and very common component of everyday life. As D. Norman would say, computers become *invisible* [119]. The children receiving the XO laptop have equal access to technology. If those machine are completely accessible to them, they will rely on an environment which has an higher inclusive potential than the past educational environments. They will both participate to the global digital revolution, and be provided with useful "prostheses" to improve their learning activity.

The related literature includes a quite large number of studies about the use of technology at school. One of the most cited works reviewing the research about the relationship between computer technology and children with spe-

cial needs at school is that of Woodward and Rieth [172], who reviewed literature since 1980. Unlike the majority of older reviews, this one did not focus on academically related issues and on the effectiveness of computer-assisted instruction. They highlighted the diversity of research in special education deriving from the multiple roles of the special education teacher. Exposing the limits of previous research they remarked that:

> much of the research has looked at the way in which technology could monitor progress toward IEP [(Individual Education Plans)] goals, assess students to determine eligibility for special education services, or document how technology is used under naturalistic condition"

Lau et al. in [93] cited many studies addressing the social interaction between young children and their peers, while Johnson, in [85], offered a review mainly focused on secondary school. The core results from research with children and teenage students demonstrated:

- improved peer-related social skills of children with disabilities [14], also specifically when engaged in computer-based activities compared to table-top play activities [74]
- positive impact of Assistive Technology on the social and emotional outcomes of the students [76]
- increased participation in spontaneous turn-taking behaviours [35]
- good promises for interactive play and social interaction in preschoolers with and without disabilities [14], [37]
- increased associative play during the computer activities compared to playing with toys [108]
- improved social interaction between children with and without disabilities when they played with the computer and a remote-controlled robot [151]

- increased assistance-seeking from peers while working with the computer [31], [114], [21]
- existence of distinct types of barriers experimented by students, classified as: 1. Technical barriers, 2. Design barriers and 3. Interpersonal barriers [171]
- improved efficiency in performing educational tasks, as writing, organizing and speeding up work, and promoting personal growth [53]
- crucial importance of faculty and staff involvement in the implementation of Assistive Technologies [147].

Johnson in [85] suggests some further research ideas which were considered interesting as a strategical starting point for the present work:

> One suggestion for future research could be to reduce the scope of technologies used and the population using those technologies. [...] In addition to narrowing the scope, it might be interesting to add a component that also discusses the challenges for students to independently perform educational tasks if technologies are inaccessible to students in multiple locations like home or public libraries due to cost, maintenance, need for trained staff, etc.

## 2.2 Constructivism and Constructionism

Under a pedagogical point of view, this work is inspired by Constructivism and by the Constructionist learning theory. Information and Communication Technologies seem to have given them renewed strength, based on the principle of auto-construction of knowledge. Thanks to technology everyone can build a personal network of active knowledge. This tendency to autonomy moves the responsibility for learning from the teacher to the pupil (and to the technology in use). Teachers retain a role which could be described at best

as that of a distant tutor. Constructivism and the Constructionist learning theory are often considered the same. Edith Ackermann, in [1], tried to solve this apparent ambiguity by analytically comparing the works of the founders of the two theories, respectively Jean Piaget and Seymour Papert.

Piaget's constructivism is mainly an epistemological theory arguing that humans generate knowledge and meaning from their experiences. His idea of knowledge was dynamic and he defined it as *a system of transformations that become progressively adequate* [135]. He suggested that children intelligence develops in distinct phases (see [134] and [136]):

- sensorimotor intelligence;
- preoperational or symbolic intelligence;
- concrete operational intelligence;
- formal operational intelligence.

Piaget thought this sequence to be genetically determined, but also influenced by the activity of the contextual environment. The process of intelligence development consists in balancing interior structures in response to an input (in the form of stimulus or constriction) received from the environment. This happens through processes of *assimilation* and *accommodation*, with which individuals construct new knowledge from their experiences. Assimilation is the practice of incorporating the new experience into an already existing framework without changing that framework. This usually happens when individuals' experiences are aligned with their internal representations of the world, but may also occur as a failure to change a faulty understanding. In contrast, when individuals' experiences contradict their internal representations, they may change their perceptions of the experiences to fit their internal representations. Accommodation can be understood as the mechanism by which failure leads to learning: when we act on the expectation that the world operates in one way and it violates our expectations, we often fail, but by accommodating this new experience and reframing our model of

the way the world works, we learn from the experience of failure, or others' failure.

Constructivism is not a specific pedagogy, but the theory of learning supported by the constructivist framework has had wide ranging impact on learning theories and teaching methods in education. It is also an underlying theme of many education reform movements. In Ackermann's words:

> Piaget's theory provides a solid framework for understanding children's ways of doing and thinking at different levels of their development. It gives us a precious window into what children are generally interested in and capable of at different ages.

Another important contribute to Constructivism came from John Dewey. He called for education to be grounded in real experience, believing that if someone has doubts about how learning happens, the best way to solve those doubts is to study, ponder, consider alternative possibilities and arrive at a belief grounded in evidence. *Inquiry* is hence a key part of constructivist learning.

Social constructivism, the branch of constructivism traditionally associated to Vygotsky's work (particularly to [164] and [165]), views each learner as a unique individual with unique needs and backgrounds. The learner is also seen as complex and multidimensional. Social constructivism not only acknowledges the uniqueness and complexity of the learner, but actually encourages, utilizes and rewards it as an integral part of the learning process [169]. Vygotsky defined the concept of *"zone of proximal learning"*, according to which students solve problems beyond their actual developmental level (but within their level of potential development) under adult guidance or in collaboration with more capable peers.

In past decades, constructivist ideas were not widely valued in the education field due to the fact that they concentrated a lot on children's play. This focus was seen as aimless and of little importance. Piaget believed that

children not only have their own views of the world, differing from those of the adults, but also that these views are extremely robust and coherent. This for him implies that teaching is an indirect activity, because kids do not simply accept what is taught to them, but they elaborate on it, making interpretations which are conditioned by their direct experience. Knowledge is experience that is acquired through the interaction of the child with the context surrounding him or her. Children develop a form of resistance to the learning environment and that fact cannot be ignored by the educational system. Piaget saw play as an important and necessary part of the student's cognitive development and provided scientific evidence for his views.

The work of Seymour Papert was heavily influenced by Piaget's constructivist theory. The two scientists worked together in Geneva in the late 1950'ies and early 1960'ies. In [127] Papert states:

> Constructionism – the N word as opposed to the V word – shares constructivism's connotation of learning as "building knowledge structures" irrespective of the circumstances of the learning. It then adds the idea that this happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity, whether it's a sand castle on the beach or a theory of the universe.

Papert's approach is more focused on learning than Piaget's work: he particularly values learning through practical activity. To him, one of the key aspects of learning consists in projecting out one's inner feelings and the ability to produce something tangible and shareable reflects the faculty of expressing ideas. This process also shapes and sharpens the expressed concepts, and helps learners communicate with others. It is hence an iterative process, by which self-directed learners *invent for themselves the tools and mediations that best support the exploration of what they most care about* ([1], page 4).

Piaget and Papert share the view that children are the authors of their own

cognitive tools, and that the reality in which they live and their own knowledge of it are directly shaped by their personal experience. This process of uncovering the real world's shape through the lenses of experience is common to children and scientists. Their view of knowledge construction is incremental: it is a process through which human beings can better understand themselves and the environment in which they live.

One of the most important differences between Piaget and Papert resides in how they theorize the learning process: the former considers it as a progressive detachment from the contingent, concrete world, during which the child gradually gains the ability of mentally manipulating concepts in an hypothetical realm; the latter seems to reject this idea of detachment by attributing great importance to deep involvement in the learning activity.

### 2.2.1 Papert's principle

Seymour Papert was not only influenced by Jean Piaget's work: he also collaborated with Marvin Minsky at the MIT. Minsky – one of the fathers of computer science and cofounder of the Artificial Intelligence Laboratory at MIT – thinks that every time we talk of mind, we are actually considering the chain of processes which take the brain from one state to another ([111], page 563). He gives a revolutionary answer to the "How does the mind work?" question by portraying the mind as a "society" of tiny components that are themselves mindless. He concentrates on the relationship between mind states, rather than on the states themselves. Also in [111], page 102, Minsky elaborates on the concept of *mental growth*, reporting what is commonly referred to as Papert's principle:

> **Papert's Principle**: Some of the most crucial steps in mental growth are based not simply on acquiring new skills, but on acquiring new administrative ways to use what one already knows.

The formulation of this principle goes back to the 1960s: after that period, Papert did a lot of research on the cognitive development of children with help of computers and created a programming language named "LOGO"[1] to help children develop their problem solving skills. In [126] he also demonstrated the correlation between learning to program with Logo and increasing the logic skills and the scores in Maths tests.

The One Laptop Per Child project which will be described in the next chapter is expressly based on Papert's ideas: it provides the children with an instrument (the computer) equipped with many tools useful for stimulating their learning and knowledge-administration abilities.

## 2.3 Digital Natives

A *Digital Native*, as in Prensky's definition discussed in [138], is a person who has grown up in the Information Era, surrounded by technological devices such as computers, internet and mobile phones. Following the ideas discussed by the author, at the time in which this work is being written the oldest Digital Natives in the United States have an approximate age of 20, and the average time they have spent reading is roughly 5000 hours, while for 10000 hours they have been playing videogames and have seen 20000 hours of television.

The youngest Digital Natives, who are currently attending the first years of primary schools in both the developed and developing countries, have learned how to use various types of technology before learning how to read and write, also before going to school. Prensky suggests that their thinking patterns have changed in respect to those of the previous generations. In his definition they are *"native speakers of a new language"*.

[1] LOGO is a computer programming language used for functional programming created in 1967 by Jorge G. Bobrow, Wally Feurzeig, Seymour Papert and Cynthia Solomon. It is an adaptation and dialect of the LISP language. Today, it is known mainly for its turtle graphics, but it also has significant facilities for handling lists, files, I/O, and recursion.

Compared to them, people of older generations are *Digital Immigrants*, who learned how to use technology later in their education. They learned it in the same way a second language is learned: they mainly adapted their habits to the new possibilities which technology offered, following the strategies they had previously consolidated with analogical media. For them, who had formed their sort of Universal Grammar [30] to apply to every situation of their lives, the digital revolution of the last two decades meant something very similar to learning a new language. They became Immigrants without moving from where they used to live.

One of the most important questions which arise from this situation is about the school system: even the richest and most developed countries still have educational systems which are based on an analogical approach. Such school systems were designed by people who could not imagine that Digital Natives would exist one day, who were born analogical: schools are led by Immigrants. Modern schools mainly use books and frontal lessons, while Digital Natives enter them with a personal education background based on simulation games, hypertexts, network competition and cooperation.

Both communication and education need to be contextualized in what Ferri describes as "a crossmedial scenery, which no more considers Gutenbergh's book an communication in presence as the main vectors of education" ([52] p. 18). The relationship between different generations is the most problematic aspect of this transformation. The problem of the *"intergenerational digital divide"* was originally discussed by Seymour Papert in [129]. He described it in terms of different competence level and different ability in the use of technology between children and adults, particularly parents. Papert's analysis highlighted the emerging of a social and educational delay, mainly due to a generational divergence in learning styles and in technological alphabetization models. Among the possible solutions proposed for this problematic situation, Marc Prensky proposes what he calls *"Pedagogy of partnering"* [139].

Digital Natives have some distinctive traits, among which their orientations as consumers and as learners are particularly interesting. In Veen's opinion, the values which mainly influence them are self-expression, customization, information sharing and peer confrontation with people of the same age. They are evolving from *homo sapiens* to *homo zappiens* ([161] and [162]).

Defining who is a Digital Native and who is not is quite a difficult issue: John Palfrey e Urs Gasser in [125] tried to tell the story of the first generation of boys and girls who grew up in the Internet era. They extended the definition of Digital Natives to all people born after 1980, the period when technologies such as Usenet and Bulletin Board Systems (BBS) appeared. This obviously applies to people of the industrialized countries: technology is not absent from the poorest countries, but its availability on a everyday basis is less frequent[2].

Palfrey and Gasser also defined some guidelines, in terms of common practices, which they used to describe the typical traits of Digital Natives:

- the time spent using digital media;
- the tendency to multitasking;
- the way of expressing and of relating with peers with the support of digital media;
- the ability in using any technological media to obtain and use information and to create new forms of art and knowledge.

The country where the fieldwork was conduced poses little problem to the identification of the children as Digital Natives: as will be explained in the following chapters, all children in there received their first personal computer at primary school. They can hence be safely defined Digital Natives. They spend a large amount of time in direct, 1-to-1 contact with digital media,

[2]As an example, consider that the majority of Uruguayan children did not have a computer at home before the CEIBAL project started, but they could count on cheap access to computers from a large number of internet points present in almost every part of the country.

and they do it in a multitasking fashion: following the ideas exposed in [6] multitasking can be:

- *cognitive*, when we are looking at the mental consequences of doing more than one thing at the same time;
- *social*, when we are interested in the social effects of doing two (or more) things at once.

in both levels, new technologies are considered to be among the main causes of the multitasking style. The other key features of Digital Natives, regarding expression, relational abilities and information manipulation will be central in the analysis exposed in chapter 5.

One last thing which is worth considering while talking of Digital Natives is the process of transformation of social identity in the digital context. Barry Wellman and Maria Bakardjieva, as cited in [15]. They introduced the concept of "networked individualism", which is based on the idea that social relationships based on physical proximity are being substituted by interactions of individuals who are not strictly linked to their backgrounds: according to [168], the group ceases to be the foundational element of social connections, being substituted by the individual with its own network of contacts with other individuals.

In the networked environment offered today by Internet, according to H. Jenkins [82], new possibilities for structuring the cultural world are offered: the new communication technologies are the realm and the field of possibility of a *participatory culture*, in which traditional barriers to freedom of individual expression and to access to public discussions are drastically removed. This new form of culture conflicts with the traditional hierarchical model of production and broadcasting of cultural products. The 'author' as a single person is hence being substituted by a community of individuals sharing their own creations and collectively contributing to the production of new content. This new form of culture is, for Jenkins, the common trait between

specific practices as the affiliation to online communities, the creation and sharing of creative contents (also through *mash-up* techniques), the diffusion of collaborative problem-solving techniques in which the net encourages the formation of active groups dedicated to the creation of new knowledge.

### 2.3.1 Studying technological appropriation

The above cited theories all point towards the same direction: technological appropriation is different for people who approach computers and other digital devices at different age. Children of today live in a world where technology permeates the environment, and the children involved in this work were no exception: they were given a personal laptop during the period between June and October 2009 and started their own technology appropriation processes. Among those who elaborated models for describing such processes, S. Turkle proposed a three-phases classification (in [157], as discussed by Garzia and Ripamonti in [107]):

1. *metaphysic phase*, 3 to 8 year old children: the encounter with the machine generates questions about life. The object is treated as animated, as alive and capable of understanding feelings. Typical reaction to this encounter with the machine are attempts of dominating it, by unplugging it or by pushing any button. This often results in breaking and in 'mutilations', as with dolls.

2. *ability phase*, from the age of 7-8: children are now more interested in understanding and dominating what surrounds them, rather than in speculating about its nature. Normally this is facilitated by games: they allow measuring competences and abilities. Children want to play, to win, to dominate the machine, not to reflect about it. In this sense, the computer can be an instrument for developing independence and for acquiring self confidence, dropping some links with parents for turning towards other children, with whom it is possible to compete and to

cooperate.

3. *identity phase*, from late childhood and pre-adolescence: at this stage, the control over novelty and over property becomes a synonym of identity. The computer is an alternative to motors and to other complex 'subjects': programming and creating multimedia objects can be a way for developing a stronger idea of self, as a reflection of the work of mind.

This process is not linear and can vary a lot also for children who live in the same context, but the model still offers a perspective through which it is possible to read how the use of technology can interact with the development of children's subjectivity. There is a sort of natural progression from an exploratory approach to a communication-oriented one, which requires higher competences.

After the exposition of this theoretical panorama, the next chapter will deepen the focus on technological aspects, explaining also some peculiar traits of the environment studied.

# Chapter 3

# The Social and Technological Background

The previous chapter depicted the theoretical background and the educational framework in which this work is set by introducing the epistemological debate about disability, the constructivist/constructionist perspective and the category of *Digital Native*. This chapter examines the socio-technological counterparts of those topics:

- **Assistive Technology** is the 'solution' proposed by the traditional engineering approach to functional limitations imposed by personal impairments; as seen in 2.1.2, there is proof of various positive implications that the use of technology at school can have on social skills for disabled children. This creates a point of encounter between Medical and Social Model;
- OLPC and CEIBAL are two projects aiming to the massive diffusion of 1-to-1 computing in primary school classes in the poorest areas of the world. The latter is the local application of the former in Uruguay. Both projects are directed to Digital Natives and are based on Constructivist and Constructionist theories.

This chapter serves as a completion to the preceding one and as a direct introduction to the research work on which this work is based.

## 3.1 Assistive Technology

Assistive Technology (AT) is the usual point where Technology and special education meet themselves. AT allow disabled people to find "their way" of doing something (see Gold in [66] and Dell et al. in [39]). This, together with the possibility of living an independent life (Besio in [17]) is the major advantage of these kinds of solutions. Many AT tools are computer related: they can be hardware devices or software programs. Choosing a good technological solution for one particular person is not easy: these aids are not industrial products with well defined capabilities; they need to be tested, combined and moreover accepted by the person who will use them. Normally, they cannot be used off-the-shelf: they need to be adapted, and the environment in which they will be used also needs to be prepared to receive them (Bell et al. [39]). Traditionally, usage of these kinds of technologies in schools has been considered as a way of empowering a few individuals to bring them (almost) to the same level of the rest of their classmates (see Kintsch and DePaula in [89]).

Following the ideas proposed by A. Canevaro in [23], a good approach to AT in classrooms should consider the following three aspects:

1. Every child in the class, disabled or not, should know how the assistive tool works, what it is useful for and what parts it is composed of;
2. Every child should learn how to use the assistive tool;
3. The set up of the environment for the disabled children should be considered as part of the learning activity for every child.

The context studied leads to the reconsideration of these concepts and guidelines from a new point of view. The following paragraphs will explain the

concepts of Assistive Technology and Universal Design. Some practical examples of usage will be discussed, in order to better support the description of the solutions adopted in the fieldwork.

### 3.1.1 Assistive Technology definitions

The federal law of the United States known as the *Individuals with Disabilities Education Act* [77] includes an interesting and broad definition of Assistive Technology (AT). This definition consists of two parts, regarding *devices* and *services*.

> (1) Assistive technology device.
>
> (A) In general.–The term 'assistive technology device' means any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of a child with a disability.
>
> (B) Exception.–The term does not include a medical device that is surgically implanted, or the replacement of such device.
>
> (2) Assistive technology service.
>
> The term 'assistive technology service' means any service that directly assists a child with a disability in the selection, acquisition, or use of an assistive technology device. Such term includes–
>
> (A) the evaluation of the needs of such child, including a functional evaluation of the child in the child's customary environment;
>
> (B) purchasing, leasing, or otherwise providing for the acquisition of assistive technology devices by such child;

> (C) selecting, designing, fitting, customizing, adapting, applying, maintaining, repairing, or replacing assistive technology devices;
>
> (D) coordinating and using other therapies, interventions, or services with assistive technology devices, such as those associated with existing education and rehabilitation plans and programs;
>
> (E) training or technical assistance for such child, or, where appropriate, the family of such child; and
>
> (F) training or technical assistance for professionals (including individuals providing education and rehabilitation services), employers, or other individuals who provide services to, employ, or are otherwise substantially involved in the major life functions of such child.

When considering AT as a device we can assume it impacts mainly on the *functioning* of a person with disability, by enabling him or her to actions which would normally be impossible or very difficult to accomplish. It is important to note that this definition does not only include devices which are specifically designed for people with disabilities. Common objects, which can be bought on a supermarket shelf, are included: importance is given to the way this devices are used. A very large monitor can be useful for a photographer working with photo editing software, but can also be very useful to another person with low-vision. Also, a device can be modified to be more effective with a particular person. As there is no person with disability which has exactly the same needs of another person with the same diagnosis, AT devices need to be flexible, or to be modified. Some devices are designed to be customizable: it is clearly the case of communication boards used in Alternative and Augmentative Communication (see Johansen in [84]), which need to be configured by a teacher or by a child's family in order to be used properly. The law cited above also defines AT *services*, including some sub-definitions which describe how an intervention based on AT should be led. This means that simply providing AT to disabled people

is not enough: a person will need to be trained on how to use the device and to be assisted when it needs adaptation, repair or substitution. This involves a wide number of professionals, spanning from technicians to teachers and experts, and normally involves the family.

### 3.1.2 Universal Design

The term universal design (UD) was coined in the early 1970s by Ronald Mace, the founder of the Center for Universal Design at North Carolina State University (NCSU). UD refers to a wide range of solutions which are used in designing and producing buildings, products and environments that are intended to be usable and effective for everyone, not just for people with disabilities. UD can be considered both as deriving from AT and as complementary to it.

Universal design is all around us, as a part of everyday living. The curb cuts in most platforms are a good example; additional examples include cabinets with pull-out shelves, kitchen counters at several heights to accommodate different tasks and postures and low-floor buses that kneel and are equipped with ramps rather than lifts.

The official definition of UD is provided by the Center for Universal Design at NCSU in [28]:

> the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design

The main consequence of this definition of UD is that a solution which is originally designed and implemented as AT - in the sense that it is meant to make some action easier for someone - can become useful and in some cases necessary to everybody. The curb cuts of the above example were originally designed to make navigating city streets more accessible to wheelchair users

(see Jacobs in [80]), but are now something very useful for everybody has to carry something with wheels up and down a platform.

The Center for Universal Design also mentions seven principles which are the basis for UD (see [153]). The purpose of those principles is to guide the design of environments, products and communications:

- equitable use
- flexibility in use
- simple and intuitive use
- perceptible information
- tolerance for errors
- low physical effort
- size and space for approach and use

Such principles are applicable to the evaluation of existing designs, to the guidance of new design processes and to the education of both designers and consumers about the characteristics of more usable products and environments. Universal Design is a practice which favours the idea of inclusion described above: buildings and object designed following its seven principles are a good example of what can be done to create receptive environments which take into account the different abilities.

### 3.1.3 The Assistive Technology *continuum*

Given the above definitions of AT, they can be represented as a *continuum* (see Dell et al. in [39]) varying from very low-tech (pen supports, reclined tables) to very high-tech devices (speech recognition software, eye-tracking). The next paragraphs will list some of the most common AT devices and explain how they basically work. As will be showed while describing them, some AT aids are not designed to be 'assistive technology'. Examples will be

provided of objects coming from different fields, or designed with different purposes in mind, which still serve as aids to people with some different kinds of physical impairment.

### Hardware Assistive Technology

The application of AT principles *to the hardware* of a computer can happen following three main approaches:

- making the interaction with existing input/output devices easier;
- adapting said devices in order to improve their accessibility;
- designing new devices, by keeping in mind one or more particular accessibility problems.

In some cases, objects created for very specific tasks and objectives can also be useful to people with some form of disability, as long as they also fall into the above three points. The above introduced "Assistive Technology continuum" is hence not only a *horizontal* concept: the continuity is valid also among different aspects of reality and of everyday life. As an example, modified keyboards used by video games players are often easier to use and most comfortable than ordinary ones. Those adapted devices can also count on a market base which is often larger than the typical audience of assistive technology, hence the price for those devices can be significantly lower.

The following paragraphs illustrate some of the most typical computer related AT and try to pinpoint examples of creative use of specific devices designed to support various forms of impairments.

**Keyboard.** A keyboard can cause problem to everybody, if it is placed in an inconvenient position. Arms and, in general, the body of a computer user must be in correct position in order to avoid pain and further complications. It is possible to set the keyboard height and inclination properly by using adequate support systems. Some supports for the arms can be assembled on

a computer table in order to allow users to rest their superior limbs at the correct height allowing freedom of action in the hands. More problematic cases, which involve low movement control, can take advantage of keyboards screens, also known as "shields", that can prevent accidental key pressures (See fig. 3.1). Actually this kind of solution can be applied to a standard keyboard, allowing the pressure of one key at a time.

**Figure 3.1:** A keyboard with a "shield" applied on it

Another interesting solution is offered by "chording keyboards". They follow a principle which is common to music keyboards: the pressure of a specific combination of keys produces one result, which in this case can be a character, or a command. The keys are arranged following ergonomics principles: movements only involve the finger, thus eliminating the necessity of changing the arm or hand position.

Braille keyboards (see fig. 3.2) are also based on this kind of paradigm: the famous non-visual alphabet can be written with special devices with a button for each point and a space bar. The user can hence enter the points forming each character and then move to the next. Braille keyboards have their output counterpart in Braille displays, which can form letters and words using a mechanical surface where small spheres move up and down.


**Figure 3.2:** A Braille keyboard with chording keys

There are also keyboards of different sizes, which vary for the expansion or for the compaction of the keys: they support both those users who have difficulty in touching only the right keys, or in touching one key at a time, and those users with limited but precise mobility. Finally, keyboards adopting alternative schemes exist, like the Dvorak keyboard, in which the keys are arranged following different principles than in ordinary QWERTY keyboards. This can speed up typing for users with limited movement, but can also help people with problems in characters recognition or in writing, because of the improved organization of the keyboard.

Even the visual appearance of a keyboard can be modified in order to facilitate its use: a high contrast between the colour of the keys and the characters, as well as the subdivision of the keyboard map in different areas (letters, numbers, function keys ...) on a colour basis, can be a valid form of help for those with perceptive problems.

As mentioned above, keyboards meant to provide a better user experience to video games players can also be useful for people with hand mobility limitations: it is the case of the device showed in fig. 3.3. The keyboard is composed of a magnetic tablet where single keys can be arranged in order to meet with the user's needs and preferences. The keys can also be assigned

to complex commands (*macros*) in order to save time on the most common actions and to enhance the independence of the user in accomplishing determined tasks.

**Figure 3.3:** A customizable keyboard designed for video gamers

**Mouse and other pointing devices.** Mouse users can also count on a large number of assitive devices which can make the mouse usage easier (in some cases, also *possible*). As seen in the case of keyboards, arm supports exist, together with wrist-resting pads, which can leave hands free while lowering the fatigue charge for the rest of the muscles.

A valid alternative to the mouse, which can be viable for those users who can still move their fingers, is offered by trackballs (see fig. 3.4): they allow moving a cursor without needing a full arm mobility. In this case, users directly interact with a sphere protruding from the upper part of the device, as if it was an ordinary mouse turned upside-down. Joysticks are also similar to trackballs: they are small, easy to manoeuvre directional levers, normally used with the fingers of one hand. Some models exist which are expressly designed to be used with a foot or with the mouth, and also with the nose or with the eyebrows.

As in the case of figure 3.3, special mice exist which are designed, again, for video games players. Figure 3.5 shows a mouse with five buttons (a mouse normally has 2 buttons plus one wheel which is used for scrolling and as a third button). The buttons are in this case customizable, and the mouse


**Figure 3.4:** A trackball

can be adapted to the user's comfort by adding or removing weights from its interior, in order to get the preferred friction level on a table.

Together with mice and trackballs, many other devices exist which allow pointing on a computer screen: they can be grouped under the categories of graphic tablets, touch screens and touch pads. All these three families of devices allow pointing by direct interaction with a plain surface: in the case of graphic tablets, a pen must be used in order to produce any effect on the tablet, while touch pads and touch screens allow direct interaction between finger and screen. Touch screen solutions can be particularly effective because of their immediateness: on the software side they are often supported by programs allowing direct interaction with virtual objects, such as images. The ultimate technological innovation in this field is represented by multitouch screens, devices which can take the form of a smartphone (fig. 3.6) or of a large table (fig. 3.7) and allow complex interactions with vir-

**Figure 3.5:** A customizable mouse designed for video gamers

tual environments. Gestures associated to combinations of movements allow many actions and make the interaction with the machine simpler and more intuitive.

### Software Assistive Technology

As in the case of the hardware, software technology can be accessible or not. In this particular case, the approaches which can be followed are only partially the same as in hardware: the interaction with other software pieces can be made easier, or in some cases even *possible*; specific software for specific needs is also available. The former two are the most common forms in which software Assistive Technology is used and referred to. Adapting software in order to improve its accessibility is not a straightforward task for everyone: while in the case of hardware many adaptations can be designed and implemented very quickly by anybody having a little practical attitude, software normally requires a certain amount of expertise.

Some AT solutions rely on both hardware and software: common hardware devices can be applied to uncommon uses if specific software allows new


**Figure 3.6:** Two smartphones with touchscreen

**Figure 3.7:** Microsoft Surface, a table with multitouch screen

ways of interaction with them. It is the case of the MouseKeys functionality which is available in all major operating systems: in this case the mouse cursor can be controlled by pressing a limited number of keys. This means providing the users with a more comfortable and precise way moving a cursor without any need of changing the standard hardware configuration of their computer.

What follows is a description of some of the most used software solutions, starting from the built-in accessibility options of the major operating systems and going further along the above mentioned multi-directional *continuum*.

**Accessibility options in major operating systems.** Major operating systems allow small modifications to the input and output hardware behaviour, in order to help the user in reaching the best usage experience possible. Those option also involve the keyboard and the mouse. Table 3.1 compares the accessibility options available in Microsoft Windows 7, Apple MacOS X 10.6 and Ubuntu Linux 10.04[1], which at the time of writing are the three most common desktop operating systems. The listed features are those available on the three OS after a clean install, some other accessibility tools can be added in all three of them by the means of third party software packages.

| Features: | Windows 7 | MacOS X 10.6 | Ubuntu 10.04 |
|---|---|---|---|
| Step by step configuration wizard | Present | Not present | Not present |
| Screen reader | Present | Present | Present |

[1]Ubuntu Linux is here taken as representative of all GNU/Linux distributions because of the fact it is the most used and downloaded distribution at the time of writing, as reported bt the DistroWatch website, `http://www.distrowatch.com`. Due to the high flexibility of Open Source software, some distributions exist which concentrate on accessibility related issues. Those distributions are optimized for users with special needs, mainly visually impaired. See `http://www.tiflolinux.org/` and `http://sodilinux.itd.cnr.it/zoomlinux/` for more information.

| | | | |
|---|---|---|---|
| Screen zooming/magnifying | Present | Present | Present |
| colour inversion | | Present | Present |
| High contrast GUI theme | Present | Not present | Present |
| Contrast regulation | Not present | Present | Not present |
| Screen flashing/visual notifications | Present | Present | Not present |
| Stereo to mono audio reproduction | Not present | Present | Not present |
| Single pressures for key combinations | Present | Present | Present |
| Sound notification on modifier keys only | Not present | Present | Present |
| Delay between key presses and acceptance | Present | Present | Present |
| Filter of fast duplicate key presses | Present | Not Present | Present |
| Audio feedback for key presses when delayed | Present | Present | Present |
| Repeated keys speed regulation | Present | Present | Present |
| Repeated keys delay regulation | Present | Not Present | Present |
| Mouse pointer size regulation | Present | Present | Present |
| Mouse pointer controlled by numeric keypad (MouseKeys) | Present | Present | Present |
| Mouse pointer delay regulation (when controlled by keyboard) | Present | Present | Present |

| | | | |
|---|---|---|---|
| Mouse pointer maximum speed regulation (when controlled by keyboard) | Present | Present | Present |
| Mouse cursor size regulation | | Present | |
| Force typing break after a fixed amount of time | Not present | Not present | Present |
| Secondary click triggered by long click | Not present | Not present | Present |
| Persistent drag and drop (click lock) | Present | Not present | Not present |
| Primary click triggered when mouse stops moving | Not present | Not present | Present |
| Configurable click emulation | Not present | Not present | Present |
| Automatic positioning on active buttons | Present | Not present | Not present |
| Mouse track while moving the cursor | Present | Not present | Not present |
| Mouse detection from keyboard | Present | Not present | Not present |
| Support for external Braille keyboard | Not present | Present | Present |
| Speech recognition | Present | Present | Not present |

**Table 3.1:** Comparison chart of the accessibility features of the three major Operating Systems

The table takes into account only what is present in the control panels of each operating system, as they are available to users 'out of the box'. All three operating systems accessibility features can be expanded with other

software which can be open source, free, or proprietary. They can support a variety of external hardware devices and can also be at various level modified by the users in order to meet the user needs.

**Text-to-speech (TTS).** Users who are blind, have low vision or cannot read a text directly because of a learning disability can find text-to-speech systems particularly useful. This technology is often part of a more complex software solution, but can be used alone or in dedicated devices. TTS systems reproduce the sound of a human voice[2] by using different techniques in order to create sounds which are text-independent. This means that there is no pre-recorded word: the sound of each word is determined by combinatory rules and generated directly by the TTS system.

These systems are based on a combination of algorithms and acoustic samples which tend to simulate the natural functioning of the human speech apparatus. They can generate sounds which vary from almost-intelligible to very naturalistic-sounding. A speech synthesizer is substantially a software which can translate a text string into a sound which is recognizable as spoken language. Practical applications of such systems vary from automatic phone answering to non-visual browser agents.

As seen in table 3.1, the major operating systems include this functionality in their accessibility options list. They also allow using TTS to send vocal alert messages to the user, or to provide him/her with useful and unobtrusive information while working on something else. One of the most interesting aspects of this technology is hence its high versatility.

**Screen readers and non-visual browsers.** Screen readers try to identify and interpret what happens on a computer screen and communicate it to the user. They commonly use text-to-speech systems as output channels, but they can actually communicate with every other output device, as the

[2]Some voices are actually simil-human, as in the case of the robotic voices available in MacOS X. Note that the highly recognizable sound of those voices has served also for scopes which are not directly related with AT: the music industry adopts synthetic voices in order to obtain some particular effects.

Braille display mentioned in 3.1.3.

Screen readers exist since the era of command line interfaces. They were particularly efficient on those systems like UNIX or MS-DOS which only prompted simple text messages to the user: the paradigm adopted by such systems allowed the development of a linear interaction between the user and the machine. In the case Graphical Users Interfaces things are more complicated: they present graphics and text on the screen in a non linear way, compromising the user experience for those who cannot perceive the spatial organization of the screen. For this reason modern screen readers adopt a low level strategy and basically intercept signals going from the lower levels of the operating system to the higher ones.

Screen readers are particularly useful for people with partial or total blindness, low vision and other difficulties in reading. They are available for all the major operating systems: JAWS[3] and NVDA[4] for Microsoft Windows, Orca[5] for GNU/Linux and VoiceOver[6] for Apple MacOS. There are also some web implementations of typical screen reader functionalities, like Fangs[7] and WebAnywhere[8]. Also mobile phones have their screen reader solutions, like

[3]JAWS is produced by the *Blind and Low Vision Group* at Freedom Scientific of St. Petersburg, Florida, USA. The name is the acronym for *Job Access With Speech*. It is actually the most used accessibility solution for people who are blind or otherwise visually impaired.

[4]*Non Visual Desktop Agent* is an open source project which aims to offer a good replacement to the commercial JAWS. One of its most interesting aspects resides in the fact that it can be installed on a USB pendrive and carried everywhere. The software can be downloaded from `http://www.nvda-project.org/`.

[5]Orca is an open source scriptable screen reader for the Gnome desktop. It works with all Linux applications adopting AT-SPI (http://directory.fsf.org/project/at-spi/) and can be installed on any GNU/Linux system.

[6]Voiceover is the default screen reader application which is included in MacOS X. It can be easily activated via the preferences panel.

[7]Fangs is a plugin for the Mozilla Firefox web browser which can emulate the behaviour of a screen reader. It renders pages as row text, adding tags corresponding to what a non-visual browser would output. The project's homepage is available at `http://sourceforge.net/projects/fangs/`

[8]WebAnywhere tries to enable blind people to access the web from any computer they happen to have access to that has a sound card. It can be tried directly at `http://webanywhere.cs.washington.edu/beta/`.

Mobile Speak from Code Factory, available for Windows Mobile and Symbian. The touchscreen devices which recently became very common are now exploring new ways of combining interfaces without keyboards and text-to-speech: an interesting example is offered by the Eyes-free project[9] by Google Inc., which aims to render the mobile OS Google Android fully accessible for blind persons.

**Magnification.** Computer screens, especially those of laptops, have a limited range of dimensions. A smaller screen generally means smaller characters, but all mayor operating systems offer the possibility to change the characters size for windows and other graphical elements. In cases of low vision this could simply be not enough. This problem can be solved using a magnification solution, such as a lens applied to the screen (which would be a hardware solution). As long as external lenses could introduce many issues (they can be fragile or uneasy to handle) some software packages exist with magnification functionalities and some simpler magnification options are available in the operating systems default configurations.

Another advantage of a software magnifier used instead of an hardware one is the possibility to selectively augment contrast for the portion of the screen which is being magnified. This allows better recognition of the magnified area in opposition to the rest of the screen. In some software this is obtained by displaying negative colours. The magnification ratio can also be changed dynamically, which allows better adaptability and reduces the possibilities of assuming an incorrect posture while sitting in front of a computer.

Some examples of magnifying software are Ai Squared ZoomText[10] and Virtual Magnifying Glass[11].

[9]The Eyes-free project is free and open source. It is available at `http://code.google.com/p/eyes-free/`.

[10]ZoomText is a commercial product for Windows. It can be bought online at `http://www.aisquared.com/`.

[11]Virtual Magnifying Glass is an open source magnification tool available for Windows, MacOS and Linux. It can be downloaded for free at `http://magnifier.sourceforge.net/`.

**Speech recognition and dictation.** Speech recognition is the process with which a computer interprets and elaborates human oral language, transforming it into digital signal. This signal can hence be translated into text or into some sort of high-level command. No particular hardware than the audio card of a common personal computer is required in order to achieve good speech recognition and to be able to dictate text to a computer.

This solution can be adopted in many different fields, varying from healthcare to military purposes. It can also be used in order to automatize some particularly simple and repetitive tasks, like answering to the requests a public information phone service receives. Obviously this is a very good solution for people who cannot access a computer directly because of mobility impairment, but it can also be interesting for providing services while hands are already occupied: it is the case of GPS navigation systems for cars. The cited examples represent a way of *humanizing machines*, by following a logic of economy and simplification.

Modern general-purpose speech recognition systems are based on acoustic models. Stochastic algorithms, which consider small portions of speech (fragments of 10 milliseconds) as stationary units, allow calculating a statistical distribution of sounds. This process is commonly based on the use of Hidden Marcov Models (see Gales and Young in [58]), but other techniques are also adopted, such as Dynamic Time Warping (see Rabiner et al. in [140]). Speech recognition systems can be grouped into two categories:

- *speaker dependent*: they are trained in order to recognize one user per time, in the most efficient way. They adapt the above mentioned Hidden Markov Model to the user's voice and are able to recognize the most part of what they receive as input[12]. Software packages of this kind are not really useful when a large number of people is accessing the same service, specially if they do not have time for proper acous-

[12]Dragon Naturally Speaking by Nuance Communications, Inc. is declared able to reach a 99% accuracy rate in transcribing speech, as reported at `http://www.nuance.com/naturallyspeaking/products/editions/preferred.asp`, visited in July 2010.

tic model training. They are instead very good for people who need high level speech recognition in order to dictate text and to operate a computer.

- *speaker independent*: based on the same acoustic models of the speaker dependent recognition systems, speaker independent software allow less accurate recognition and a larger users base. This trade-off allows building specialized systems which only include a relatively compact vocabulary and few grammar rules. This fits perfectly with the needs of an automated information centre, but does not grant flexibility to the system.

Dictation systems were initially developed with the aim of simplifying and optimizing the data entry procedures for medical professionals, lawyers and clerks. They had a large market base, just like in the case of some special hardware mentioned above. The advantages that this software category can have on people with different kind of mobility impairments, like phocomelia, tetraplegia or muscular distrophy, and in general on whoever has difficulties in using a regular mouse or keyboard. The only prerequisite for using such a solution is the ability of speaking in an almost fluent way. People with mobility impairment are often equal to the able bodies under this particular aspect.

**Optical tracking.** Modern computers, especially laptops, are often equipped with a webcam. This kind of device, which is often the low-resolution version of a digital camera, has become cheaper and better in quality in the recent years. A webcam can be used in combination with specific software in order to recognize user movements and to associate them with actions. An example of this is nose tracking, a practice which allows to move the mouse cursor on the screen by simply moving and tilting the head. The software recognizes the position of the user's nose and follows its movement as a trackpad would follow a finger. Clicks can be triggered by pausing over an element for a minimum amount of time decided by the user, according to his or her ability

to stand still. An ordinary mouse can still be attached to the same machine without conflicting with the nose tracker, hence clicks can also be triggered in the traditional way by people without the possibility of moving the whole arm.

Among the existing nose tracking software we can mention Headdev[13] for Windows, Enable Viacam[14] for Windows and Linux and iNavigate[15] for MacOS. All three these pieces of software are free, the second and the third are released with open source licences.

### 3.1.4 Choosing an Assistive Technology solution

Choosing the right Assistive Technology solution for a particular person is not an easy task. It requires the person's collaboration and patience, but that is not enough. As Phillips and Zhao point out in [133], Assistive Technology devices cease to be used for many different reasons:

- change in user's needs in time;
- difficulty in finding the necessary tools;
- low quality, efficiency or efficacy of the chosen devices;
- scarce consideration of real user needs at the moment of choosing the device to be used.

According to Besio [17], the most important steps in the process of defining what particular technological aid is the best for one particular person are *evaluation* and *choice* of the AT solution. Both steps must take into consid-

[13]Originally developed by the Spanish Vodafone Foundation, it is now downloadable for free at `http://www.integraciondiscapacidades.org/index.php?m=Descargas&op=descargar&did=3`. The major drawback of this software is that it is only available in Spanish. The project also earned the Fundetec 2006 prize as non-profit project for citizens.

[14]The project binaries for both Windows and GNU/Linux and the source code are available at `http://eviacam.sourceforge.net/`.

[15]The project binaries and a tutorial video are available at `http://code.google.com/p/inavigate/`.

eration the user's needs, but also his or her peculiarities. Other important moments of this process are *comfort and satisfaction assessment*, which come after the adoption of the chosen device.

The Matching Person & Technology Model (MTP) proposed by Scherer in [145] individuates the causes for inappropriate use or total rejection of AT solutions in not considering critical personality preferences, psychosocial characteristics or needed environmental support. User's satisfaction is there defined as the degree of ease and gratification that the user expresses, while comfort is measured in terms of self-control and freedom of an user in a defined moment.

The process of choice, adoption and use of AT solutions is hence largely depending on users themselves, as the European Commission pointed out in [48]. Users are in the best position to evaluate the solutions they adopt and the services they receive. In the *rehabilitation* perspective, the process which leads a person to an autonomy increase and to a responsible and exigent way of acting is called *empowerment*. Following the ideas exposed again by the European Commission in [50], a user who undergoes and completes the *empowerment* process acts as a responsible, exigent and informed AT consumer.

This view derives from a long tradition of the medical and rehabilitation field. The professionals involved in supporting the choice of AT solutions normally evaluate the damaged functions of a patient, take account of his or her preferences and then discuss with him or her and with the patient's family the proposals of adoption of a particular aid.

As seen in section 2.2, the processes of appropriation of instruments and techniques is particularly important for children. A study from Verburg, described in [163], demonstrated that children who received a powered wheelchair show important improvements in both social development and in academical outcomes, while no significant changes were registered in communication and in physical development.

The utility of AT solutions changes as a child grows. We can describe four phases, basing mainly on Brinker and Lewis [18].

- before the age of 2, AT is useful to the child in order to obtain desired results;
- between the age of 2 and 6, AT solutions are used by the child to interact with objects on a more symbolic dimension;
- at 7 and until adolescence, children learn how to apply logical operations to the solution of practical problems, using AT in the most convenient way;
- during the adolescence, AT interventions focus on developing *problem solving* abilities and decisional activities.

As summarized by Besio in [16], the earlier children adopt AT solutions, the more advantages they gain in developing the related skills. AT acts as a facilitator for the empowerment of already present cognitive skills or for the acquisition of new ones.

## 3.2 One to one computing

As R. Penuel pointed out in 2006 (see [130]), one to one computing appeared as a school innovation model since the mid-1990s, when Microsoft sponsored the *Anytime, Anywhere Learning* program described by Rockman et al. in [142]. Apple Computer Inc., one of the main competitors of Microsoft, has also been funding many other initiatives in the USA and Canada, as those described by Silvernail and Lane in [148] Zucker et al. in [176].

All one-to-one computing initiatives share the idea that students must have individual access to technology, but they can be different with respect to some other criteria:

- *machine property*: in some initiatives, computers are property of the

school and remain there after the completion of the whole school cycle; in other cases, children are granted with the ownership of the device also after the school;

- *age of involved students*: one-to-one projects can address children of primary school, as well as high school students;
- *saturation*: the majority of one-to-one initiatives are pilot programs or are limited to a small number of schools and classes; a minority of projects involves the school population of a country with no exclusion;
- *connectivity*: depending on the project, there can be a focus on persistent networking connectivity or on occasional local networking exchanges;
- *software licensing*: some projects are based on machines on which proprietary software is installed, while others prefer to adopt Open Source Software only; a mix of the two options is the most frequent scenery.

Research on the topic of one-to-one computing based on USA projects reported various achievements and results. In general, one-to-one computing:

1. **increases students' motivation and engagement**: Russell et al. in [144] reported that mean level of engagement for students in 1:1 classrooms was significantly higher compared to that of the shared classrooms; increased student engagement was also cited as a result by Cromwell in [34] and by Rockman et al. in [142];
2. **lowers conduct problems**: in the case studies described by the Maine Education Policy Research Institute in [101], decreased disciplinary problems are cited among the results, as Baldwin in [5] reported of less problems related to conduct in a rural area;
3. **convinces teachers of the improvements in the skills of their students**: Drayton et al. in [42] reported extensively on how teach-

ers use technology and how their use is related to their judgement of the benefits of particular technologies for their teaching and for their students' learning and engagement;

4. **improves writing skills**: Rockman et al. [143] found that students who used laptops performed better than the others, Jeroski in [83] reported that giving students laptops increased the percentage of them who met performance standards by 22% over the course of one year; Lowther et al. in [99] found significant improvements in writing and problem-solving performance for students given 24 hour access to laptops; Mann et al. in [102] reported higher performance on a state examination for students with laptops, and in one South Carolina middle school, students with laptops sustained their achievement gains over their middle school years, in contrast to students who did not have laptops (see Stevenson in [152]); Suhr et al. in [154] reported on a two-year study of upper elementary classrooms where 1:1 students outperformed non-laptop students on English Language Arts (ELA) assessments.

Critics of one-to-one computing programmes sustain the ideas that such initiatives have too high costs (see Fitzgerald in [55] and Mowen in [113]), especially if the returns on investment are considered (as emerges from the works by Means and Haertel in [109] and by Oppenheimer in [123]).

Another common critique to one-to-one computing is linked to the higher problems in controlling the classroom for teachers (see Turnbull and Gilmour in [158], Newhouse in [116], Hill et. al. in [71], Kerr et al. in [88], Zucker and McGhee in [176], a heavier charge of work for teachers, (Kerr et al. in [88], Zucker and McGhee in [176]) and the difficulty of relating laptop usage and standard evaluation (see Newhouse in [116]).

Other problems, such as excessive weight and frailty of the machines, are documented, as well as scarce battery duration (which implies logistics problems disturbing classes), problems in software resources, loss of data, unstable networks issues and a general and widespread structural inadequacy of school

buildings (see Rockman in [141], Bartels in [7], Kerr et al. in [88], Lowther et al. in [99], Efaw et al. in [44], Hill e Reeves in [72], Garas et al., in [59]).

The following paragraphs describe the one-to-one initiative which constituted the background for this work.

### 3.2.1 The One Laptop Per Child initiative

In January 2005 Nicholas Negroponte presented the idea of a $100 laptop at the World Economic Forum in Davos, Switzerland. The news had worldwide resonance: the average cost of a laptop at that time was of several hundred dollars, and sub-notebook (also known as *netbooks*) did not exist yet. The idea of shipping a low cost laptop to the developing countries, providing them with an accessible instrument to bridge the digital divide, raised a lot of interest. This announcement had been preceded by a number of conferences where the topic of breaking down digital barriers was central: in 1997 the 2B1 Conference hold at the MIT Media Lab brought together educators from developing countries around the world to "break down world barriers of race, age, gender, language, class, economics and geography" [16]. After the 2B1 Conference the Nation.1 project[17] and the Junior Summit[18] were established.

The mission statement of the project retrievable from its website (`http://www.laptop.org`) clearly defines it as "an education project", and not "a laptop project". The initiative produced a low-cost laptop - known as the XO laptop - with low power consumption and resistant to physical damage.

[16]The quoted fragment comes from a the web page available at `http://web.mit.edu/newsoffice/1997/2b1.html`, last visited in October 2010.

[17]Nation.1 was a project to create what was described as an "online country", based on the Internet and only populated by young people. The country draft constitution is available at `http://www.fit.vutbr.cz/study/courses/OMP/public/software/sqcdrom2/Squeak_Swiki/718.html`

[18]The website of the international Junior Summit is available at `http://www.jrsummit.net/`

The Operating System is totally open source, based on the Fedora[19] Linux distribution, and adopts the Sugar[20] graphical interface. Sugar adopts a zooming metaphor instead of the classic desktop paradigm.

The five principles which constitute the pillars of the project[21] are:

1. *Child Ownership*: the ownership of the XO by the children is considered a basic right, coupled with new duties and responsibilities, including protecting, caring for, and sharing it;

2. *Low Ages*: the laptop is designed for the use of children ages 6 to 12, even if nothing precludes its use earlier or later in life; a basic idea is that children do not need to know how to write or read to enjoy and learn with an XO;

3. *Saturation*: OLPC appoints to reach "digital saturation" in a given population, by choosing the best scale in each circumstance: a country, a region, a municipality or a village, in which every child and teacher will own a connected laptop;

4. *Connection*: the XO has been designed to provide an engaging wireless network; the laptops can connect to others nearby also in absence of an external network infrastructure;

5. *Free and Open Source*: as the objective of OLPC is to create open learning communities, Open Source software is preferred for the possibility it offers to be modified and adapted to learning needs.

The learning vision of OLPC is that by giving children direct access to connected laptops, they can actively take part in processes of knowledge construction, and not be limited to passive reception of information. The XO

[19] Fedora is the Open Source version of the famous GNU/Linux dstribution called Red Hat. Its official website is available at `http://fedoraproject.org/`

[20] Sugar is developed by a volunteer association called SugarLabs (`http://sugarlabs.org`)

[21] The Five Principles are listed on the project's wiki, at `http://wiki.laptop.org/go/OLPC:Five_principles`

laptop and Sugar follow the theories of constructionism developed by MIT Media Lab Professor Seymour Papert ([126], [128]) and the principles articulated by Nicholas Negroponte ([115]).

### 3.2.2 The XO laptop

The most famous facet of OLPC is the XO laptop: a tiny machine designed for children, made highly distinguishable from the majority of devices for its particular look. Many versions of it exist, but the ones actually being used in the deployments are the models known as XO-1 and XO-1.5. At the time this project started, only the former was available. The XO-1, as shown in figure 3.8, is a white and green device, measuring approximately 242mm x 228mm x 32mm and weighting 1.5 Kg.

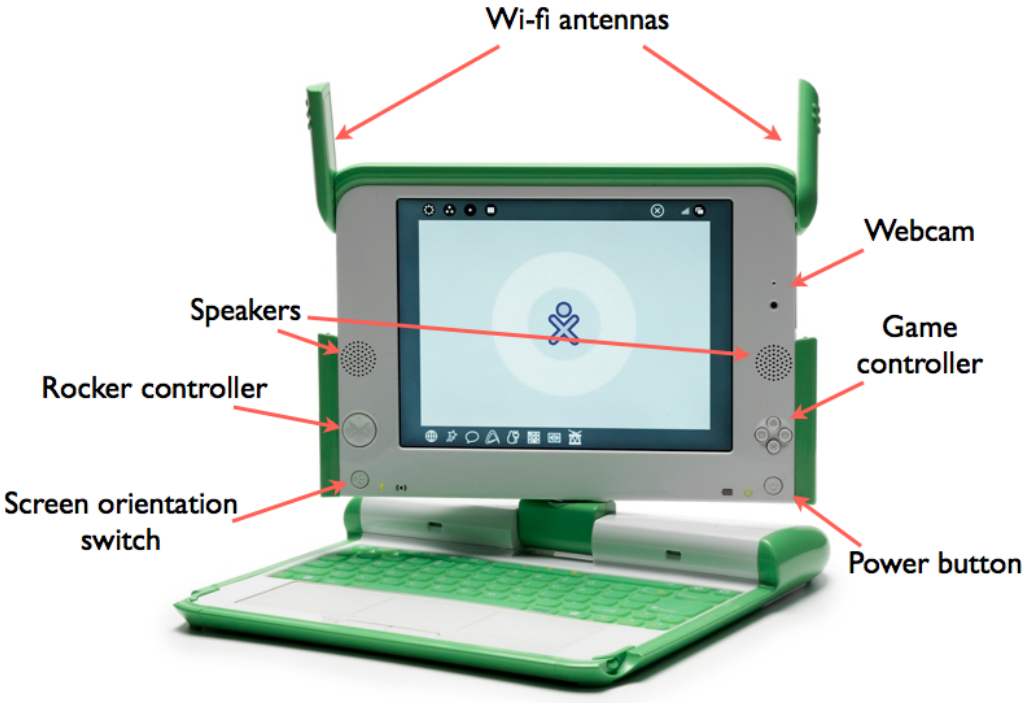


**Figure 3.8:** The XO-1 laptop

The XO-1 features two wi-fi antennas, a rugged keyboard, game controllers on each side of the screen, speakers, a microphone and a webcam. The screen can be turned on its back and then closed, transforming the device into a sort of tablet/game console. The processor is quite slow (AMD Geode LX-700@0.8W, with a clock speed of 433 MHz) and the RAM is limited to 256 MB. The main hard drive is 1GB solid state. Every component of the machine was chosen with the aim of reducing the power consumption, granting a duration of more than 3 hours to the NiMh battery. The device also supports standard connectivity to external hardware through three USB ports, has audio input and output ports, includes a memory card slot and can also be used under direct sunlight, thanks to the display which can turn monochrome maintaining readability.

The XO-1.5 is externally identical to the XO-1, but includes more powerful hardware, as a VIA processor with 1GHz clock, 1 GB RAM and a solid state 4GB hard drive. As of August 2010, these improved machines are being introduced in the deployments. A slightly modified version of the XO-1.5, known as XO-HS (XO for High Schools) is blue and features a keyboard which is more similar to those of common laptops.

In December 2009 OLPC founder Nicholas Negroponte, after having proposed the idea of an innovative XO-2 made of two touchscreen panels, announced a newer device, called XO-3: it will consist of a tablet pc, with no keyboard, as the visual prototype reproduced in figure 3.9. The idea raised great expectations in OLPC supporters, even if it is not clear how this change in the hardware paradigm could influence the learning experience of prospective users.

### 3.2.3 The Sugar Learning Platform

Sugar is the name of the Graphical User Interface adopted so far by the XO laptop. It was originally part of OLPC, but now is independently developed

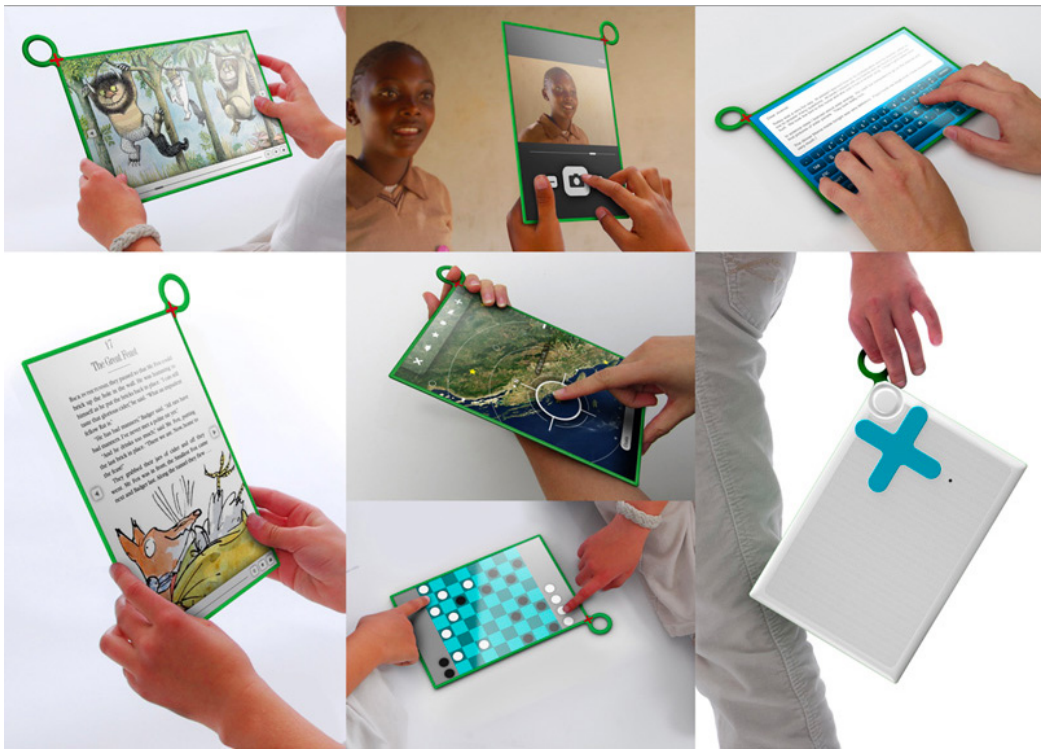

**Figure 3.9:** The XO-3 tablet

and distributed by a non-profit foundation called Sugar Labs [22]. According to the project website, Sugar "promotes collaborative learning through Sugar Activities that encourage critical thinking" and it "offers an alternative to traditional office-desktop software".

Sugar, which is technically a substitute to other more famous Desktop Environments available for the GNU/Linux operating system[23], uses a graphical paradigm which is completely different from the *de facto* standards of desktop environments of every OS, Windows and MacOS included: its interface

[22]The SugarLabs website provides software downloads, installation instructions and a wiki covering the various aspects of the project. A public software repository is available at `http://activities.sugarlabs.org` which allows Sugar users to download and install several programs. The community of developers and sustainers of the project is active on the 'It's An Educational Project' (IAEP) mailing list.

[23]Gnome (`http://www.gnome.org`) and KDE (`http://www.kde.org`) are probably the most famous and the richest in functionalities, but many other Desktop Environments exist and are preferred by the users for their diverse features.

is zoomable[24], allowing the children to focus on themselves, on their close friends or on the school/class group at any time. Strictly, there is no desktop: the metaphor which used to directly link the computer to the office environment by simulating a desk was abandoned in favour of a more child-centred one. Sugar applications are called "Activities", and the most common among them have names such as "Browse", "Write", "Paint": clearly inspired by the Constructionist learning theory discussed in the previous chapter, they are the instrument with which the user *acts*, and represent what one can do with the machine. They also make the user experience more direct: a child who knows the concept of "writing" does not need to know what is the name of his or her writing tool. He or she just needs to write.

The whole Sugar project is composed by different parts, which are organized following this structure:

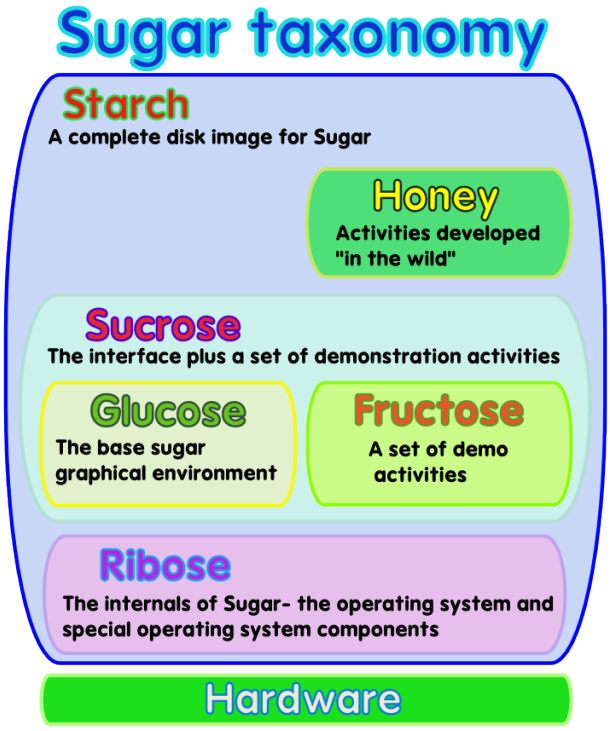


**Figure 3.10:** Sugar Taxonomy as schematized in the SugarLabs Wiki.

[24]For a review of the different kinds of interfaces, see [32]

SugarLabs calls "Sweet" the abstract design of the interface's appearance and behavior, independent of any code actually implementing it. By extension, Sweet is the learner experience. At the base of the system there is 'Glucose", the minimal collection of software packages that must be added to a standard GNU/Linux distribution in order to enable Activities to run. This includes all the source code and graphics files that implement the shell. Glucose depends on general purpose software, like the X graphics server[25] and Xulrunner[26] which are not present in all GNU/Linux distributions by default. Glucose does not include any Activities except the non-optional ones.

On top of Glucose is installed a basic set of Activities, called "Fructose". Those activities are selected in order to make the environment attractive for a potential user. Packages grouped in Fructose are stable and exercise the widest possible range of features. Fructose may also serve as a collection of examples for people developing their own Activities. Glucose and Fructose together form Sucrose, which therefore represents a complete example Sugar environment, ready to be installed through a package manager. Sucrose is mainly intended to provide prospective deployers with an easy to install package displaying all Sugar potentials.

On the hardware level, "Ribose" is a set of software components that have been developed throughout the Sugar project, since it was part of OLPC. It includes the XO laptop kernels, any init-script customizations, etc. Ribose includes all components necessary to boot the system, enough to install Glucose if it has not yet been installed.

Sugar is often distributed in complete disk images, ready to boot from a CD or from a pendrive. These images are composed of multiple elements of the above stack. Each image series is named separately, to minimize

[25]The X.Org server is a graphic environment allowing programs to be displayed on the screen on top of various operating systems. See `http://www.x.org` for details.

[26]XULRunner is a runtime environment developed by the Mozilla Foundation to provide a common back-end for XUL applications, allowing to add webpages rendering capabilities to other software packages. More information is available at `https://wiki.mozilla.org/XUL:Xul_Runner`

confusion.

Besides the officially developed and maintained Sugar system, some Activities exist that are packaged by outside developers. Sometimes they are ports of programs for other Operating Systems or Desktop Environments.

### 3.2.4 Sugar User Interface

As mentioned above, the Sugar GUI is revolutionary for not being based on the most common Desktop metaphor. It is designed as a zoomable interface and opened Activities automatically go fullscreen when launched, displaying toolbars in the upper part of the screen. Users can switch at any moment from an Activity to another, or to one of the "Views" available by default: the Neighbourhood view, the Friends view and the Home view. When a user boots into Sugar the Home screen is the default view, showing the user's avatar and the favourite Activities surrounding her/him. On the other side, the Neighbourhood shows the avatars of the children connected to the same network, the wifi access points and the Activities they are actually sharing. The Friends view is a sort of bookmarking area, acting as a filter for the neighbourhood where children marked as friends are displayed. Their avatar is grey when they are not connected, but has colour if they are online.

By moving the mouse cursor in the corners of the screen, a panel appears on the four sides. This panel shows relevant information about the status of the computer in the lower side, a list of icons of the available Views and of the opened Activities on the upper side, a list of copied elements ready to be pasted or to be opened with an Activity on the left and a list of connected users on the right.

There is no limit, other than disk space, to the Activities which can be installed on a XO laptop. Sugar allows to mark an Activity as "favourite", which determines its visibility in the "Home" screen. Note that the more favourite Activities are displayed, the smaller they become. It is not rear to

see a child in trouble with his or her XO because of too small icons which do not help in finding the desired ones.

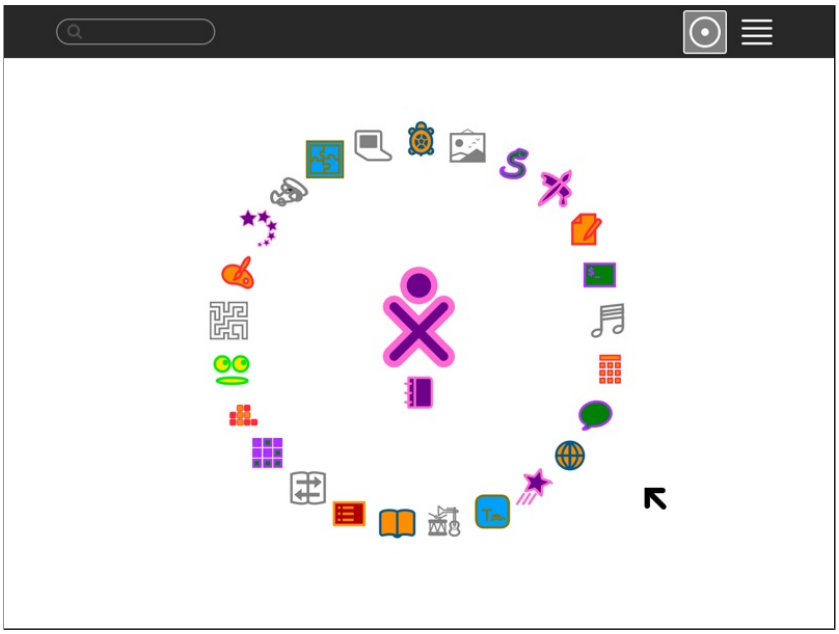

**Figure 3.11:** The Sugar Home screen, with a child avatar in the center and a circle of Activity icons surrounding it.

In Sugar there are no folders: every piece of information is automatically stored by a special Activity called Journal, which can be searched by content, by type and by editing time. In earlier versions of the software, the Journal entries were saved without notifying the user, while in more recent releases the system pops up a dialog window which still saves entries as a default, but contextually allows the user to enter a description and/or some keywords for that particular entry.

While using Sugar, from the above mentioned Neighbourhood view, the children can see how many other users of the same system - hence, their classmates, or other children from the same school - are active nearby or are connected to the same collaboration server. They can share their activities by actually collaborating in real time, not only by sending files to one an-

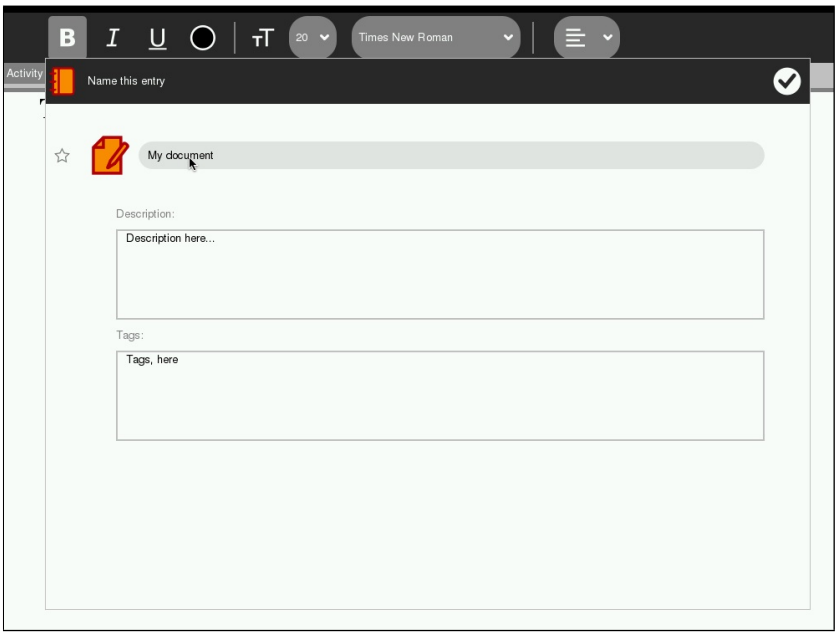


**Figure 3.12:** The Sugar Journal saving dialog, allowing to add metadata.

other[27]. Once an activity is shared, the Journals of the involved children are populated with the same entry, which means they can actually have their own copies of text documents, images, videos and chats.

Sugar is an environment designed for clients, but the OLPC project also developed a custom Operating System for servers, to be used in schools: it is called "XS". Users connecting to a school wifi network can be automatically provided with some services: XS hosts a Jabber server, which makes the connections between the laptops stabler, a proxy server capable of optimizing network traffic and filtering inadequate contents and a backup service, which can free up space on the XOs transparently. The XS school servers can also host upgrade packages for Sugar which can be installed automatically from a trusted source.

[27]The collaboration features are based on the XMPP protocol, which is the same protocol used by the famous instant messaging service Jabber. This allows point-to-point and client-server communication.

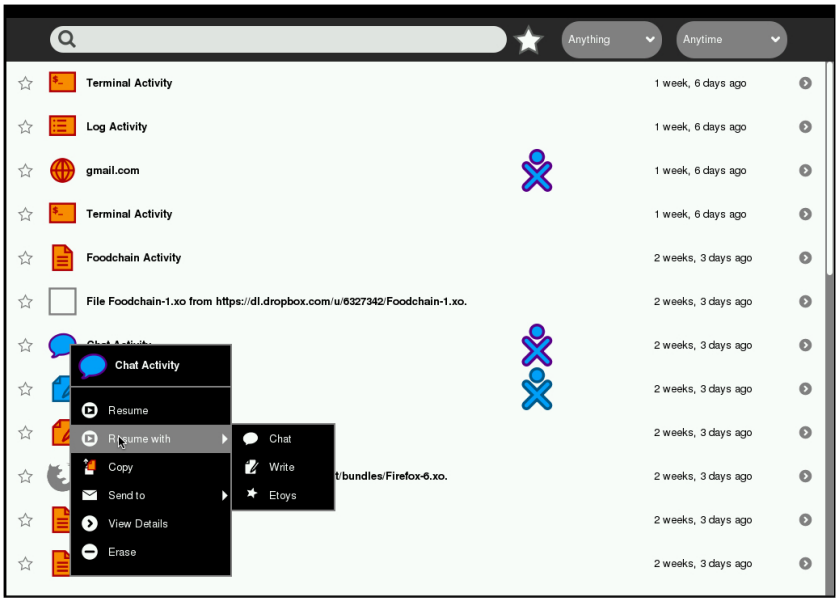


**Figure 3.13:** The Sugar Journal Activity displaying recent jobs. The avatars listed on the same line of an entry actually tells with whom that activity was used that time.

### 3.2.5 Sugar (and the XO) as a Personal Learning Environment

The idea of Personal Learning Environment (PLE) as opposed to Virtual Learning Environment (VLE) is an emerging, relatively recent one. A VLE is normally associated to a Learning and Course Management System, such as Moodle[28], Dokeos[29], ILIAS[30] or Docebo[31]. The most common definitions

[28]Moodle (abbreviation for Modular Object-Oriented Dynamic Learning Environment) is a free and open-source e-learning software platform, also known as a Course Management System, Learning Management System, or Virtual Learning Environment (VLE). Its website is available at `http://www.moodle.org/`.

[29]Dokeos is a company dedicated to open source Learning Management Systems. Its main product is a SCORM-compliant learning suite used by multinational companies, federal administrations and universities. The company website is available at `http://www.dokeos.com/`.

[30]ILIAS (`http://www.ilias.de/`) is an open source learning management system for developing and realising web-based e-learning.

[31]DoceboLMS is a SCORM compliant Open Source e-Learning platform used in corporate, government and education markets. The community website is available at `http://www.docebo.org/`.

of PLE which can be found in the literature include various views:

- technically, they are a hub for contents and contacts related to the learning experience of a single person. They can be composed by both desktop and web applications, with every piece of software supporting the user in a particular task [4];
- in opposition to Virtual Learning Environments and LMS platforms, they prefer the usage of independent (even if interrelated) web 2.0 applications, following the "Software As A Service" model; as [40] suggests "it is not just Web 2.0, but it is certainly Web 2.0 in the sense that it is (in the broadest sense possible) a read-write application";
- socially, a PLE is a set of instruments which gives value to individual contributions in a learning ecosystem. [29]

Following the above definitions, Personal Learning Environments provide learners with the possibility of combining the tools they need for searching, editing, mashing up and sharing contents, information, networks of contacts. Both the perspectives of self-directed learning and peer-to-peer learning are involved. The role of the teacher seems to loose (part of) its centrality, becoming a *facilitator*. The whole process leads to *disintermediation*[24]: by building a personal set of tools, the learners consolidate their social network as a learning community.

According to [69], technology-enhanced student-centred learning environments have been touted as means to support the processes of "divergent reasoning, problem solving, and critical thinking". This statement fits perfectly with the OLPC educational mission and describes the ideas on which the Sugar Learning Platform is based.

A PLE is, at first, *personal*. It is composed by a selection of software tools on a personal computer. This selection must be made by the computer owner. Children involved in OLPC deployments own the computer they use (as said above, it is one of the five principles of the project) and the Sugar GUI

allows them to install a wide range of applications. Sugar Activities are structured as plug-ins and a large collection of them is available at `http://activities.sugarlabs.org`.

A PLE is for *learning*: Sugar can be useful in different learning settings:

- *self-directed learning*: a user can read, write, record audio, watch videos, search information;
- *teacher-directed learning*: in the classroom context, the teacher can use the computer as a means to support contents presentation;
- *cooperative and peer-to-peer learning*: Sugar allows sharing contents and whole activities in a real-time collaboration environment. The special hardware of the XO allows point-to-point connection even without network infrastructure such as an Access Point, favouring the creation of flexible social networks. When connected, the GUI shows the presence of other users by the means of their avatars. A single user can start an Activity and then share it with his/her neighbourhood, or directly invite someone else to join it.

A PLE is an *Environment*: the Sugar UI adopts a spatial metaphore where the user's avatar is located at the centre of the screen. This child-centred environment is not isolated: every XO laptop can become automatically a node of an interconnected, shape-changing network. Every node can connect to the internet and to the other nodes, with no hierarchy.

According to Attwell, as in [4], the only thing on which the existing literature seem to agree about PLE is that it is not just a matter of software applications. There is a border category between interaction design (ID) and cognitive psychology that could be used as a definition of what a PLE is. A PLE could be represented as a *cognitive artifact*.

In the ID perspective, cognitive artifacts are *"... man-made things that seem to aid or enhance our cognitive abilities, and some examples are calendars, to-do lists, computers, or simply tying a string around your finger as a reminder"*

[78].

According to [119], cognitive artifacts may also be defined as *"those artificial devices that maintain, display, or operate upon information in order to serve a representational function and that affect human cognitive performance"*.

An educational point of view is offered by Seymour Papert with the constructionist learning theory seen in section 2.2. As explained above, this theoretical framework suggests that the mind involved in a learning process needs to build objects and devices in order to generate ideas. It also needs to use appropriate materials, adopting the "trial and error" procedure. Papert considers this kind of learning materials as "objects to think with" [126] and calls them cognitive artifacts. Each attempt in the trial and error cycle aims to represent the world around the learner by the construction, dismantling and reconstruction of cognitive artifacts and at the same time developing analysis, comparisons, and discussions with peers. Also according to Papert, this condition applies at any age, to children, adolescents or adults. PLE development satisfies the need for a *life-long* and *life-wide learning tool* adaptable to personal learning styles.

Norman says that cognitive artifacts *"make us smarter"* [118], allowing us to overcome the limitations of human memory and reasoning by enhancing our cognitive abilities through external devices.

Personal Learning Environments seem to fit perfectly with the concept of cognitive artifact introduced above. Their commonly accepted definitions describe them mainly as software suites, but during our learning sessions we do not only need software. Let us think to the most common activities in which we engage while studying and learning:

- we read texts;
- we manually highlight important passages, take notes and sketch diagrams;

- we look for information and contents, then we directly manipulate and share them with our peers;
- we collaborate, online or offline, with other people.

In order to do all these things, we need an ergonomic support designed to cope with our needs. This physical device, which could also be a collection of devices, can be considered as part of our PLE. Following the ideas about cognitive artifacts described by Papert, the hardware cannot be separated from the use we make of it. When the cognitive artifact is ubiquitous it starts to "melt" with the background (see Norman in [119]): its pervasive presence is no more a novelty or an oddity, but a precondition in the learning environment. When this kind of devices are treated as basic learning enablers they become invisible, in the sense that nobody pays any attention to them: all the interest is for the service which is being offered.

The XO laptop adopted in the environment studied is an *inclusion instrument* in the learning environment, by the fact it is an egalitarian, basic dotation for everybody. But this laptop is also an *inclusive learning environment*: it is in the hands of all the actors of the educational process, from teachers to children. Through Sugar, it allows to create and to share knowledge in a multidirectional, non-hierarchical way. Being highly recognizable as "the OLPC laptop" and not as "an ordinary laptop" it helps aggregating its users in a community oriented to learning objectives and not only to technology.

In the first OLPC deployments, technology becomes a *commodity*, the computer is a context-variable, an element of the infrastructure for networked learning in which the children operate. This means that this cognitive artifact is starting to fade out and is becoming invisible, in the sense exposed above.

Functionally, the XO is:

- a *cognitive amplifier*: a tool designed for children and equipped with software which can empower their cognitive potential (computation

abilities, memory, writing skills, etc.);

- a *relational amplifier*, which can connect (automatically) its owners. According to Metcalfe law, the network value increases as saturation increases. The XO actually multiplies the opportunities for creating social links.
- a *platform to access instructional contents* which can be online or can be hosted by the machine itself;
- a *knowledge-creation tool* by the means of individual and collaborative activities;
- an *instrument for sharing knowledge* with peers and, in presence of internet access, for publishing.
- an *e-portfolio*: with the journal Activity that Sugar uses to store every single action, the children can dispose of a chronological archive of all the instructional activities, the working sessions and the materials produced and shared.

But the XO laptop also presents a few issues:

- *pluggability*: Sugar allows to easily add instructional activities as plug-ins. Children can choose, download and install hundreds of applications from `http://activities.sugarlabs.org`, but this software collection cannot be run natively on the rest of the operating systems. This limits Sugar in a closed environment. A PLE should be totally open to web 2.0 resources and integrated with its services;
- *widget based interface*: a PLE is often represented as a customizable dashboard composed by widgets that visualize data flows from different learning resources and networks. Sugar presents a unique GUI that puts the child at the centre of the graphical space among activities and learning networks. It does not provide any useful and handy way to monitor real time information flows;

- *life-long learning and life-wide learning tool*: a key objective of a PLE is to provide an environment for tracking learning outcomes deriving from both formal and informal experiences. Hence the PLE is an artifact structured around the life-long and life-wide learning concepts. XO and Sugar look more like a "childhood-long" learning environment because the hardware ergonomics and the software characteristics are straightly addressed to K6-K12 targets.

### 3.2.6 Criticisms on OLPC

Besides receiving the critiques which are common to all one-to-one computing projects exposed in 3.2, OLPC has been criticized for its ineffectiveness in enhancing the learning experience of the children involved in the various deployments around the world: this critique is reported by Buchele in [22]. The majority of those criticisms come from individual blogs and websites, from comments on the official project wiki or from the independent blog OLPC News[32].

One of the most criticized points is the appropriateness of using economical resources to provide laptops for children in those areas of the globe where food, water and basic medical care should come first. The main answer given to such objections by OLPC supporters is that education is a primary need, just as nutrition and peace are. Even with this focus on education, there seem to be other priorities: many poor countries in the world do not have adequate classrooms, or enough teachers to offer a good education to their children. If governments of poor nations spend the little money they have on laptops, they are necessarily spending less money on textbooks, teachers, and schools. The OLPC project promises to bring whole libraries of textbooks, and other educational resources, directly to the children.

[32]OLPC News is an *independent source for news, information, commentary, and discussion of One Laptop Per Child's '$100 laptop'*, as can be read on `http://www.olpcnews.com/`.

OLPC points the finger at the lack of educational resources, at the ineffective educational structures and methodologies, and at the time it would take for some governments to bring basic educational services to all its children:

> Many children – especially those in rural parts of developing countries – have so little access to school – in some cases just a tree – that building schools and training teachers is only one way – perhaps the slowest way – to alleviate the situation. While such building programs and teacher education must not stop, another and parallel method advised by OLPC is to leverage the children themselves by engaging them more directly in their own learning. It may sound implausible to equip the poorest children with connected laptops when rich children may not have them, but it is not. Laptops can be affordable and children are more capable than they are given credit for.

### 3.2.7 OLPC and the disabled

Notably, the OLPC website (the domain `http://laptop.org`) does not seem to mention disabled children at all[33]. But children with special needs are not absent from the developing countries: according to [45] and to [19], their percentage is higher in poor areas.

As will be discussed later in this work, the XO and the Sugar GUI offered no one of the accessibility options listed in table 3.1. This other fact, added to the lack of a discourse about disability, seems to lead to an easy conclusion: OLPC did not include accessibility, at least in its traditional computer-related meaning, and Assistive Technology in its original plans.

My intention here is not to draw naive conclusions from these facts, but to

[33]The research of the words “disabled”, “disability” and “accessibility” with Google on the OLPC website gave no results in January 2010. An accessibility related mailing list does exist under the same domain, even if its activity is quite low.

open up a new perspective, which allows considering OLPC as an inclusive project: the XO laptop seems to be perfectly adherent to the principles discussed in section 3.1 regarding AT solutions in classrooms:

1. Every child in the class, disabled or not, should know how the XO works, what it is useful for and what parts it is composed of;
2. Every child should learn how to use the XO laptop;
3. The set up of the environment for the children should be considered as part of the learning activity for every child.

In simpler words, the XO laptop perfectly fits the guidelines for AT interventions proposed by Canevaro in [23]: this fact could be considered a step towards the creation of an inclusive and equalitarian environment. The problem remains that the device, in order to be really inclusive, must be completely accessible. Otherwise it would be like creating high speed motorways for people who only have charts moved by horses.

This was one of the most important points for the first part of my fieldwork: transforming the machine in an accessible device for those who have hand mobility impairments, in order to make the creation of an inclusive environment possible.

## 3.3 CEIBAL

In December 2006 the former Uruguayan Republic president Tabare Vazquez announced the beginning of the CEIBAL plan. The plan was meant to involve every pupil and every teacher of the public schools of the country, delivering laptop computers for free to each of them.

The name CEIBAL is the acronym of *"Conectividad Educativa de Informática Básica para el Aprendizaje en Línea"* (Basic Computer Connectivity for Education and Online Learning). While announcing the plan, Tabaré Vázquez

declared that it was going to make all the children in the country "technologically equal". The name "CEIBAL" was created and chosen because of the symbolic meaning that has for Uruguayans the Ceibo, a national emblematic tree and flower. The OLPC XO-1 laptop computer used in the project is therefore nicknamed *ceibalita*.

The plan started with a pilot in Villa Cardal, in the *departamento*[34] of Florida, involving 150 laptops distributed in primary school classes. They were also provided with a connectivity infrastructure, as reported in [79], which covered the school building and allowed the children to connect from outside it.

The CEIBAL plan is divided in three phases, which can be classified geographically and chronologically:

1. covering the whole *departamento* of Florida (2007);
2. expanding to the other *departamentos* of the interior part of the country (2008),
3. covering the urban area of Montevideo, the capital city (2009).

This timetable was fully respected and the last XO laptop stock was delivered to the children of Montevideo schools in October 2009.

The plan has been developed in conjunction by the *Ministerio de Educación y Cultura* (MEC - Ministry of Education and Culture), the *Administración Nacional de Telecomunicaciones* (Antel - National Administration of Telecommunications), the *Administración Nacional de Educación Publica* (ANEP - National Administration of Public Education) and the Laboratorio Tecnológico del Uruguay (LATU - Uruguayan Technological Lab). The latter received the charge of leading the technical and operative part of the project by the effects of a presidential decree.

[34] *Departamento* is the common Uruguayan name for a province, which normally counts on a town surrounded by smaller villages.

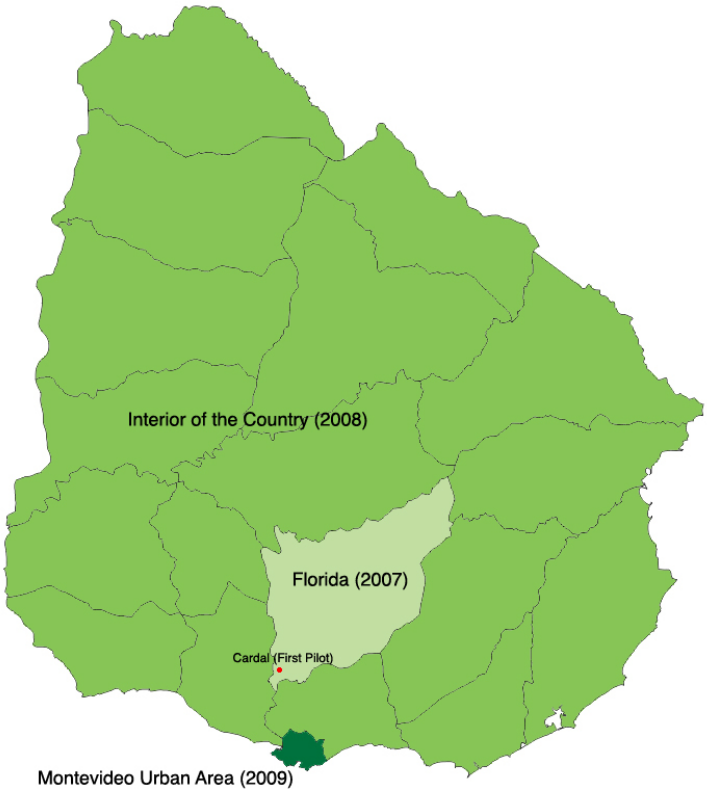


**Figure 3.14:** The expansion of CEIBAL over time

The initiative is inscribed in the *Programa de Equidad para el Acceso a la Información Digital* (PEAID - Equity Programme for the Access to Digital Information) and, on an international level, is a deployment of the above described OLPC project.

The institutional website of the CEIBAL plan[35] reports the following general objectives:

- contributing in the improvement of the quality of education by the means of integrating technology in classrooms, in schools and in the houses of the children;

[35] Available at `http://ceibal.edu.uy/`

- promoting equality in opportunities for all the pupils of Primary Education, by giving a laptop to every child and teacher;
- developing a collaborative culture in four directions: child-child, child-teacher, teacher-teacher and child-family-school;
- promoting digital literacy and critical abilities in the pedagogical community following ethical principles.

Some other objectives are then listed, referred to as "specific objectives":

- promoting the integrated use of a portable computer with the educational proposals of the class and of the school;
- achieving a better educational use of the new media, in both the technical and in the educational area, by the means of teacher training and updating;
- producing educational resources based on the available technology;
- facilitating the involvement and the technological appropriation of the teachers;
- generating support systems and specific techno-educational assistance services for schools and for the adequate development of their experiences;
- involving parents and families in accompanying and promoting an adqueate and responsible use of technology, in the advantage of the child and of the family itself;
- promoting the participation of all the people involved in the production of information relevant to decision-making processes;
- facilitating the creation and development of new learning communities by promoting autonomy.

Starting from January 8th, 2010, the law 18.640 created de Centre for Technological and Social Inclusion (CITS - Centro para la InclusiÃşn TecnolÃşg-

ica y Social). The same act officially configured CEIBAL as a legal entity directly linked to the Uruguayan Republic presidency.

### 3.3.1 CEIBAL in the special schools

In Uruguay there are 75 public schools classified as "Special Schools". Among them, 49 are in the interior of the Country, while 26 are Montevideo. The special schools of the capital city are classified on the basis of the impairment they deal with[36], as shown in table 3.2.

| **Impairment** | **Number of schools** |
|---|---|
| Mobility | 1 |
| Auditory | 1 |
| Visual | 4 |
| Intellectual | 20 |

**Table 3.2:** Public special schools in Montevideo

The population of such schools was traditionally made of children with lesser impairments. In 1985 the national education system introduced the possibility for integration in mainstream schools: since then, integration projects started, allowing the participation of hundreds of children in mainstream school classes. In the same period, special schools started receiving children with higher degrees of impairment.

Teachers of special schools do not receive focused training during their studies: they initially receive only a brief training which they are supposed to enhance with practice and with further courses after receiving the charge of teaching in a special school.

The relationship between special and mainstream schools is one of support from the former to the latter: special schools, besides directly teaching chil-

[36]Source: ANEP, as cited by MIDES (Ministerio de Desarrollo Social) in `http://guiaderecursos.mides.gub.uy/mides/text.jsp?contentid=6670&site=1&channel=mides`

dren, act as centres of training and counseling for teachers integrating children with special needs in their classes.

Among the problems of the Uruguayan special education system that teachers explained to me during the fieldwork, there are the difficulty in maintaining a continuous communication with families and the lack of specialized personnel, such as technicians, social workers and psychologists.

### The School 200

The School 200 "Ricardo Caritat" is a very small school, with a limited amount of personnel: this includes an "itinerant teacher", dedicated to following the cases of the tens of integrated mobility impaired children in the mainstream schools of Montevideo. In the past, during the 1990s, the school also had responsibility over the *departamentos* of Canelones and San JosÃľ, hence on other towns and country areas outside the capital city.

The school is active in the organization of training sessions and other public events for teachers involved in the integration of the mobility impaired. Its personnel estimates roughly 80% of the teachers of mainstream schools to be aware of the existence of such an institution. It can also count on the support of volunteer groups (often including parents of the pupils), of university students and of prospective primary school teachers.

Among the technical personnel of the School 200 there is a physiotherapist and a specialist in language disorders. A psychologist is in charge of writing evaluations of the children to set the basis for integration projects.

The school is opened to pre-school children aged 3, 4 and 5 and to primary school children in general, which in Uruguay means up to 12 years old. Children are grouped primarily by age, then by level of intellectual functioning. Classrooms are small and equipped with special 'U' shaped desks, designed for welcoming a wheelchair. As in the school there are not enough wheelchairs for all the children needing one, the pupils often sit on ordinary chairs and

are secured by Velcro belts.

Integration interventions try to be precocious, and to include children in mainstream schools as soon as possible. Since 2007 the school 200 only covers the needs of children of pre-school and primary school age. Students of technical schools and high schools, as well as university students, rely on other resources.

**Figure 3.15:** The School 200 main entrance


**Figure 3.16:** Wheelchairs at the entrance of the School 200

# Chapter 4

# Action Research in Special Schools

As can be easily understood by the variety of topics touched in Chapters 2 and 3, this research adopts a multidisciplinary approach, joining technological and educational interests in order to evaluate the inclusive potential of technology in a relatively new and unexplored setting. The project can be divided into two phases, which partly overlap. The first of these phases was dedicated to an exploratory study with the double intent of revealing the accessibility needs and understanding the idea of integration and inclusion in the Uruguayan school context. The second phase, which began during the first fieldwork experience and was terminated within the second one, concentrated upon four case studies of integrated children, in order to highlight some notable consequences of 1-to-1 computing in special education. This chapter provides all the information about the first part, while the analysis of the case studies is carried out in the following one.

Following the ideas which are commonly associated to the Action Research model, the whole project is strongly directed towards *problem solving*: children with mobility impairments were provided with solutions specifically

studied in order to facilitate the access to the machines, teachers were involved in the process of reflection and design, technicians were counselled in order to facilitate future problem solving.

The following sections report the analytical description of the whole process, starting from the definition of the research questions, telling how the project was designed and what methodological strategies were adopted during the fieldwork and finishing with the description of the main findings and results.

## 4.1 Research Design

For this first part of the research various methodologies were mixed in order to obtain the best results in studying the different aspects involved, actually developing a *research strategy*.

Under an epistemological point of view, adopting an Action Research (AR) perspective raises the problem of credibility of the results: what is described in the following chapters is the result of a day by day work in a particular environment and is not something generalizable. As Greenwood and Levin point out in [67], this is a problem of *credibility* and *validity*. They define credibility as *the arguments and processes necessary for having someone trust research results* (page 67) and distinguish two types of credible knowledge:

- knowledge that has *internal credibility*: AR projects directly alter the patterns of social action, and the results are tested by the stakeholders of where the research project is being developed. The local community will tend to trust the theoretical results of AR if they are reflected in the practice. Knowledge with internal credibility has more value for local communities than abstract social science frameworks, because of its immediate applicability to the actual community environment;

- knowledge that has *external credibility*: when an AR report is judged by an external observer it is tested against the standard logic of scientific reasoning. Someone who is not involved directly in an AR project will find it difficult to accept what an action researcher reports as scientific. Those reports, which are mainly based on storytelling, are often disqualified for not being objective and for not having a general validity. The AR position in respect to this validity objection is that knowledge achieved locally is general in respect to the context studied and can have powerful effects also outside it.

The conventional social research community accepts as credible only what is produced by generalizing and universalizing propositions, while the AR perspective accepts as credible only what is generated and tested in practice. This means that action researchers involve local stakeholders directly in order to be able to validate their results and to grant credibility to their work. In a broader perspective, meanings created in one context can be later examined in another one: the application of the scientific method to particular cases allows putting together similar scenarios in order to highlight the differences and the similarities which exist among them.

The discourse on credibility is strictly related to the problem of scientific meaningfulness: many research projects are criticized and marked as not credible for not adopting a valid scientific method. AR is often targeted by such criticisms, as social science in general is. The problem is that the scientific method adopted by other disciplines, such as Physics and Biology, is not easily transposable on the social science. The concept of *objectivity*, for example, is borrowed from those sciences and equated with *disengagement*. This means that the social sciences have been gradually abandoning the engagement in the realities they study and do not admit that social research could be both scientific and socially engaged. In Kurt Lewin's work (see [95] and [96]) the idea of engagement is well expressed by one of his most famous quotes: *"If you want to truly understand something, try to change it"*.

In the AR perspective, being scientific means understanding social problems and finding solutions to them. This involves the adoption of the purest scientific method of iterative problem solving: problems are described and analysed, solutions are deployed, results are verified. AR adopts narration as a method for reporting results: the scientific power of narration resides in its disruptive ability of falsifying generalized theories. Besides that, science can be seen as *"humans in action"* ([67], page 86): scientists often work collaboratively in order to write their articles and essays, exchange opinions and work in laboratories which are social systems where the most common practice is teamwork (see Adams in [2], Latour in [92] and Zabusky in [175]). Research projects, from the formulation of the research question to the analysis of the results, are often products of teamwork.

This work is no exception: it started with the discussion of possible research questions with some colleagues, it adapted to the local situation found in the Uruguayan schools, it allowed the co-generation of knowledge and was always tested both on the field and in the academical discussion. Several refereed scientific papers (see [103], [104], [105], [106], [146]) were accepted for discussion at international conferences during the two years spent working on this project. The solutions I adopted on the field, both for enhancing the accessibility of the XO laptop and for studying the impact of technology on the integration experiences of the selected case studies, were shared with the local community, which in turn provided me with all the information and the logistic support I needed to move among them and to better understand their problems and peculiarities.

### 4.1.1 The Formulation of the Research Questions

Before considering the possibility of exploring the inclusive potential of technology in a 1-to-1 computing setting, this work moved from one simple question. Following the ideas exposed, among many others, by Cardano in [25], the possibility of changing it was considered since the beginning, in order

to both expand the area of interest of the whole research project and refine the final outcomes. The original research question was quite simple in its structure and had a mainly technological interest:

[q1] *Is the XO laptop accessible?*

In this formulation, the research question is generic and ambiguous, because it includes various problems and distinct theoretical references which need to be clarified:

- a definition of accessibility is needed, in the sense that accessibility is a wide topic and it can be addressed under various perspectives (see Vanderheiden in [160]);
- a reflection on what makes the XO laptop really interesting is also essential: a large amount of facts about the use of computers in a school context can be found in the literature, but studies based on 1-to-1 computer deployments are only a minority (see section 3.2 from page 50 for a review of 1-to-1 computing experiences);
- while talking of access and accessibility, the risk of adopting a deterministic point of view has to be considered: the implementation of AT solutions does not ensure any positive effect on the general "quality of life" of the persons who will use them, but this aspect is important in order to evaluate the impact of the proposed solutions and to support future projects.

In order to solve these ambiguities and to clarify the way I was conducting my research project, I tried to make this first question more explicit and to integrate it with other questions.

In the effort of finding a more definite focus to concentrate upon while talking of accessibility, I chose to focus on solutions dedicated to individuals with mobility impairments, primarily because I had more previous experience with such kind of impairments. Besides that, physical disabilities are commonly considered something easy to know and understand because of their visibility,

but can determine some other forms of invisible handicap, like cognitive or sensory limitations, especially when they derive from brain damage.

In these cases the computer, which I previously described as a *cognitive amplifier* (see section 3.2.5), is a device basically designed to support our cognitive skills, hence it can also be considered as a "universal" AT tool. My hypothesis was that granting the children with basic access to the computer could have immediate positive reflections on their overall possibilities. I lately rejected this view for its intrinsic determinism and for its scarce demonstrability.

My primary concern about the accessibility of the laptops was modified by this focus on mobility impairments. A new formulation of the research question came out of my first reflection:

[q1a] *Is the XO latop accessible* for children with mobility impairments*?*

which then I reformulated in a way which was more compliant with the AR setting:

[q1b] *How can the XO laptop accessibility be improved for children with mobility impairments?*

This formulation is to be preferred because the concept of 'accessibility' is measurable, but can assume many states, disposed in a continuum: objects and systems vary in their proximity or distance from an ideal total accessibility which does not seem to be possible at all.

As stated at the beginning of this chapter, the final objective of this research was to study the effects of an accessible laptop on integration and inclusion processes. In order to obtain useful knowledge about integration and inclusion dynamics I planned an exploratory study, mainly based on the following question:

[q2] *What is the idea of integration and inclusion in the environment studied?*

I considered the answer to this question essential in order to clarify if the

accessible device was actually being useful. As seen in section 2.1, the debate about disability and the meaning given to the term can vary a lot, from a medical point of view to a dialectic of oppression. The social and educational context strongly influences the way people think of and represent disability. This ubiquitous technology was supposed to have some effect on the relationship between disabled and able-bodied children. My original idea was that the access to what the computer offered could have a positive reflection on the quality of those relationships. I later gave a more practical formulation to this research question:

[q2a] *What do 'integration' and 'inclusion' mean for the actors in the environment studied? How they do it?*

moving the focus on the actual integration practices. As I was meeting a different cultural framework, I felt the need to know how to correctly interpret the discourses I was about to witness.

In February 2009, when I entered the studied environment, the computers were about to be delivered to all the children in the public schools of Montevideo, which meant that the AT solutions I was about to study could also be accessed by a large number of children for whom they were not originally designed. As in the curb-cut example reported at 3.1.2, the computers would be made accessible to children with physical impairments and would be potentially effective on the whole school context. This reflection raised a secondary research question, which could be made explicit in this form:

[q3] *How does the laptop accessibility relate with the fact that it is distributed on a 1-to-1 basis?*

This last question, together with questions [q1b] and [q2a], was formulated after entering the field. The first question followed a technological approach, adopting a "functional" idea of accessibility: what I wanted to know was if those particular hardware and software were both ready to be used by children with mobility impairments and what kind of improvements could be

done; the second question aimed to the exploration of the local context in order to grant a valid foundation to the rest of the research; the third one opened up the research objectives to a wider perspective, by considering the school context and the 1-to-1 laptop program carried out by CEIBAL as a meaningful and interesting factor to be considered while talking of accessibility.

### 4.1.2 Action Research: Entering the Environment to Start a Change

As mentioned above, the Action Research model was first proposed by Kurt Lewin in the area of Social Psychology. In his original definition, Lewin described AR as opposed to the traditional reductionist and classificatory approaches commonly used in research work. Those approaches are rejected in favour of methods involving analytical studies of environmental and situational factors, in which the subjects involved in the research live and work. In Lewin's opinion it is not possible to understand the complexity of a phenomenon studied only by the means of statistical models and classificatory operations which abstract objects from their contexts. The main objective for the researcher should be the study of particular, concrete situations, in which the relationships between factors could be easily highlighted.

Doing AR in an educational context means participating to the research in first person, belonging to the environment studied with an active role, as for example the role of a teacher in a school. Initially, this was a critical point for me: I was *not* part of the environment I was about to study. Actually, I was an active supporter of Open Source software, and I was entering one of the largest and most famous deployments of Linux-based machines for schools. It was sort of my responsibility to solve problems in there. But the real fact was that the teachers and children I was about to meet did not actually care about this: they cared, respectively, about their role as teachers and about

their possibility to play with a new toy.

In order to accomplish with the basic principle of participation in the environment, and also to meet the expectations of the people I was about to work with, I adopted a sort of mimetic technique, trying to become what Greenwood and Levin [67] describe as a *Friendly Outsider*:

> A professional action researcher must know how to be "the friendly outsider". This role is vital in AR because the external perspective is a key element in opening up local group processes for change. But this outsider is friendly in a special sense. He or she must be able to reflect back to the local group things about them, including criticism of their own perspectives or habits, in a way that is experienced as supportive rather negatively critical or domineering. Good professional action researchers achieve a balance of critique and support through a variety of actions.

I then acted more as a consultant than as a researcher for the most part of my first field experience.

The main objective of an AR project is normally to collect useful data from the environment in order to facilitate the decisional process of the leaders of that particular reality. In this sense, this paradigm is more oriented towards *problem solving* than experimental or interpretative research.

According to [156], AR does not follow a rigidly predefined research design. It can start from a set of hypothesis, but its primary objective is not to validate them. The research process is then something cyclical: every new empirical evidence can be useful to the formulation of new hypothesis.

In developing my research plan, I followed the phases described by Trinchero as foundational:

- identifying a *problem situation*;
- forming a research group;

- planning an intervention against the *problem situation* based on realistic and easily achievable objectives;
- acting in order to make the intervention happen;
- pointing out the effects of the intervention;
- reflecting upon the intervention in order to understand if it had the desired effects or not.

I followed all of this steps with only one exception: being this work a PhD thesis, I mainly worked alone during the fieldwork, without forming a proper research group. I still took advantage of some connections which helped me in planning, developing and reflecting upon my research during all its duration. I prefer to call them a *network* on which my research was based.

Paragraph 4.2.1 explains the process which turned me into a Friendly Outsider for the CEIBAL plan context. Paragraphs from 4.3.1 to 4.3.6 offer an overview of the phases listed above, describing how every issue was addressed and what techniques were applied. It is important to notice that an urge to modify the research process overtime came from direct, real time field experience, so that the whole research was subject to continuous, cyclical re-evaluation of the background questions.

## 4.2 Research Strategy and Context Analysis

As stated in section 4.1, this work attempted to build a research *strategy* by combining distinct *methodologies*. The approach I followed during the fieldwork experience took inspiration from different research techniques and data collection instruments. I selected these techniques in concordance with the nature of the different levels of the complex environment studied. The three research questions described above explore different facets of the en-

vironment studied and for each of them I chose one or more data collection instruments.

For the first research question,

[q1] *How can the XO laptop accessibility be improved for children with mobility impairments?*

I needed two things: a place where to start and knowledge about the machine. This meant travelling from school to school during the first period of my 2009 fieldwork experience and visiting a total of 25 schools. The majority of such visits were paired with a training session I gave to the teachers, which allowed me in turn to obtain their collaboration. I concentrated upon a school, which will be described later, and there I started a cycle of interventions on the machine's accessibility. I also maintained a contact with the CEIBAL technical area, sharing my results with them and obtaining technical advice.

For answering the second question,

[q2] *What do 'integration' and 'inclusion' mean for the actors in the environment studied? How they do it?*

I chose to interview the personnel of the schools I visited, both special and mainstream ones, together with the parents of some integrated children and external professionals (an AT expert from a private foundation and the director of a private special school). I also interviewed the head of the Uruguayan special education inspectorate. The interview tracks are available in appendix A. The analysis was supported by the use of a Computer Aided Qualitative Data Analysis System, RQDA (see [75]).

To maintain a link between this research question and the next one,

[q3] *How does the laptop accessibility relate with the fact that it is distributed on a 1-to-1 basis?*

I held two focus groups with teachers, one in 2009 and one in 2010. Then I entered the mainstream schools where some mobility impaired children were

integrated and through direct observation, interviews and tests I collected all the information I needed to depict a complete profile of such integration projects.

### 4.2.1 A Friendly Outsider in the CEIBAL Plan: Summary of the Research Activity

What follows is a brief summary of my six months experience in Uruguay, in which I worked side by side with the people involved at different levels in the CEIBAL plan previously described in section 3.3.

At the beginning of the fieldwork, for the first 7 weeks, I spent a considerable amount of time in the LATU, the main technical structure responsible for logistics, technical research and development for the CEIBAL plan. During this period of time I asked for the possibility to work side by side with the local technicians; I was assigned to the Research and Development department, which in February 2009 was composed by two engineers and two Engineering students. After the first week, another person entered the department, a student in Engineering who was in charge of leading a new project in partnership with a local organization[1]. This project, which will be described later, addressed children with mobility impairments. All the people working in the R&D department saw a direct association (which was not so obvious) between my work and this particular project, because they shared the same area of interest. This gave me the possibility to meet the people who lead the external organization and to see how they worked in what was commonly considered one of the most advanced AT and rehabilitation centers of the whole country.

Meanwhile, I also took contact with the ANEP, and particularly with the Inspectorate of Special Education. This department is in charge of directing

[1] *Fundación Teletón*, a private organization assisting children with mobility impairments.

the Special Schools of the whole country, coordinating the didactic activity for all the schools which have children with special needs in their classes. This means that the Inspectorate is also responsible for the children who undergo integration projects in mainstream schools.

First, the Inspectorate of Special Education staff offered me the possibility to visit some schools, in order to give me an overview of Special Schools conditions. At that period of the year children were still on vacation, so I had the opportunity to meet the teachers and the school directors alone, outside the educational context. They almost immediately came up with the request of some guidance on technical matters, because they knew I was working with the LATU technical area. Even though I stated clearly that I was there to do research and not to teach them, they invited me to some meetings where volunteers from RAP CEIBAL[2] explained how to use the XO laptop and the Sugar desktop environment. After my initial doubts on how teaching them could be useful to my research, I accepted to help them. I was then hoping to be able to consolidate my contacts with them, who were the true *gatekeepers* [25], to use a term which is common in Anthropology, of the environment I was about to study. They were the main force on which the CEIBAL Plan could count, and they would later allow me to observe the environment without posing too many restrictions on my work.

The teachers' and inspectors' need for guidance on technical matters - they almost desperately wanted to know how to use the computer - drove them to consider me a teacher, a peer with whom they could exchange opinions, impressions, ideas and complaints. This happened with many teachers I met in the schools or at public events organized by RAP CEIBAL volunteers. Some school directors invited me to their schools, in order to show me how things worked where resources were scarce and the children came from critical

[2] *Red de Apoyo al Plan CEIBAL* (Support Network to the CEIBAL Plan) is a non-profit, volunteer organization mainly composed by teachers and devoted to supporting the CEIBAL plan by training teachers and helping in the solution of technical problems. Their support gained great appreciation both from schools and from the technical staff. The group maintains an information website located at `http://rapceibal.blogspot.com/`

contexts.

After this first period spent visiting schools and working in the LATU offices I chose to focus on the "School 200 - Ricardo Caritat", the only public school in Montevideo which is specifically for children with mobility impairments. I first met the teachers during one of my "XO classes" at the beginning of March 2009. They showed a lot of interest in my research project, and they considered me an important resource not only because they needed guidance on XO laptops, but also because of their lack of knowledge in Assistive Technology matters. The school had 98 pupils, each one with some level of mobility impairment. The children attended classes three hours per day, from 9.00 to 12.00 in the morning or from 12.00 to 15.00 in the afternoon. Only 8 pupils stayed at school from 9.00 to 15.00, and they spent the afternoon hours doing workshops in a special room. Some other children, a total of 6, attended classes only for a limited number of days per week: they were involved in integration projects with mainstream schools and they spent the majority of their school time elsewhere. These integrated children obviously had distinct kind of impairments and different personal stories. They were also involved in different levels of integration projects, so their stories will be discussed later on in this work, with a particular focus on four of them.

During May and June 2009 I visited four of the common schools where these children were integrated and I spent one day per week in two of them. These schools were located in the suburbs of Montevideo, one of them was marked as "critical context school". I had the opportunity to interact with the children, to see the teaching methods of their teachers and to show them the XO computers for the first time. The teachers warmly welcomed me and I was involved in the class activity. I mainly brought to them digital contents to support their classes by downloading videos on my XO or by organizing demonstrations of what some XO activities could do. I also assisted the children in their first internet searches.

At the beginning of May 2009 two volunteers of a group called CEIBAL Jam[3] contacted me: I had first met them one month before, while I was participating in a conference about CEIBAL in the town hall of Montevideo. They showed interest in my work and wanted to take direct contact with teachers and school directors, so I introduced them to the School 200 personnel. At the end of the same month I was involved in one of the events they organize on a regular basis, proposing the development of a new Sugar activity dedicated to children with special needs. The project, called "Prestame tu Voz" is an attempt to create an Augmentative Communication system using the XO hardware. The project is described in appendix D and in [106].

While working with the children at school, both in mainstream and special schools, I had the opportunity to hold semi-structured interviews with some teachers and to assist them in a more specific way. After one year, in May 2010, I recontacted the majority of them and interviewed them again, adapting the track of the interviews according to the experience so far. This longitudinal set of interviews aimed at exploring the changes that had took place in the scholar environment during the first year of CEIBAL deployment.

## 4.3 The Research progress

As emerges from the above summary of my experience, this part of the research involved an explorative study of the environment and the technical support to the local community. This was accomplished mainly by the means of tests, but also by direct observation, which allowed me to single out the interesting aspects and dynamics which characterized the environment studied.

[3] *CEIBAL Jam* (`http://www.ceibaljam.org/`) is a non-profit, volunteer organization mainly composed by young engineers and teachers, devoted to supporting the CEIBAL plan by developing new software to be used by teachers and children at school. They organize public meetings where software developers work together on shared projects. They also support the other volunteer associations on technical matters.

Those aspects and dynamics were confirmed by semi-structured interviews with the gatekeepers and the other actors of the project.

The following paragraphs describe the research process and, in detail, the methodologies adopted during the first part of the field experience. Data from tests, focus groups, interviews and observation sessions is reported in order to highlight the main findings and support the decisional process adopted.

### 4.3.1 Exploring the Environment and Identifying a *Problem Situation*

At the beginning of the fieldwork experience, after spending a relatively small amount of time with CEIBAL technicians and with teachers, one thing struck me: the two fronts involved in the project seemed not to know each other in depth. The main concerns of the LATU technical staff where about logistics, technical support for broken laptops and school servers, wireless networks coverage, delivery of laptops to the last schools of the city. All these points, which were totally legitimate, did not match the teachers' anxieties about one thing in particular: the need for being trained for the adoption of computers. This was particularly true for the teachers of special schools: they needed both training for using the XO and for adapting it to the special needs of the children they were working with. When I arrived in Uruguay, the majority of the teachers of special schools were about to receive their own laptops and some training.

The first action I undertook was to visit both the LATU and the schools. The CEIBAL technical area was based in a building on the rear part of the LATU complex, which occupies a vast area in the East zone of Montevideo. The building included three main offices: *soporte* (support), *conectividad* (connectivity), *despliegue y optimización* (optimization and development)[4].

[4] As of June 2010 I was informed of the creation of a new office: *mantenimiento*, maintenance.

The first one was dedicated to studying the logistical problems which arose during the implementation of the plan, like network connectivity and machines delivery. The connectivity office provided monitoring of the school servers of the whole country and was responsible of the customizations applied to the local Sugar distribution. The optimization and development department, actually a traditional R&D office in which I was welcomed as a consultant for accessibility matters, had in charge the study of new solutions for problems related to features which were absent from the XO laptops or from the other devices involved in the plan. Besides these three departments, CEIBAL also included a logistics area (taking care of the deliveries) and a support call centre, which offered continuous technical support by a free phone number.

I was granted with the possibility of using a desk and a computer in the R&D department and of asking as many questions I retained necessary for my work to the people in the three technical departments. I hence had the possibility to understand how the project was organized: every school in the country was equipped with a server computer, which is normally installed in the director's office and is connected to a number of wifi access points which varies in relation to the school's building size and architecture. The anti-theft system for the servers consists of a robust cage, while the laptops have a software one. Every XO is univocally linked to its owner by associating the machine's serial number to the standard personal identification code of the child, hence a stolen XO can be retrieved remotely simply knowing the owner's data.

As I mentioned in the above summary, short time after my first visit to the CEIBAL technical area an Engineering student was hired to work on a project together with Fundación Teletón: they wanted to create a software interface for controlling a wheelchair using an XO and a usb to serial port adapter. This had already been done by the people at Fundación Teletón, but with an ordinary computer. Porting such a system on the XO laptops meant melting

the CEIBAL project with Assistive Technology and was actually the first step undertaken by the technical area towards accessibility since the whole project had started. When I went back in Montevideo the next year, I found that the efforts made by the technical area in this direction had multiplied: they had not only implemented all the solutions I experimentally developed in 2009, they had also concentrated more forces on accessibility, with two more people working on AT solutions. They showed me the software improvements and also a special device: a controller for the mouse pointer which could be used simply pushing one large button. They had also concentrated on how to adapt keyboards and on how to build simple switches with material which was no more useful.

On the other side, I took contact with ANEP and especially with the National Inspectorate of Special Education. We had a meeting together in which I got an introduction to how the Uruguayan school system is organized. They immediately expressed their concerns about how the project was going to impact on special schools, and particularly insisted on the fact that even if some AT interventions and computer adaptations were programmed for the near future, they were mainly addressed to the less numerous part of the population they attended. As I mentioned in section 3.3.1 at page 75, in Montevideo there are twenty schools attending children with intellectual impairments (more than 75% of the special schools of the urban area). The technical area had only started one project so far, which was directed to children with mobility impairments. No other decisions had been taken in respect to the special needs of other categories.

In February 2009 I had the opportunity to visit ten of the special schools of Montevideo, including the only school for mobility impaired children, the one for the deaf, two of the schools for blind and low-vision children and six different schools for intellectual impairments. In all of these schools, where some times I met with teachers from different institutions grouped together, I held one-day training sessions, explaining how to use the XO to the teachers.

This activity, which as I mentioned above was not originally meant to be part of my work there, opened up to me the possibility of meeting more directly with the gatekeepers. I received lots of appreciations for my work as a teacher trainer and this often translated into invitations to visit schools and to do more training. The educators at all levels were starting to consider me as a colleague, more than an outsider: I felt I was on my way to becoming the *friendly outsider* which would allow me to better study their environment and hence to better understand the impact of the solutions I was about to propose.

### Initial Focus Group

At the beginning of March 2009 I visited the School 200 upon an invitation made by the Inspector who was in charge of that area. I spent one full day with the teachers, from 9.00 to 15.00, having lunch with them, teaching them and asking them many questions about their institution. Because of the fact that I had some experience in mobility impairments, but also because their school also included several other kinds of disability (there were also children with low vision, deaf, or with communication problems) I decided to focus on that school for the rest of my experience. This did not mean interrupting the visits and the training sessions with other schools: at the end of the six months period I spent in Montevideo during 2009, I totalized 25 visits to special schools, part of which were outside the urban area.

After my initial visit to the School 200 I decided to start my intervention there, by spending my time with teachers and children regularly during the school time, starting by March 23rd, 2009. In the meantime, I did not stop my tour of other special schools. They accepted me with great expectations, mainly because they were not used to receive any form of extra help from the regular institutions. After getting acquainted with all the teachers and with the most part of the children, I started my work as a researcher by meeting the entire group of teachers for an initial focus group. Ten of them

participated. The starting topic which I proposed them to think about was not that of Assistive Technology, as they probably expected: I asked them what they thought of disability, and particularly what they thought of this provocative sentence:

> *We are all, more or less, disabled.*

They immediately responded with great entusiasm to my question: one of them mentioned the *"multiple intelligences theory"* by Howard Gardner, while others introduced the environment in the discourse, as an important aspect to consider. They almost immediately moved the debate towards technology, and particularly towards the implications that they saw in adopting it at school, probably because they were influenced by my presence and by the hype about CEIBAL. The discussion made them virtually divide in two groups: Seymour Papert would have called them Cybertopians and Cybercritics, as in [129].

The former group showed to be convinced that the introduction of technology at school would be an opportunity for opening up new channels for learning, prospecting a change in the professional profile of the teacher. They substantially agreed with the idea that the computer can be a facilitator for sociality and that it can help in developing abilities which are not commonly trained. One of the teachers reported an anecdote involving a child who had not only mobility impairment, but also intellectual deficits, trying some educational games on the XO laptop:

> *cuando se enfrentó a los juegos que se le puse, ella supo lo que tenía que hacer [...] algo que yo no pensé nunca...*
>
> when she was faced with the games that I proposed her, she knew what she had to do [...] it was something I had never thought about...

On the other side, some teachers were less enthusiastic about the introduction of the computers at school. They expressed their concern about the changes

in the role of the teachers that the other group foresaw, which they saw as a risk of a nullification of such role. One of them saw this change as an opportunity to reflect on what they already had:

> *Se dice que no todo lo nuevo es bueno, no todo lo viejo es mejor: me parece que entre tres o cuatros años esto va a servir para redimensionar o revalidar lo que se hacía antes*
>
> It is commonly said that not everything which is new is good, and not everything which is old is better: I think that in three or four years this will be useful to redimension or revalidate what we did before.

while others remarked the necessity of the gratification which can only come from a direct human interaction.

I then asked them to go back to the topic of disability and difference. The discourse moved towards the problems of identity and acceptance, with some teachers reporting that the children in their classes (who were grouped by age before than by level of impairment) did not accept each other. The interesting thing for me here was that all the examples they cited were about children who were integrated in other schools: they seemed to share one problem, regarding the fact that they became conscious of their differences. The teachers agreed on the point that the children in the School 200 do not develop the same social dynamics as able bodied children do: they do not play together in the break time, they show more interest in socializing with the teachers than with their peers, they suffer for the frustration imposed by not being able to express themselves. The gym teacher brought forward the idea that making them play was the best way to make their problems come to light.

The discourse then moved from personal differences to the egalitarian possibilities offered by technology. They started discussing the usefulness of teaching some classical skills, like cursive handwriting, in the ICT era: some

of them, again, supported the idea that technology could be a facilitator for their pupils, as long as it allowed them to write as fast as the others and to remove part of their frustrations. Others took a more traditional position, arguing that teaching in the classical way is more egalitarian, for the fact that the same instruments are given to everybody. At this point the 'Cybercritics' lost part of the effectiveness in their discourse: the other group tried (and partially succeeded in) poking fun at the utility of such teachings, substantially arguing that it has more utility for the teachers (that can display the successful results of their teachings to others) than for the children. One of the sentences I found interesting and quite amusing from the Cybertopians side was:

> *porqué tenemos que perder tiempo enseñando papel y lapiz cuando podriamos ir directos a la computadora?*
>
> why should we waste our time in teaching pen and paper when we could go directly to the computer?

Figure 4.1 shows the main topics emerged from this focus group in the form of a conceptual map. Looking at it from the distance I found particularly interesting the fact that the adoption of technology seemed to introduce an advantage for the children, if not for the teachers. It was no surprise for me to find people with opposite positions towards the use of technology in education, as this debate is quite vivid at every level. What surprised me was seeing that all those teachers substantially agreed with the fact that their children felt different from the others, both in the same special school and in the mainstream schools. They also agreed on the fact that it was important to make them develop better social skills, by direct confrontation with their peers in everyday activity.

This initial discussion made me reflect on the importance of the social effects of the use of technology: I had arrived there with in my mind the idea that it was important to raise the accessibility level of the machines in order to turn them into *functional prostheses*, but then the fact that they were already

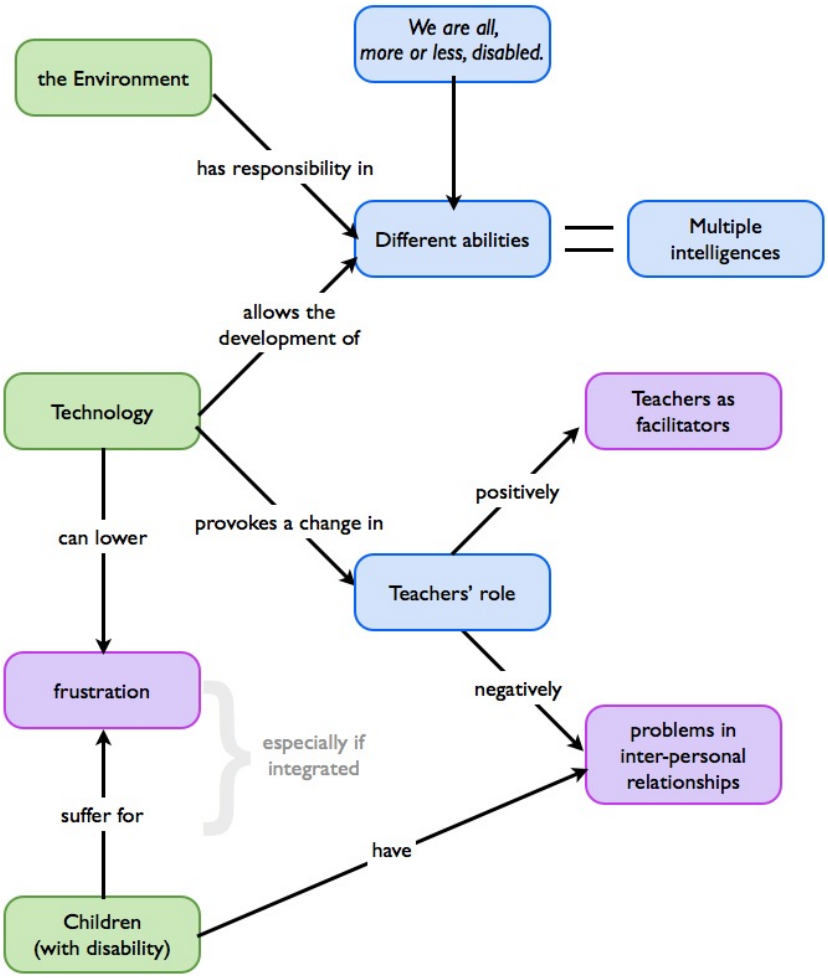


**Figure 4.1:** A conceptual map of the first focus group, held on April 21st, 2009

thought of as *social prostheses* captured my attention and my curiosity.

### The First Interviews

During the first weeks at the School 200 I started interviewing the teachers in depth, with semi-structured interviews, in order to reach a better comprehension of some of the above mentioned points. As seen above, part of the personnel of the School 200 (as well as that of other special schools I visited) was already well disposed to considering technology as a good instrument for working with children with special needs, so they expressed great interest and expectations towards the XO laptops. In general, also the teachers who acted as Cybercritics in the initial focus group, showed a form of suspicious interest towards them.

One of the most positive supporters of the introduction of technology told me once:

> *siempre me pareció que la tecnología es maravillosa, al servicio si de esas capacidades diferentes, [...] pero poder hacerlo, tratar de comunicarse, tratar de hacer, quizás de repente necesitan sus adaptaciones.*
>
> I always thought that technology was something wonderful... it serves the special needs [...] they can actually write, they can try and communicate, tray and do something, perhaps they need some form of adaptation.
>
> (A.A., teacher in a special school)

Another teacher used even more enthusiastic words:

> *Es un instrumento precioso que va a optimizar el funcionamiento de los chicos. Tiene varias puntas y puede ser visto desde varios ángulos... primero permite que el niño este más en contacto con la realidad social en la que vivimos. Pero necesita adaptaciones*

*para que lo pueda vivenciar.*

> It is a gorgeous tool, which will optimize the functioning level of the children. It has many advantages and it can be seen under various perspectives... First, it allows the children to keep in touch with the social context we live in. But it needs adaptations in order to be experienced by the child.
>
> (D.U., director of special school)

Both of them outlined the need for adaptation: this is, together with the lack of training for the teachers, one of the most critical points in the XO laptops deployment: at the time the computers arrived in Uruguay they lacked all the accessibility options which can commonly be found on a computer running one of the major Operating Systems.

Besides the absence of any of the most common accessibility options discussed in section 3.1.3, there was a complete lack of accessible or adapted hardware, not to mention the poor knowledge of it. The School 200 only disposed of very basic technological aids, like the manually modified keyboard of picture 4.2.


**Figure 4.2:** A modified keyboard with improved contrast available at the School 200

During the initial focus group I had with them, the teachers of that particular

school complained about their needs in both training and equipment. The introduction of the CEIBAL plan certainly raised optimistic expectations in them:

> *Ahora que llega la XO algo tiene que pasar.*
>
> Now that the XO laptops are coming, something must happen.
>
> (C.M., teacher in the School 200)

But at the same time the massive deployment of XO laptops fostered a certain degree of anxiety. This feeling was probably caused by the novelty they were about to face. They outlined the aspect of newness and, again, their need for training.

> *XO es un mundo distinto, lo que hay es que aprender a usarla... como todo: un vaso nuevo tenés que aprender a tomar del vaso, un auto modelo nuevo y tenés que aprender a manejarlo...*
>
> the XO is a different world, what we need is to learn how to use it... like everything else: with a new glass you need to learn how to drink from that glass, with a new car you have to learn how to drive it...
>
> (C.M., teacher in the School 200)

As happened in the focus group, some teachers took a defensive position when talking of the "classical" school, invoking the human-based, direct interaction as something that technology will never be able to replace:

> *Todo esto es maravilloso, pero la escuela te da la parte humana y eso no lo podes sustituir con nada.*
>
> All this is wonderful, but the school can give you the human part and that can't be substituted by anything.
>
> (L.M., teacher in the School 200)

Their general feeling about the XO and the changes ahead in their everyday

activity were mostly positive. They saw in technology a friendly instrument for the children, allowing them to do the same things as the able bodied. They often expressed this idea by suggesting that working on a computer is "easier" for them, but this is rather naïve: as my further work suggested me, the computer was not totally accessible for them and that provoked anxiety and frustration. Children seemed to prefer the computer to pen and paper not because they could do the same things faster, but mainly because they could do *other things*.

> *A mi me parece super positivo la XO, es muy productivo para ellos, para que se sientan integrados con sus compañeros que van a tener computadoras y las van a poder utilizar, como las utilizan ellos, que es más fácil para ellos la utilización de la computadora que la utilización manual de un lápiz, aunque no se pierda la tarea en el cuaderno.*
>
> I think the XO laptop is something very positive, it is very useful for them, in order to make them feel more integrated with their classmates who will receive computers and they will be able to use it, in the same way the others use it, because it is easier for them to use a computer than the manual usage of a pencil, although the habit of doing homework in the notebook must not be discontinued.
>
> (P.M., teacher in the School 200)

I also found a recurrent concern, regarding the possibility that the machines could be stolen. The technical area of CEIBAL put a particular effort on this aspect of the project, developing an efficient anti-theft system which not only prevents the risk of stealing (a stolen XO automatically blocks the first time it is connected to the internet) but also grants that no black market can be started.

> *Los cuidados y las adaptaciones y que no haya comercialización.*

> *Esos son para mis, cosas a tener en cuenta, porque todo lo demás lo veo positivo.*
>
> The care [for the laptop] and the adaptations and the fact they do not sell it. Those are for me the things to consider, because I consider positive all the rest.
>
> (P.M., teacher in the School 200)

This last quote resumes the concerns and sets the basis for my action research intervention in the field of adaptations. At that time, the *problem situation* I considered most urgent was the lack of Assistive Technology solutions to be used with the XO for improving the quality of the learning experience for children with mobility impairment. I write "at that time" not because I now think that it could be something different, but because I had to give priority to one of the various problematic points that my initial overview had revealed. As I had already argued from the analysis of the contents of the first focus group, there were enormous possibilities for research on the topic of the social effects of the use of technology at school. First, I had to know the children better. Then I had to see how the integration processes in mainstream schools worked. Finally, I needed to find a way for collecting useful data about the social relationships that the children were developing with their peers, with and without the computer.

### 4.3.2 Forming a Network for the Research

One of the most important things in Action Research is the interaction with local actors, as long as the research intervention aims to make improvements in the environment. As I mentioned above, my personal involvement in the environment studied was not exactly what the definitions of Action Research commonly suggest: I was not working for the School 200, neither for the ANEP or for the LATU (hence neither for CEIBAL). And in this case, being a *friendly outsider* does not completely justify my work. Being an action researcher means being part of the environment, and this obviously required me to know exactly to what environment I belonged to.

As an Open Source Software activist, the answer is simple: I was then involved in one of the largest deployments of machines with Open Source software existing in the world, the project was interesting for me both from the professional and the personal point of view. I was determined to give my contribution to this scenario, in order to prove it to be efficient.

In order to be able to work at best in this setting I spent my first weeks in Montevideo in the effort of building a social network of contacts who were involved in the project at all levels. My participation in the activity of the CEIBAL technical area, as well as my visits to the special schools, proved to be very effective ways for meeting interested and involved people: after few weeks I had the personal phone numbers of many of the directors of the schools I had visited, and some of the teachers who were most committed to the cause of CEIBAL also showed interest in contacting me. One of those teachers invited me to a public encounter organized by RAP CEIBAL: it was a three-days free training session, with workshops about many distinct topics, varying from theoretical to technical matters[5].

During the whole event I was not only able to form a general idea of the

[5]The event was called *IV Jornadas de Educación y TIC "La XO una herramienta para apropiarse de la tecnología"* and was hosted by the city town hall from 12th to 14th March 2009.

feelings of the teachers towards the whole project (which substantially confirmed the anxieties I described above), but I could also take direct contact with schools. This was important for me as I wanted to avoid the risk of being shown only selected schools: visiting distinct realities, even with no direct relation to the area of special education, proved to be useful for understanding the most important social differences between the various zones of the city.

I also met some of the volunteers of CEIBAL Jam, the NGO I cited above. They participated in the event by maintaining a stand during its whole duration, where they demonstrated what they had developed and accepted ideas from the teachers for new projects. They also proposed a workshop to show how a Sugar activity must be designed, starting from use cases. They proved to be a very helpful contact later, when we started a new project together (the already cited *Prestame tu voz*).

Another person also took part to this project: she attended the three days of the event representing *Fundación FREE*, an international foundation working in the area of Assistive Technology and special education. She would later offer me an interesting point of view on Uruguayan special education and particularly on the relationship between CEIBAL and AT.

Last but not least, during the *Jornadas* I met the volunteers of three distinct organizations interested in Open Source software (*UYLUG*[6], *MontevideoLibre*[7] and *Cultura Libre Digital*[8]). They later invited me to participate in the *Festival Latinoamericano de Instalación de Software Libre* (FLISOL), an event that took place on 25th April 2009 and in which I held a speech on Assistive Technology. This offered me a good chance to sensitize people

[6] *Uruguay Linux Users Group* is the oldest group of volunteers supporting the use of Free Software in all the country. Their web site, `http://www.linux.net.uy/`, offers information about their activity.

[7] The group, whose name means *Free Montevideo*, has the mission to create an urban network for point to point high speed connectivity by setting up antennas on the roofs of the houses of the members. Their website is located at `http://montevideolibre.org/`.

[8] *Cultura Libre Digital* (`http://cld.org.uy/`) is an organization that promotes Free Software and all other forms of open knowledge, covering also social and artistic areas.

towards the topics I was working on and opened the possibility for further projects.

### 4.3.3 Planning an Intervention

The design and implementation of accessibility solutions was preceded by two steps:

- analysis of the state of the art, by the means of comparison with the major operating systems;
- analysis of the requirements, conducted adopting a simple grid of seven items in order to test the accessibility needs of every single child in the School 200.

The results of the state of the art assessment were quite simple and very interesting: the Sugar GUI offered no one of the accessibility options listed in table 3.1.

In order to determine the initial accessibility level of the machine and of the OS installed on it, I took the table 3.1 I reported at page 42 as a reference. The standard reached by the mayor operating systems is probably still far from total accessibility, but it is well representative of the average accessibility options which are available to any user on an average personal computer.

I was then on my way to try and answer to the first research question I had chosen:

[q1] *How can the XO laptop accessibility be improved for children with mobility impairments?*

Being directly related with AT and accessibility options, this first question can be answered by determining the initial accessibility level of the XO laptop and by testing the needs of the mobility impaired children attending the only

public special school available in Montevideo for this kind of impairment, the above mentioned School 200.

After verifying the starting accessibility level, I visited each class of the School 200 and surveyed the needs of the pupils. I created a list of 'missing features' which I considered sufficiently easy to develop in the short time I disposed of. I then associated them with the ability or inability of doing some actions (for the chart I used for collecting the data, see appendix A, on page 231). This allowed me to depict a landscape of the needed adaptations. I chose to develop them in accordance with my own abilities, hence not necessarily in order of urge, but I still considered important to clarify the needs of the environment in order to be able to counsel the local technicians on what they should do first for accessibility.

| **Feature** | ***Ability involved*** |
|---|---|
| Mousekeys | *use a trackpad/use a numeric keypad* |
| Sticky keys | *use a keyboard/use one finger only* |
| Screen magnifying | *read from the standard screen* |
| Virtual keyboard | *use a trackpad/use a numeric keypad* |
| Key echo | *read from the keyboard* |

**Table 4.1:** The associations between accessibility features and children's abilities

The ability to use the trackpad and the keyboard were tested using some simple games available through the installation of the GCompris suite[9].

The trackpad control ability was tested using the three 'brush' games (see figure 4.3). The first game only required the ability to move the pointer intentionally on specific areas of the screen, the second one required one click to confirm the movement, while the third one required double clicking. The abilities of the children were classified as 'can acceptably use the XO trackpad', 'can barely use the XO trackpad', 'cannot use the XO trackpad'

[9]GCompris is an educational software suite comprehensive of numerous activities for children aged 2 to 10. It is open source software and can be downloaded for free at `http://gcompris.net/`. It includes various software categories, such as computer discovery, algebra, science, geography, games, reading and more.

**Figure 4.3:** One of the brush games of GCompris: the user has to clean the screen from the blocks to reveal an image

by directly observing the effort they had to put in moving the mouse pointer. No much importance was given to timing, because many of them (76% of the children who participated in the test) did not have a computer at home and had only accessed one at school, hence they lacked familiarity with the device.

The GCompris suite also offered a game which was useful in order to assess the ability in reaching the keys on the XO keyboard. The game is called 'Simple Letters' and consists in typing the letters which appear on the screen. These letters fall from the top to the bottom of the screen and must be typed before they hit the 'ground'.

Using this, together with direct observation of the children writing freely using the Write activity of the XO, allowed me again to classify their abilities as 'can acceptably use the XO keyboard', 'can use the XO keyboard with one finger', 'cannot use the XO keyboard'.

Even if problems related to vision were not at the core of my research interest, I could not ignore that the majority of the children had problems in reading from the screen or in recognizing letters on the keyboard. I marked the complaints about difficulties in reading from the display and annotated


**Figure 4.4:** Simple letters: a game where falling letters must be typed before hitting the ground

the other vision-related issues. What resulted from this initial inquiry is illustrated in table 4.2. The total amount of children examined was of 91 out of 98 (93%).

| **Accessibility need** | **% of children** |
|---|---|
| can use the XO trackpad | 26.37% |
| can only use an external mouse | 40.66% |
| cannot use neither trackpad nor mouse | 32.97% |
| can use the XO keyboard | 49.45% |
| can use the XO keyboard with one finger only | 23.08% |
| can use an external keyboard | 24.18% |
| cannot use neither internal nor external keyboard | 3.30% |
| complains about vision problems (screen) | 53.85% |
| complains about vision problems (keyboard) | 13.19% |

**Table 4.2:** The summary of the accessibility needs observed at the School 200 in April-May 2009

### 4.3.4 Making the Intervention Happen: Improving the XO Laptop Accessibility

After assessing the needs, I personally set up some simple solutions on a test machine, primarily by the means of re-using opensource programs already available for Linux and adapting them to the particular hardware and OS of the XO laptop. I then transferred those adaptations to two other XO laptops available in the School 200 to be able to test and fine tune them directly with the children.

#### Mousekeys

The possibility of moving the mouse pointer by using the numeric keypad keys is offered by all major operating systems. In order to add this feature to the XO I had to install a small piece of software on it, called AccessX[10]. I found useful information about how to do it on the OLPC wiki site[11] which allowed me to set up my machine for using Mousekeys, both from an external numeric keypad, connected to the machine through one of its usb ports, and from the 'rocker' controller which is included in every XO laptop, on the left of the screen (as showed in figure 4.5).

Using the 'rocker' controller for moving the mouse means something important: the XO laptop, which has no apparent accessibility features, is still something designed for children: the presence of a game controller improves its ergonomics. Using this controller in a way which is different from the one it was designed for means offering accessibility by using commonly available solutions, not having to provide users with devices marking them as different.

[10] AccessX can provide various accessibility features to any operating system using X11 as a graphical server for displaying the GUI. It comes with a configuration panel written using the Tcl/Tk libraries but an also be used from the command line.

[11] `http://wiki.laptop.org/go/AccessX`: the page provides a download link for the binaries, installation instructions and a tip for starting AccessX at boot.

**Figure 4.5:** The 'rocker' controller of the XO laptop, usable as a mouse pointer controller after installing AccessX

Being on the left side of the screen, the rocker controller can only be used with the left hand, which makes it useless for people who only have control over the right hand. This problem can be easily solved attaching an external numeric keypad to the machine, which also can offer larger keys. Another possibility, which I did not implement, is to remap the game buttons on the right side of the screen in order to give them the same functions of the rocker buttons. This would allow children who can only control their right hand to access the Mousekeys functionality from there.

The Mousekeys solution was tested with the children who were marked as *unable to use a mouse* in the above mentioned accessibility needs survey. For every one of them I had to reconfigure the cursor's speed, hence I suggested to the CEIBAL technical area to develop a control panel for handling it. The tests, as in the case of the accessibility needs survey, consisted in using the 'computer discovery' software offered by GCompris and particularly the applications involving mouse movement and mouse clicking.

One case in the school was particularly interesting at this point of the work: one of the youngest girls in the school had received from fundación Teletón a special device, made of three distinct numeric keypad connected to an USB hub: the first keypad had been modified eliminating all the keys but numbers 8 and 2, actually the up and down arrows; the second keypad had only the 4 and 6 keys, corresponding to left and right arrows; the third had only the number 5 keys, which in Mousekeys mode corresponds to the mouse left click.

**Figure 4.6:** The special Mousekeys enabled device created by Fundación Teletón.

The device was originally designed for the needs of this particular girl, but could also be useful for many other children in the same school. The problem with the School 200 was that nobody among the personnel working there was able to configure an XO laptop in order to make the expanded keypad work. The application of the Mousekeys solution allowed to enable also this device, which is currently a reference for the teachers of the school.

### Keyboard Options

The XO laptop not only lacked a traditional set of accessibility options: the teachers of many of the schools I visited expressed their concerns about a missing Caps Lock key. The simple key which locks letters and allows writing in uppercase was not included in the keyboard layout, which also left out some other keys, like Cancel[12] and Insert. I was not able to figure out exactly why this key had been excluded from the XO keyboard[13], but that was not the only difference between the XO keyboard and the regular ones: the XO presented some extra keys with no functionality which were introduced for prospective developments. Those extra keys are highlighted in figure 4.7.

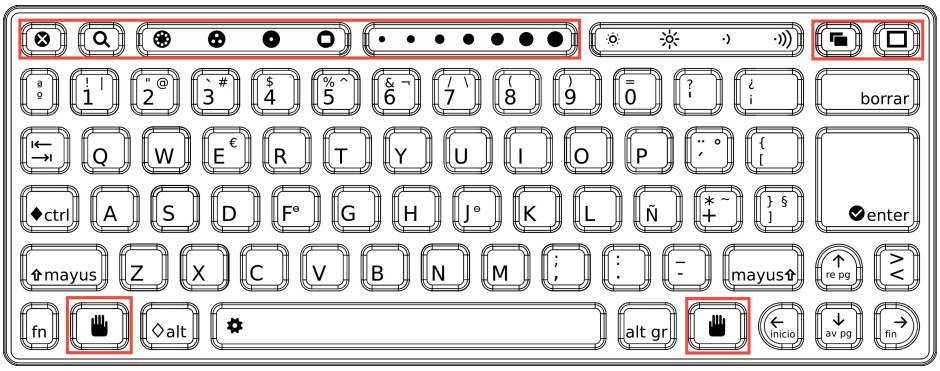


**Figure 4.7:** The Spanish layout of the XO keyboard. Special keys not belonging to standard keyboards are highlighted in red.

The complaints of the teachers were mainly due to the difficulty that the youngest children had with lowercase letters: they learned first uppercase letters and had trouble in understanding why the pressure of one sign on the

[12]Cancel is obtained by pressing Fn+Backspace, which is common on the keyboards of some laptops, like Apple Macbooks, but not very common on Windows laptops.

[13]The OLPC wiki site contains a page about keyboard design. The section accessible at `http://wiki.laptop.org/go/Keyboard_design#Omit_CAPS_LOCK`, which I visited last in August 2010, shows some comments from users substantially agreeing with eliminating the Caps Lock key. A person working for CEIBAL also reported to me that some not better identified OLPC engineers had once told her that it was inconvenient to let children shout while writing, with reference to the netiquette: writing all in uppercase is considered shouting (hence bad habit) in internet forums, mailing lists and chats.

keyboard produced a different result on the screen.

In order to solve this problem I thought of mapping the Caps Lock key on one of the unused extra keys and the left 'Hand' seemed the most suitable one. After doing the remapping, I packaged it into a simple Sugar activity which allowed to automatically apply this modification on any XO laptop by simply running the Activity once. This proved to be a useful solution for many teachers and children of both mainstream and special schools and was diffused by volunteers until the LATU technical area dispatched a system update including the same remapping.

Adding this feature made me agree even more with the Disability Studies perspective I exposed in Chapter 2, sections 2.1 and 2.1.1: Caps Lock is not something commonly considered Assistive Technology, but this experience showed me how such a simple functionality can be deeply linked with accessibility issues. Eliminating the Caps Lock key meant excluding a part of the OLPC target population (children not knowing lowercase letters) from part of the resources offered. This particular group, which is obviously a minority, is not one normally considered: it does not have the same *status* as a group as for example mobility impaired do. They were actually excluded, or limited in their ability to access the machine, in an attempt which was probably meant to optimize the keys on the keyboard. The interesting thing, in my opinion, is that *being able to read and write in lowercase* is not commonly considered something which could mark someone as 'disabled'. By the way, not granting a solution for those who belong to the group of *'non-lowercasers'* provoked results which are not dissimilar from what happens when the needs of a particular impairment are ignored. Obviously, the ignorance of lowercase characters is not considered here a form of impairment at the same level of a spinal chord injury or of a cerebral palsy, but the fact remains that our society and our technology is much more inclusive for children who cannot read lower case characters than to children who cannot read at all.

The modifications I applied to the keyboard were not limited to the simple

Caps Lock mapping: the above mentioned AccessX package allowed me to enable also Sticky Keys and to set a delay between multiple key pressures (a feature commonly called "Bounce Keys"). The former functionality allows, when enabled, the composition of key combinations using only one finger: in order to write a capital letter (without using Caps Lock) a user normally has to use two fingers, and that is not the only case. Sticky Keys allows pressing 'Shift' and then release it in order to reach the following key *without* maintaining the Shift key pressed. On the other side, setting a delay between repeated key pressures allows users with poor control over their hands' movements to avoid pressing more than one key at a time, or repeating the same key because of a shaking movement.

### Magnifying Glass

As seen at page 45, virtual screen magnifiers can be useful especially for those who have trouble in understanding very small characters or who cannot distinguish text from background because of insufficient contrast. Visual impairment is often linked to mobility impairment for at least two reasons:

1. mobility impairment can make it difficult to sit correctly in front of a screen;

2. many forms of mobility impairment descend from brain damage, which often has consequences on more than one area of functionality.

As shown in table 4.2, 53.85% of the children at the School 200 had difficulties in reading from the screen and also in recognizing the smallest figures. In order to make the whole Sugar environment more accessible to them I tested various screen magnification software packages[14]. The one which gave the best results in terms of integration with the existing software environment

[14]The software packages tested included Xmag (`http://www.xfree86.org/current/xmag.1.html`), Kmag (`http://kmag.sourceforge.net/`), Virtual Magnifying Glass (`http://magnifier.sourceforge.net/`) and the magnifier tool included in Orca (`http://live.gnome.org/Orca`)

was Virtual Magnifying Glass, an open source solution I already cited in section 3.1.3. I installed it on my own test machine and then wrote instructions for the technical staff of CEIBAL, in order to make it easier for them to add it to next operating system updates.

I chose to bind it to another unused special key, this time the second from the right in the top row of the XO keyboard[15] (see figure 4.7 on page 116 for the complete keyboard layout). This allowed calling the magnifying glass only when the user needed it. The approach used by this software is to make the magnified area follow the mouse cursor and disappear on mouse click, hence if the user wants to click on a determined point of the screen he or she must activate the magnifier, position it over the target area, click to make it disappear and then click again for real interaction with the system.

This adaptation was then improved by the CEIBAL technicians, by direct modification of the source code, and was included in the Uruguayan Sugar distribution short after I terminated my first fieldwork period, hence I was not able to test it directly with the children until the next year. When I went back to Montevideo in 2010, I found out that the magnifying glass, even after further improvements, was not very popular: the lack of hardware graphics acceleration on the XO made it quite slow (even if still usable) and it was not considered very useful by teachers of special schools I met during my second fieldwork experience.

#### Experimental Adaptations

While testing the above described adaptations directly with children I spent some time on experimenting two other solutions and designing a new one. The first one followed a request I received there, from both the CEIBAL technical area and the volunteers. Among the various accessibility options

[15] As a developer explained to me, the key used for this functionality was originally introduced in the XO keyboard for activating a contextual chat. As of September 2010, this interesting collaboration feature has not yet been developed.

lacking from the XO laptop, one was considered as a priority by many people (not by me, as my ideas was to work with mobility impaired children): the provision of a screen reader. I tried installing Orca, an Open Source screen reader adopted by the Gnome Desktop Environment. Being Sugar based on some of the same technologies as Gnome is, I thought it would be quite easy to integrate Orca in it. In tune with the Action Research principle that the knowledge generated during the fieldwork must be shared with the local actors, I wrote an installation guide for the CEIBAL technicians in order to allow them reproduce my experiments whenever they wanted (the text of the guide is reported in appendix C at page 249.)

My installation tests gave some good and some bad results: Sugar does not support the AT-SPI library, which is essential in order to make Orca interpret the events happening on the screen and translate them into speech. I was still able to install some AT-SPI enabled software, like the text editor Gedit or the web browser Firefox, and they worked well with Orca, as on any other Linux machine. The main problem was that, being the rest of the system inaccessible, it was impossible to provide a blind child with the possibility of using it as the rest of his or her class. I contacted the Sugar developers, who then told me that they were planning to support AT-SPI in the next releases. While I am writing these lines, I know that the CEIBAL technical staff has not given up trying this solution: the accessibility team is still testing Orca with newer releases of Sugar.

Another solution I was able to show to some of the children was a software I have been personally developing during the last four years. It is called Farfalla and is described in detail in appendix B starting from page 241. Being it mainly a web browsing tool, it raised few interest in the children, as in that phase of their technological experience they were more attracted by games and by the discovery of the Sugar system. I was still able to make them try some of the solutions I had then developed inside Farfalla. The feedback I received from them was not very positive, especially due to the

fact that the program had lots of visualization problems on the small XO screen. I then realized that the solutions I was adopting were too complex and that there was much more to do on simple adaptations. This made me think of a complete rewriting of the software, using a different architecture and basing the work on different technology. Such a change, together with the previous software structure, is described in appendix B.

The last experimental adaptation I tried during the fieldwork was a communication system based on the principles of Augmentative and Alternative Communication (AAC)[16]: it is called *Prestame tu Voz* (see appendix D at page 253 and [106]) and is an Activity meant to transform the XO into a picture based communicator. The idea for this came from some informal chats I had with the teachers of the School 200, especially with those who worked with multi-impaired children: at that time, they were testing some AAC solutions with the youngest children and they found this method to be very successful. I hence designed an application which would take advantage of what the XO already offered and would allow teachers and children to create communication tables. This project is still under development[17].

### 4.3.5 Pointing Out the Effects

As described in section 4.3.3, the process of developing accessibility solutions for the XO laptop was preceded by a reflection and by a series of tests on the obstacles posed by the machine to the children. The developed solutions were applied to test machines and could not be directly installed on the children's own laptops because of a delay in the delivery of the computers. When I left the School 200 at the end of June 2009, what I had been able to do was

[16] AAC is a technique used to teach how to communicate to children, but also to adults, with pathologies like autism or aphasia. Many AAC interventions are based on the use of a codified image system which serves both as a form of reality labeling and as a communication system.

[17] As of August 2010, I have received a communication from the two persons who are currently maintaining it that a test version is nearly ready to be released.

pointing out the effects of my work to the teachers and to the technical area of CEIBAL.

During my last month there in 2009, I held a sort of advanced XO training at the School 200, during which I met the teachers in small groups of three and explained them not only the basic functionalities of the Sugar desktop, but also how to set up and configure the adaptations I had tested, which they could be free to use until the CEIBAL technicians had integrated them officially in their custom Sugar distribution.

The effects on the children were tested using the same techniques adopted at the beginning of the fieldwork: the games and activities described in 4.3.3 were tried with them by me or by the teachers in order to fine-tune options such as mouse pointer speed, key repetition delay and 'bounce keys' timings. The result of these tests is not measurable in terms of a degree of success: the main effect was that of enabling them to do things they could not do before. The testing of their actual skills and particular problems was left to the teachers at this point.

Also at the end of my first fieldwork experience I held a seminar about what my work had been during those five months. Many of the people at CEIBAL technical area participated and I took that opportunity not only to make a list of the solutions I had been studying and developing (which they already knew) but also to show them what other work was missing in the same direction and what kind of impact I was expecting on the educational experience of the integrated children. I pointed out that the accessibility of the XO laptop was not only important on a personal level, but also under a social perspective.

### 4.3.6 Reflect Upon the Intervention: the epilogue of the research

I left Uruguay on July 3rd, 2009 and went back there from May 5th to May 31st, 2010. Ten months had passed, the school year had finished and a new one had begun. The XO laptop had reached all the children I met during my first visit, the internet connectivity problems experienced in some schools had been solved and some important Assistive Technology interventions had been applied.

I went back to the most important places I had visited, including ANEP, the Special Education Inspectorate, the CEIBAL technical area, now called *Centro para la Inclusión Tecnológica y Social*[18] (CITS), the School 200 and the schools where three children were integrated, numbered 50, 62 and 166.

In ANEP I was updated on the interventions they had promoted in the field of special education and of teacher training. The coordinator of CEIBAL there expressed her satisfaction for how the AT related issues had been faced until then: they had organized teacher training sessions, which happened primarily in the same special schools where those teachers worked. Some of those trainings were held by external experts, like the people from *fundación FREE*, who focused on mobility impairments and taught how to build some low-cost AT tools which could be used with the XO laptop (or actually with any computer, being those adaptations mainly hardware modifications).

The Special Education Inspectorate, in the persons of the National Inspector and of two Inspectors, expressed general approval for the plan and happiness for the results they had obtained during the first year in Montevideo, even if they admitted the lack of some important steps in the development of the project:

*Darle una computadora a cada niõ ha sido un impacto intere-*

[18]The *Centre for Technological and Social Inclusion* is located inside the LATU campus, but is an independent organization, acting as a private company but owned by the State.

> *santísimo de llevar y de observar científicamente, con un seguimiento ... yo creo que nos falta seguir una linea de investigación profunda, eso lo siento.. pero si veo que en todo el país tenemos una respuesta omogénea.*
>
> Giving a computer to every child had a very interesting impact, which needs more work and scientific observation, and also needs to be continued... I believe that we need to follow a deeper research project, and I am sorry of it, but I still see that the whole country is giving a homogeneous response.
>
> (C.S., National Inspector of Special Education)

The major complaint of the teachers I met was about the training they received: the interventions I heard of in ANEP were considered interesting and useful, but still not enough. They were especially concerned by the almost-total lack of adaptations, in both the forms of AT and special contents, and they thought the work in the schools of the whole country to be fragmentary. They knew that, besides the efforts put in the sensitization of the teachers, only some of them had showed to be receptive to the technological proposal, while many of them were simply adopting it as an imposition from above. This often ended up in very low usage of the machines at school and in an ineffective management of the resources offered by the available educational technology. In the three mainstream schools I had the opportunity to visit during my second stay in Montevideo the teachers plainly told me that they were using the XO only for a maximum of two or three times per week. Even if this data is not representative of the general penetration level of technology in the teaching and learning activity, it is still interesting that this frequency was so low in classes integrating children with special needs. Surprisingly enough, none of the teachers of those integrating schools told me about disabled children using the XO as a substitute for pen and paper: they seemed to think of it as a "subject" which had to be taught in dedicated hours, not as an instrument for improving the overall learning experience.

Another general complaint was about the high percentage of broken machines after the first year, a problem which I found affecting all the schools, not only special ones, almost everywhere I went to ask some questions about CEIBAL. This problem partially affected the tests I administrated to the children at the end of the fieldwork experience: as I will explain in the next chapter, many of them had problems with their laptops, varying from totally non-working ones to damaged hardware and software.

A visit to the CEIBAL technical area allowed me to appreciate the great effort put in the area of assistive technology. When I met the Project Manager of the Development and Optimization area, she proudly presented me the list of initiatives they had been promoting in the field of assistive technology:

- *accessibility kit*: every school was given a kit of several instruments, including enlarged keyboards, adapted pointing devices, switches. Those kits served as a reference for testing accessibility needs in the school: teachers were asked to order the adaptations needed by the children directly from CEIBAL after deciding what was exactly needed by each child;

- *teachers training*: teachers of special schools received extra training about AT in dedicated sessions led by experts of the field;

- *meetings with private organizations*: as disabled children often rely on extra-scholastic support coming from private organizations, the personnel of such groups received extra training about the XO laptop;

- *wheelchair control*: the agreement signed with Fundación Teletón in 2009 was still active in 2010, even if no real test with the children had been made until May;

- *'do it yourself' AT devices*: the technicians of the R&D area had been able to create switches out of old CDs and mouse controllers out of unused keyboards and those practices were being transferred to the teachers;

- *new AT devices*: a switch-controlled mouse replacement was designed and prototyped by the engineers of CEIBAL. It was waiting to be patented when I saw it for the first time.

On May 12th, 2010 I was invited by the CEIBAL technical staff to a workshop about accessibility where people from different institutions discussed the solutions adopted by plan CEIBAL in this sense[19]. During the event many teachers complained about the lack of equity in the interventions of CEIBAL on special schools: while a good plan of training was offered to teachers of children with mobility impairments, the rest of the special education areas were not given almost any new resource. The only exception to this were the blind, who had received an ordinary laptop (not an XO) with the commercial software JAWS installed: their teachers were already confident with that platform and required less training or no training at all. The schools which complained more about the lack of support from plan CEIBAL were those dedicated to the various forms of intellectual disability and to deafness: their students' impairments did not allow them to benefit of any physical assistive technology, their needs were more concentrated on special educational software. Actually, software requires more time to be developed compared to standard AT solutions. Even if many packages of educational software exist addressing a variety of special needs, few of them can be used on an XO laptop, mainly for two reasons: they do not run on Linux[20] and they can have huge system requirements, which the XO laptop cannot satisfy.

[19]The workshop was organized by *Red Especial Uruguaya - Poder, sin límites* for celebrating its 10th anniversary. The complete title of the event was: "Primer seminario sobre TICS y Discapacidad: Barreras Virtuales = Barreras Reales" and it took place at UNIT (Instituto Uruguayo de Normas Técnicas).

[20]Actually, some assistive software for Microsoft Windows can be run on an XO laptop through WINE, a software package recreating a Windows environment in a Linux system. More information about this technique is available on the OLPC wiki site, at `http://wiki.laptop.org/go/Wine`, and on the main WINE page, `http://www.winehq.org/`

### Final Focus Group

In this panorama, the School 200 distinguished itself from the publicly perceived average: the teachers there were very motivated (not without some exceptions) and many hardware adaptations were being used. The training had brought some interesting effects and a close collaboration with the CEIBAL technical area had allowed a larger adoption of the XO in the daily school activity. Even though, many problematic aspects emerged from the teachers. I held a second focus group on May 28th, 2010, thirteen months after the one I described in section 4.3.1. Ten teachers participated in the meeting.

I started the discussion by quoting a sentence from the preceding year: one of the participants had proposed the substitution of pen and paper at school with computers. This had lead to an interesting discussion about the changes in the role of teachers. They started from this point and told me about the experience they had had so far with the XO laptops: again, some of them were very enthusiastic towards technology, while others remarked the lack of training. The director of the school synthesized their needs in "one curriculum per child": special education is obviously more than AT.

They reported another interesting data: when the new school year began in March 2010, only three children arrived at school with a working XO. The total population of the school was of 98 for that year, and even if some of the children had not received their computer yet (because they were too young) the ratio is still very impressive. Not all the machines were broken: many of them could not be used because of a broken charger and the majority had been automatically blocked for not being connected to the school network for more than three months. This last case was a consequence of the anti-theft system that the technical area had developed. Instructions for unlocking the computers were available on the official CEIBAL website, but the teachers agreed that families often ignored this and many other things.

Talking about families and parents, it came out that when the laptops were delivered with an official ceremony at school 100% of the parents was present. This seem to be a national fact, but the teachers immediately remarked that after this initial excitement, nothing followed from the parents' side. They told me of a workshop they organized, during which they taught how to legally unlock a blocked machine: only 10 parents participated, and even less (only 2 of them) declared they were using the XO at home with their children. Some of the teachers attributed the responsibility for this situation to the CEIBAL plan itself, which was not addressing parents and families with the right resources and timings, while others argued that the teachers themselves had part of this responsibility. One teacher widened the discussion, by suggesting that this order of problems was common to every kind of educational intervention, not only to the XO. The school's population was composed of children coming from different zones of the city, some of which were very far and very poor. They had difficulties in making the parents respect even more important tasks and it was no surprise that they did not care too much for the computer after an initial excitement[21].

While many of the teachers complained about the lack of training, one assumed a provocative position, stating that they actually had everything they needed, and that they were only justifying themselves for not being able to deal with the novelty introduced by CEIBAL. She asked her colleagues to be honest and to admit how many times did they update the computer since they had received it: one immediately admitted not to have installed any software ever, while others rapidly reported their achievements (one had learned how to unlock it after some efforts, another had been attending an extra course, another used it for managing the school canteen reserves). The others sat without reacting.

[21]I was told many anecdotes about problematic families. The one I most vividly remember is about the parents of a deaf and mobility impaired child: the parents had sold the hearing aid of their son twice in order to buy drugs, to the point that when the child went home from school, the aid was guarded in one of the wardrobes of his classroom.

The discussion was then moved towards the children, and I encouraged the teachers to tell me about the kind of relationships they saw growing and which could be associated to the introduction of the XO at school. One teacher, which during the 2009 school year had her class composed by integrated children who had been interacting a lot with me, reported that two of her pupils helped each other a lot more, with one suggesting to the other to use the adaptations. Another teacher echoed this contribution by highlighting that the kind of help they gave each other was mainly physical: they seemed to share strategies for accessing the machines, more than knowledge. This feeling was not a common one among them: some other teachers reported that their pupils had no initiative in helping each other and had to be encouraged. This was perceived as a consequence of the distinct cognitive level of the children in the classes of the school.

Talking about the integration of the children in mainstream schools, they expressed their confidence in the idea of the XO as a useful instrument for facilitating social inclusion: they agreed on the fact that this could only be achieved with an efficient machine, which the XO had not proven to be. Only one of the teachers disagreed, defending an interesting point of view:

> *A mi me gustaría más que la usaran para jugar*
> I would prefer it if they used it for playing

She gave two reasons: they cannot move, and they like playing just like any other child. When one of the colleagues reminded her that the topic was the integration process, she answered that in her opinion 'personal' had a priority on 'social'. The main comment she received was about the need of an educational end in playing, which can only be granted by an intervention from the teacher. During this discussion an interesting statement came out: accessibility is a matter of priorities, in which at first it is necessary to grant disabled people with the physical and functional possibility of doing something. After this step, instruments reveal their true utility. Such instruments can then be used for the social part of the inclusion process. The inadequacy,

be it apparent or effective, of the XO laptop to this scope lead some parents and some teachers to consider the possibility of adopting other technologies, but more than one teacher involved in the discussion disagreed. They attributed the power of solving this general problem to training interventions, again. Still, the teachers who were more sceptical about the CEIBAL plan, delivered me a synthesis of their experience:

> *Es más el trabajo que la satisfacción!*
> The trouble is more than the satisfaction!

This is probably the main cause of the marginal use of the XO laptop in schools: it requires too much energy in order to obtain the same results which were easily achievable using traditional teaching techniques.

## 4.4 Main Findings

One of the first impressions I received from the field was that CEIBAL had somehow postponed every decision about special education and assistive technology to a second phase: at its beginning, the project was more concentrated on the objectives of coverage and saturation, which implied less attention on circumscribed interventions. On the school side, the fact that special education is prevalently practiced in special schools or in private centres made the problem even more serious: those institutions suffered for the same difficulties of other schools, plus had trouble in understanding the utility of the machine, which the received "off the shelf", just like the others.

As discussed in 4.1.1, starting from page 82, this work originally moved from three main research questions, which I report and discuss here:

[q1] *How can the XO laptop accessibility be improved for children with mobility impairments?*

[q2] *What do 'integration' and 'inclusion' mean for the actors in the environment studied? How they do it?*

[q3] *How does the laptop accessibility relate with the fact that it is distributed on a 1-to-1 basis?*

This first part of the research mainly addressed [q1] and [q2]. What follows is an attempt to answer them, while the following chapter will explore the perspectives opened up by [q3] by analysing four case studies in depth. Some critical points in the development of the project were also outlined during this phase, but they are more related to one-to-one computing in general than to assistive technology and special education.

### 4.4.1 Improvements to the laptop accessibility for mobility impaired children

In section 4.3.4 I presented a list of simple adaptations I applied to the XO laptop during my first fieldwork experience. Those modifications were all included in the official CEIBAL distribution of the XO operating system. As those solutions were not a real innovation, being already used on the majority of the operating systems, there was no real need of evaluating their usefulness: they constitute the foundations and the basic components of an accessible computer environment. Before May 2010 the list of AT solutions was enlarged by the addition of an on-screen keyboard, which could be used in a modified version of the Write activity or as a standalone software.

What is important to notice is what effects, both direct and indirect, those simple solutions had on the whole CEIBAL environment:

- assistive technology solutions tested by me and deployed by the CEIBAL technical area have spread throughout the country, positively affecting the computers of more than 400000 children. Even if the School 200 is the largest school in Uruguay addressing the needs of the mobility impaired, that does not mean that there is nobody else outside it needing those solutions. In a larger perspective, this contribution will reach in the long period all the computers of children involved in OLPC

deployments around the world;

- CEIBAL now counts on the existence of a dedicated update management system for accessibility solutions, together with an area specifically dedicated to the development and the deployment of newer aids. As of October 2010, I am still in contact with the technicians working on these aspects of the project and we regularly exchange ideas and suggestions about other solutions to be added to the XO, as programs allowing to control the mouse with the movement of the head and augmentative communication boards (see Appendix D)

- together with better infrastructures, the attention paid to accessibility solutions generated the need for training sessions with teachers. Being teachers training one of the most critical points outlined by the majority of the people I interviewed, the focus on accessibility certainly contributed, even if with limited effects, to the improvement of this particularly critical aspect of the whole CEIBAL project.

With particular respect to the first of these three points, I will report here an anecdote coming from one of my visits to the mainstream School 62 in May 2010: one of the most lively children in the class I was visiting, who I came to know in 2009, showed me his XO laptop. Its keyboard, which like every other XO keyboard was once made of a unique piece of gum, was completely broken. This means that the gummy cover had gone and only the contacts under it were visible. The child told me he was still able to use the computer. When I asked him how, he showed me that he had learned how to access the on-screen keyboard; he only needed his trackpad to be able to do the majority of things. He proudly explained me he could still use the XO, even if slower than the classmates.

This episode made me reflect once again upon the importance of an accessible environment: Assistive Technology disseminated horizontally in an environment lowers the obstacles that in everyday life can appear on anybody's path. Technology, for many distinct reasons, can generate new problems. It

can also be an obstacle. Assistive Technology serves not only people with a physical impairment, but also people suffering from a problem generated by the environment itself.

### 4.4.2 Integration in CEIBAL schools

The theoretical definitions of 'integration' and 'inclusion' I discussed in section 2.1 have not the same meanings given to the terms *'integración'* and *'inclusión'* in the environment studied. In Uruguayan schools the words integration and inclusion are often used as synonyms, even if it is still possible to track some interesting differences: *integración* describes both a process and a result. On the other side, *inclusión* seems to be mostly referable to a result only, and in some cases as a sort of *side effect*. Actually, the discourse on integration and inclusion involves a **functional** and a **social** level. The following paragraphs are an attempt to clarify this difference:

**Functional level.** A child is considered integrated when he has access to a mainstream school, when he has no physical barriers and when he participates of the class activity without acting as an obstacle to the mainstream group. Integration is seen as something children should want for themselves, as a consequence of a sort of curiosity towards a world which is outside their usual context. Teachers of special schools have a fundamental role whenever a decision is needed to start an integration process: they can express their personal opinion about how compatible with the integration project a child is, depending on the child's self confidence, fortitude and determination.

The phases of an integration project are normally three: initially the child only attends a special school, then for a variable amount of time he or she starts attending both a special and a mainstream school, to end up finally attending a mainstream school only. There are full-time and part-time integration projects: even if the former type is prevalent, the latter is quite common, especially in those transition periods when a child attends both

types of schools.

Technology in general, and AT in particular, is mainly considered useful in integration for the possibility it offers of enhancing one's skills and residual abilities. Computers are seen as ideal functional prostheses and the possibility of enhancing personal productivity is an highly appreciated feature.

**Social level.** When an integration project involving a child and a mainstream class group is started, the teachers and the other professionals involved evaluate the relationship between the disabled child and the rest of the group. In some cases, social inclusion in the group is seen as a sort of fallback objective:

> *Muchas veces hay muchos chicos que si bien no pueden cursar el programa académico del año que le corresponde sí puede hacer una óptima integración social. [...] Siempre la integración tiene que ser una integración donde se trabaje en lo académico. El chico no puede ir solamente a trabajar el área social, siempre tiene que haber aprendizajes, más allá de lo social.*
>
> Many times there are many kids who, even if they cannot attend the academic programme of the year, can obtain an optimal social integration. [...] Integration must always be an integration project where academic skills are developed. The child cannot go [to a mainstream school] only to work on the social area, learning is always needed, beyond any social skills.
>
> (D.U., director of special school)

The emphasis on learning (and implicitly on *functioning*) was normally justified by the assumption that school is a place for learning and not for social activity. Social inclusion was seen by someone as a desirable but yet-not-enough result:

> *uno pretende que esa integración no sea solo social sino de otros aspectos, que ese muchacho se enriquezca desde el punto de*

> *vista académico, ese acceso al conocimiento, ya que nosotros nos podemos integrarnos desde lo social en otros lugares y no tiene que ser en la escuela*
>
> One [a teacher] demands that integration to be not only social, but also regarding other aspects, that the kid will grow under the academic point of view, that access to knowledge, as we can integrate ourselves socially in other places, it has not to be at school. (A.A., teacher in a special school)

This view was common among the teachers of special schools, who were focused on learning. Mainstream teachers, on the other side, tended to attribute a greater importance to social integration, even if they still recognized the role of functioning. This dichotomy was quite evident when I analysed the codings associated to the interviews: of the twelve interviews with special school teachers, only in one case the social level was defined as 'the most important part', attributing to it a particular meaning:

> *Es en la parte de expresiones y actitudes que te ayuden a vivir en paz y en tolerancia. Así que como le estas pidiendo al otro que acepte al niño que entra, él también tiene que entender las palabras 'por favor', 'gracias', 'perdón'. Esa para mi es la parte más importante.*
>
> It is in the part of expressions and behaviours which help you living in peace and tolerance. As you are asking the others to accept the child entering their environment, he has to understand the words 'please', 'thanks', 'sorry'. That is, for me, the most important part.

Comparing the results of the analysis of the focus groups and of the interviews, an interesting difference emerges: while teachers tended to support social integration ideals when speaking as a group, they personally tended to put major emphasis on learning and functioning results when directly interviewed.

### 4.4.3 What changed within one year: expectations and disenchantment

The interviews allowed me to be informed about both the expectations that the development of the CEIBAL plan raised in schools and the critical points that emerged immediately after the delivery of the machines.

In 2009 the general feeling about the XO in the special schools of Montevideo was mainly enthusiastic: when I visited the schools in the initial period of my first stay, both directors and teachers showed great interest towards the training sessions I held. They already complained about the few opportunities for training: this complaint was emphasized during the second year. When I asked the teachers directly about their expectations for the upcoming arrival of the computers, they mainly answered expressing their positive feelings about:

- **Expanded functional possibilities.** They expected the children to be able to do more and to really participate in the stream of the classroom work;
- **Integration potential.** They felt positive about the fact that technology-empowered children would add to the list of those ready for integration, as the computer would expand their functioning beyond their current limits;
- **Disruptive/innovative potential.** More than once teachers expressed their hope to see real and extraordinary changes in their future way of teaching, which would cause a fracture with the past;
- **Possibility of professional growth for teachers.** Technology was seen as the carrier of new knowledge and better practices, with the possibility of positively influencing not only the children, but the teachers themselves, in the form of widened expertise in the field of teaching;
- **Engagement/fascinating potential.** The arrival of the XO laptop

was seen as a powerful way for motivating children in participating and in studying;

- **Social involvement potential.** The use of the XO was expected to be stimulating also for the construction of social relationships between the disabled children and the rest of their human environments;
- **Equity.** The computer was seen as an equitable device for the fact that everybody, disabled or not, would be using it.

On the other side, the initial concerns of the teachers were about:

- **Novelty.** As education is a rater traditional field, many of them felt uneasy about changing it in such a fast and radical way;
- **Lack of training for teachers.** The introduction of the computer required new competences, which were not seen as easy to adquire without external help;
- **Logistics problems.** The delivery of the machines was carried out in the short period of three years in the whole country, involving hundreds of schools: this had already proved to be difficult to manage and was generating even more concern, together with the problem of technical assistance;
- **Thefts.** The probability that someone stole an XO laptop was very low, but this did not make teachers feel completely safe about this point: they already had bad experience with other AT related tools;
- **Assistive Technology and adaptations availability.** The teachers knew their children and their specific needs: the lack of AT devices which was common before CEIBAL did not seem to be a point in the agenda of the plan.

The above points do not claim to establish any particular priority order: they are the topics emerged from the field and probably have more internal than external validity. What I consider most interesting is how those dispositions

changed over time, as when I visited again Uruguay in May 2010 the transition had happened: the last laptop was delivered in Montevideo in October 2009 and the schools had had time for adopting them, for vacation (summer holidays in Uruguay start in December and end in March) and for meeting them again, together with their pupils, at the beginning of the new school year.

When asked about what happened since my last visit to them, teachers and parents, together with other school personnel, mainly depicted a story of disenchantment, enriched in some cases by the presence of great enthusiasm, great involvement and great hope for a situation considered still in progress. As for the first year, I was able to identify the main points, which can be organized in two groups. The positive consequences of the deployment were:

- **Expanded functional possibilities.** Both teachers and children enjoyed the fact that the XO actually provided them with more possibilities and allowed the storage of a large amount of information;
- **Possibility of professional growth for teachers.** Some of the interviewed teachers stated that they had learned a lot since the implementation of the XO in their classes and, most importantly, they declared to be eager to learn more;
- **Engagement/fascinating potential.** Children showed great interest in the XO, especially in its most playful aspects;
- **Increased interaction with parents.** Initially, the delivery of the computers to the children attracted many parents to the institutions, which allowed better communication with families.

Again, on the other side, there were also some negative points:

- **Difficulties imposed by novelty.** Too much time was needed to adapt to the novelty and to be productive, hence the majority of the teachers tended to leave the XO in the background of their activity;

- **Lack of training for teachers.** The prevision about the need of more training than what was offered proved to be true: many teachers complained about the low impact that training sessions had had on their abilities;

- **Logistic problems.** Some delays in machines delivery and in technical assistance made the process harder than it should be, both on the end user side (with problems in delivering and in repairing the laptops) and on the school side (problems with school servers, network infrastructures and updates);

- **Lack of assistive technology and adaptations.** The solutions discussed in the above paragraphs were useful only for part of the population of the special schools, thus leaving unattended the needs of many other children and teachers; those children actually benefiting of the XO and of the related AT, seemed not to be put in the advantaged position of increased productivity which was expected;

- **Difficulties in the interaction with parents.** Besides showing great interest at the beginning of the process, families almost immediately lost their entusiasm and lowered their participation to it at the rising of the first technical, logistic and bureaucratic complications;

- **Lack of systematic research.** There was also who complained about the absence of an integrated method for monitoring the state of the project, which could be useful for solving present and future problems;

- **Hig tax of broken machines.** Many teachers complained about the fact that machines broke very frequently and that technical assistance times were too long;

- **Difficulties in understanding the software.** They not only felt Sugar to be too much different from ordinary Operating Systems, they also had trouble in imagining how to use the available tools for building effective teaching plans.

The teachers at the School 200 were the ones who received more training than the others, as CEIBAL organized a series of training sessions with experts of the field of Assistive Technology focusing mainly on adapted hardware. Nevertheless, they felt they needed more resources to be able to incorporate technology in their everyday work.

An important difference between my two fieldwork experiences regarded the opinions of the teachers about the effects that the adoption of technology could have over the integration of children with special needs in mainstream schools. The initial enthusiasm, which was mainly focused on the topic of 'computer as functional aid', left place to the diffused understanding that those kind of improvements were only achievable through time. The causes of this unattended expectation resided again in the above mentioned lack of training, but also in other factors: logistical problems certainly played an important role in it, but my personal hypothesis is that those children were not sharing the vision of their teachers: they allowed me to understand that the real revolution brought by the machines was not simply involving their functioning as bodily human beings. The next chapter is entirely dedicated to the exploration of this hypothesis through the exposition of the facts involving four of those children.

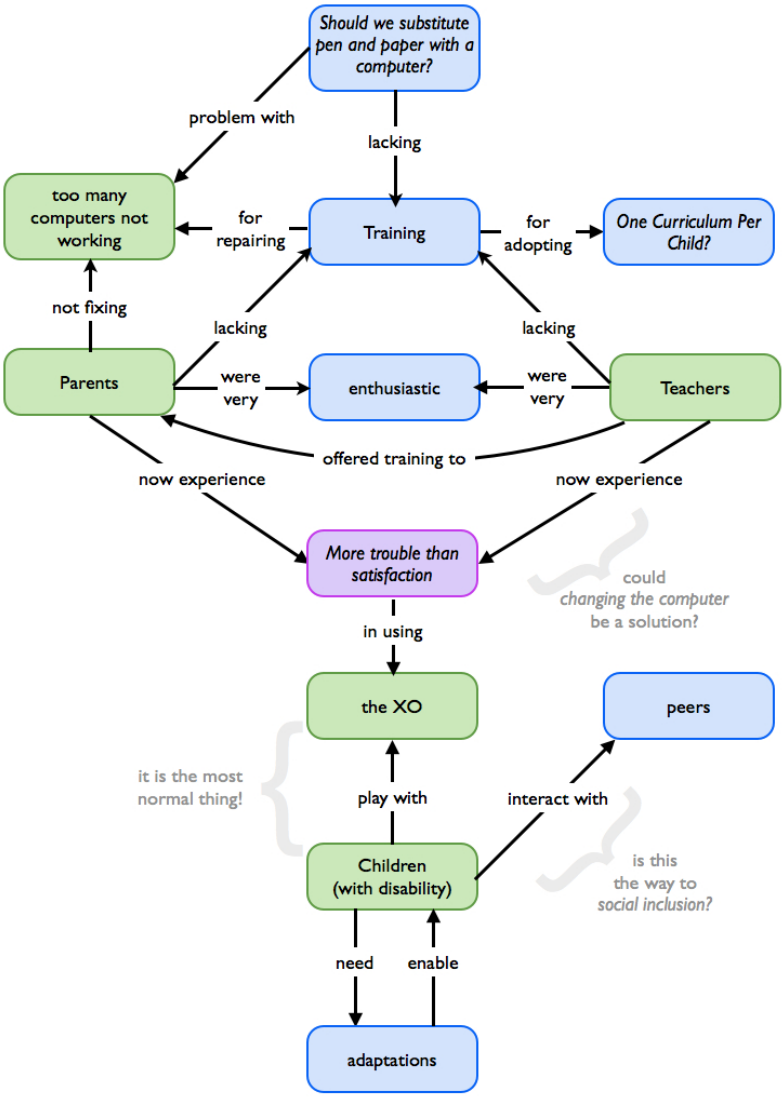


**Figure 4.8:** A conceptual map of the last focus group, held on May 28th, 2010

# Chapter 5

# Case studies

This chapter tries to explore the key points and indicators of the relationship between 1-to-1 computing, Assistive Technology and education. As in every research based on case studies, the objective of this work is the study of restricted units of analysis. Three case studies are presented following the same analysis structure, plus one more case which could not be studied at the same level of depth but which I still consider interesting and inspiring in some way. The cases satisfy the general requirements of being well delimited, unique and specific.

Following Yin's classification of researches based on case studies [174], this part of my work can be considered as an *action research case study*: the final objective is to define some best practices in the use of computer-related AT by reflecting on the role that those technologies can have not only in enhancing the intellectual and physical possibilities of a person with an impairment, but also in changing the way in which the same person interacts with his or her peers. The exploratory study described in the previous chapter is complemented by this part of the research. By zooming in on a small number of specific cases it is possible to catch some glimpse of the complexity of the largest, more complex reality in which this work took physically place. As

it will be evident in the following chapters, concentrating on those children actually allowed me to know much about the context in which they live and about the school system in general.

This part of the study addresses the complex relation between technology and education, through a reflection about the concepts of *integration* and *inclusion* as defined in the preceding chapters. The instruments adopted in order to build a solid base of useful empiric evidence are analysis of documents, semi-structured interviews, observation sessions, competence level tests and sociograms. These different data collection instruments were used in order to grant validity and reliability to the results, operating a form of *triangulation of methods* (see Trinchero in [156]). First, evidence was collected about the personal story of each child basing on the documents produced by their schools and by other institutions. After that, the interviews [1] gave me a portrait of each child and of the context in which they respectively live, together with adults' expectations and opinions about the results generated by the introduction of the XO laptop. The direct observation aimed to elaborate on those expectations and beliefs, in order to verify them and to reveal interesting critical aspects. The competence level tests A.5 were expressly elaborated in order to evaluate if one of the most widespread beliefs was true: the idea that giving a computer to a child with a mobility impairment could enhance his or her functioning level, in comparison with the rest of the class group. Finally, the modified version of Moreno's sociogram A.6 adopted allowed to take a snapshot of the structure of the network of relationships among the disabled children and the classes in which they were integrated.

The next section describes the above mentioned techniques in detail. The other sections, starting from 5.2, are dedicated to children with different levels of mobility impairments. Three of them were disabled since their birth, while one had derived his handicap from a car accident. When I started my fieldwork, they were attending the above mentioned School 200. I met them

[1] The interview tracks can be found in Appendix A, sections A.2, A.3 and A.4

twice per week for three months in 2009 and for one month in 2010, with some exceptions. I spent part of the time observing them, studying solutions for their particular accessibility problems. After finding useful solutions for them, I visited the mainstream classes in which they were integrated, in order to see what kind of impact the XO laptop would have in their relationship with able-bodied children.

The three selected cases[2], together with the cited fourth case to which I referred before, were not the only ones of children involved in integration projects within the School 200. There were actually two other cases in the school, but both of them were in some way problematic. One of them was not included in this set of case studies because of his high absences rate from both the special and the mainstream school. The other one, who had derived his disability from a recent car accident, had a very negative state of mind and was very difficult to approach.

## 5.1 Evaluation strategy

The strategy adopted in describing and evaluating each of the case studies involved three main steps:

- analyzing the context and the child's personal story, by the means of the above listed instruments (documents analysis, direct observation and semi-structured interviews with the adults who were responsible of his/her education);
- studying solutions for making the laptop more accessible to them;
- evaluating the impact of the introduction of the XO laptop in the mainstream class integrating the child, by the means of testing the overall ability level reached by the children in using the XO laptop and the relational network which existed among them.

[2]The names of the children were substituted, in order to protect their privacy.

The first two points were mainly addressed during the first fieldwork period, in 2009. The set of interviews is a subset of the one mentioned in chapter 4, which was completed in 2010. As seen before, one of the main expectations that the teachers had about the XO laptop was that it would allow their impaired students to be at the same level of the rest of the children composing a mainstream class. That was a strictly *functional* way of considering it: they concentrated on the laptop as a tool, or at best as a *Cognitive Amplifier* (see section 3.2.5). This lead teachers to the conclusion that the laptop would only indirectly influence the social aspects of the integration projects: it would enabled social interaction as a result of enhancing functional abilities. My own hypothesis was that improvements in the social areas were not to be attributed to improved functioning.

I wrote the first test following the functional expectations: it was meant to measure whether the children could be as fast and autonomous as the rest of their classmates. The second one started from the above introduced hypothesis: everybody was paying attention to the *functional* side of the problem, while the process of integrating a child involves a complexity of variables, among which the *social* component is fundamental. Hence a modified version of Moreno's sociogram was adopted, which aimed to track down the actual social network of relationships in the classes.

The following paragraphs serve as a methodological reference for the rest of the chapter, by describing how interviews, observation and assessment sessions, tests and questionnaires were structured.

### 5.1.1 Semi-structured Interviews

Semi-structured interviews differ from structured interview for not having a formalized, limited set questions. A flexible scheme was hence adopted, allowing new questions to be brought up during the interview as a result of what the interviewee said. During the 2009 fieldwork period I interviewed

teachers from both special and mainstream schools, defining a framework of themes to be explored (as suggested by Lindlof and Taylor in [97]). This included:

- previous experiences with cases of integrated children;
- issues in integration processes;
- main aspects of the active integration processes;
- expectations from the CEIBAL plan and from the introduction of the XO laptop at school.

In 2010 I interviewed the teachers again, adding one parent per child. This time, the topics explored in the interviews were:

- changes introduced at school by the introduction of the CEIBAL plan (for teachers only, including questions about the most critical factors, technical support received by CEIBAL, teachers training, class structuring, volunteering initiatives, relationship with families)
- description of the active integration processes;
- influence of the CEIBAL plan and of the XO laptop over the integration process;
- changes in the child behavior and independency after the introduction of the computer at school;
- issues and positive effects emerged since the delivery of the laptops.

Such interview guides helped me to focus on the topics at hand without constraining them to a particular format. This freedom allowed to tailor my questions to the interview situation, and to the people I was interviewing.

### 5.1.2 Observation

Following the ideas exposed in [156], we can describe observation as an intentional process performed by an *observer*, with the aim of collecting data about one or more subjects in determined situations. The data collection process tends to the detailed description of the behaviors of the subjects studied and to the comprehension of the opinions, attitudes, relational dynamics and cultural factors which lead the observed individuals to follow such behaviors.

The observations I conducted mainly followed the model of participant observation proposed by Cardano in [25], page 107-108: I was totally involved in the observation sessions, becoming part of it. This allowed me to spend time *with* the individuals I was studying and in some cases to spend that time *like them*. As I explained in the previous chapter, I assumed a particular role in the context of the classrooms, operating a "resocialization" (see Emerson et al. in [46]): I learned the values, the norms and the precepts of the guest culture.

I collected notes coming from my participant observation sessions in a diary, from which I will report here some fragments in order to clarify the most interesting points.

### 5.1.3 Tests

The tests described in the following sections were designed in order to collect some easily measurable data about the class climate and the level of computer related skills (or better, XO laptop related skills) of the classes in which the cases studies were conducted.

### Ability assessment

The first test I submitted to the children in mainstream classes involved the direct usage of the XO laptop. I asked the children to accomplish with six objectives, which I wrote on the class blackboard in the form of "missions". Those objectives were expressed as follows:

- Turn the computer on, connect to the internet and go to the "Home" screen;
- Play the game "Sonrisas sanas" which can be found on CEIBAL website;
- Take a smiling photo of yourself and save it as "Smile". Fetch the picture called "Smile" in the Journal;
- Draw a house using at least two geometrical shapes of different colors (triangles, squares, rectangles);
- Create a new document, write "hi, my name is" and your own name, then add the photo saved as "Smile". Share the document with the neighborhood;
- Connect to a shared activity. Start a chat with someone else.

The Sugar Activities involved in the test were chosen in accordance with the results of the public report that CEIBAL organization published online in December 2009 [27]. In that report, a classification was presented of the children's favorite activities: in grade 3rd and 4th, where the test was performed, the top three activities were "Browse", "Record" and "Paint". The "Write" activity is the most used in absence of connectivity, while "Chat" was added to the test in order to analyse basic activity-sharing abilities. The six tasks were presented to the children in Spanish. Their readability score is of 67, according to the Fernandez-Huerta [51] Spanish readability test. This score marks them as "normal" on a scale which goes from 0 = 'very difficult' to 100 = 'very easy'. All tasks were explained to the children after being written on the blackboard. As can be seen in Appendix A.5, each of

them was subdivided into items (for a total of 22 items), splitting the action in smaller and more measurable objectives. The instructions I gave to the children were the following:

- do what you are asked on the blackboard with your XO laptop, and do it alone;
- if you do not know or do not understand how to do something, raise one hand and wait for my help;
- if you cannot do something, simply wait for a new task, do not call your classmates or your teacher for help.

I asked the teacher not to help them, even if they called for assistance. During the administration of the test, I was helped by one other researcher. For the data collection I used a printed table where the columns represented the items composing each task and the lines represented the children. During the test my helper and I divided the class into two parts and controlled them, by marking down the successful and unsuccessful results, the requests for help and the problems caused by an error or misconfiguration of the machine. I also set a time limit for each task, and asked the children to stop whatever they were doing when time ran out.

At the end of the test, the table was filled with marks corresponding to the results of every item: an '*' marked an autonomous and successful result, an 'X' was a partially successful result, obtained by asking for help, a '/' meant that the objective could not be reached but for a problem with the machine and a '-' marked a total failure in the task. From now on, while talking of the results of this test I will use the following acronyms:

- NS = *Natural Success*, for success achieved by the child alone;
- AS = *Assisted Success*, for success achieved after an help request;
- MF = *Machine-dependent Failure*, for failure due to a problem with the hardware or the software of the machine;

- NF = *Natural Failure*, for the failure due to the child only.

I also applied a Rasch-type model to determine the difficulty of each test item for the active group of children, which allowed me to study whether the integrated child was failing on the most difficult items or on not. As the Rasch model in its basic formulation only allows dichotomous values, I operated a further simplification on the data: I assumed successes of both NS and AS type as equal, coding them with value 1, while I counted MF and NF as 0. This classification of responses can be considered biasing, as the failures due to computer problems obviously do not tell us whether a child can or cannot accomplish with one particular objective. But if we consider this test only as a measure of "what children can do" and not as a measure of "what children know", the failures depending on hardware problems or software issues assume an interesting value: they tell us with a certain degree of approximation how much reliable the machine is for the class to which the test is administered, giving us an idea of how many issues can be encountered by a child during the everyday learning activity and of the actual possibilities they have[3].

### Moreno's sociogram

The second test consisted in an implementation of Moreno's sociogram. This specific sociometric technique, which was originally developed by Jacob Moreno in the 1930's, allows taking snapshots of the relationships existing among the members of a group, whatever the grouping criterion would be (see [112]).

My main purpose in adopting this particular data collection and representation instrument was understanding if the introduction of the computers in the classroom activity had someway influenced the relations between the children. This is not a longitudinal test: given the fact that all the three

[3]Note that the low reliability of the machines is a major issue in CEIBAL plan. The topic is also discussed in section 4.4.3

classes had changed in the passage from 2009 and 2010 academic year, it did not make much sense to compare data about two different classes. Hence I chose to take a synchronous snapshot of different aspects of the class social network by considering the intersection of two dichotomies: social versus functional abilities and 'analogical' versus 'digital' schooling.

| | **Social** | **Functional** |
|---|---|---|
| **Analogical** | Diagram A | Diagram B |
| **Digital** | Diagram C | Diagram D |

**Table 5.1:** The two dichotomies at the base of the sociogram and the resulting four diagrams

As can be seen in Appendix A.6, the test was made up of nine questions. The first one had the sole purpose of determining how many children already knew each other and how many groups already existed in the class. This question was inserted in the questionnaire in order to balance the results of the test. The other eight questions can be grouped by two, and each couple explores the positive and negative side of each of the aspects displayed in table 5.1. After collecting the data I was hence able to draw four diagrams, identified by a question and by the intersection of two aspects, defining a type of interaction:

- Diagram A - Who do you want to sit next to you? - social/analogical interaction;
- Diagram B - Who would you choose as a companion to work in a group? - functional/analogical interaction;
- Diagram C - Who do you like to chat with? - social/digital interaction;
- Diagram D - In case of problem with your XO, who do you call for help? - functional/digital interaction.

By analyzing and comparing the diagrams, I was then able to identify the leaders and the isolated children of the three different classes where I held the test. My main interest was still focused on the mobility impaired chil-

dren, hence I concentrated my analysis on understanding in what kind of interactions they obtained the best results. I used a computer software[4] to draw the sociogram automatically and in order to be able to easily compare the results.

As the whole class sociograms obtained processing the data were very difficult to read, I synthesized them for each child by only showing the ties between the studied child and the peers who were chosen by or choosing him or her. The complete sociograms of the classes are available in appendix A.6.

## 5.2 Ismael

The first case I will analyze is the one of Ismael. Born in 1999, he normally sat in a wheelchair, was affected by strabismus and had limited use of both his hands. He used his left hand for writing and for operating the mouse and the keyboard when he was in front of a computer. He had evident difficulties with both the mouse and the keyboard, be that the ones integrated in the XO laptop as well as external, ordinary ones. He also was very curious and quite anxious.

He attended the above mentioned School 200 till October 2009, and was integrated in a mainstream class of the School 50 since 2008. He is currently attending only the School 50 lessons, as long as the School 200 personnel decided, together with the child's family and the mainstream school teachers, to integrate him full-time. His situation is still being supervised by a team of professionals in a private clinic.

[4]The software used for this task is Graphviz, which can draw diagrams from raw text files with a very simple markup. The software is available at `http://www.pixelglow.com/graphviz/`

### 5.2.1 First meeting and initial impressions

I met Ismael during the first day I had the possibility to interact directly with the children at the School 200. He was sitting in one of the smallest classrooms of the school, together with Michel, another child who was like him integrated in a mainstream school[5]. The teacher (P.M.) was also present during our first meeting.

He immediately showed great interest and enthusiasm towards the XO laptop, which he already knew from his teacher. He also told me he did not have a computer at home, but that he had already used the desktop PC of his older brother, who did not live in the same house.

In order to familiarize with him, after introducing myself I turned the XO laptop on and started answering to his questions about the hardware of the machine. He had many technical curiosities about it, and he started asking how much memory it had, how large was the distance covered by the wifi signal of the school, how many hours did the battery last. Then he asked me if it was possible to use some programs he already knew, such as MSN messenger, or some games he used to play on Windows. He expressed satisfaction for my answers and the teacher remarked that he was a very curious boy, always interested in exploring things and in understanding how they work.

### 5.2.2 Previous diagnosis and teachers' evaluations

Among the documents I was able to access regarding Ismael's personal history, the oldest one was a report from the Uruguayan perinatology department (*Centro Uruguayo de Perinatologia*), dated 12th May, 1999. This

[5]Michel's situation was potentially interesting for this study, but his very difficult familiar situation caused his absence from the school during my whole permanence period in Montevideo. I only saw him twice, the first time on the first day (23rd March, 2009) and then, occasionally, on 9th June, when he was convoked by the school director together with his grandmother, who was in charge of mentoring him.

means it was redacted only two months after his birth. He was born after 27 weeks of gestation and suffered for various complication during his first days of life.

According to one of the later documents, dated 2006, his official diagnosis was of *cerebral palsy*[6] with *mixed pyramidal and extrapyramidal tetraplegia*, predominated by the pyramidal component. The palsy resulted in "spastic diplegia" and this definition was confirmed by later documents.

The psychologist working at School 200 reported that Ismael showed interest for the school activities but that his attention was also labile. The conclusions of the report depicted his intellectual condition and proposed a generic intervention against his problems in maintaining attention:

> *Ismael de 7 años 7 meses de edad posee Buen Potencial Intelectual y Buen Potencial de Aprendizaje, con Nivel Intelectual Promedio. Lenguaje y comprensión acorde a la edad. Buen desempeño social. Es necesario un Apoyo especializado en las áreas perceptivas y motrices, con atención sistemática e individualizada que potencie su madurez.*
> *Trabajar estrategias de mejora de la atención.*
>
> Ismael at the age of 7 years, 7 months has good intellectual potential and good learning potential, with an average intellectual level.
> His language and understanding skills are appropriate to his age.
> Good social attitude.
> A specialized support is needed for the perception and the motion area, with systematic and individualized care in order to empower

[6] According to [11], the medical definition of cerebral palsy is the following: *Cerebral palsy (CP) describes a group of disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, cognition, communication, perception, and/or behaviour, and/or by a seizure disorder.*

> his maturity.
> Strategies must be developed in order to improve his attention level.

From the quoted fragment emerges that Ismael not only had mobility impairments, but also some perception problems, mostly due to his low vision and strabismus. His frequent lacks of attention were also highlighted in the same report and in others, produced between 2006 (the year when Ismael entered the School 200) and 2009 by the teachers of the special school. They also noticed that the child had difficulties in writing, in the sense that using an ordinary pencil was not impossible to him, but was actually very tiring.

The 2009 report, which was written after Ismael received his XO laptop, included a section about computer related abilities. The generic evaluation stated that he could use the computer very well, standing out from the rest of the class (which was actually composed by two other children, one boy and one girl). An XO usage evaluation sheet was attached to the cited 2009 report, composed by 33 items which were evaluated with three degrees of achievement: totally achieved, partially achieved, not achieved. Among these items, five were marked as partially achieved:

- Control over his impulses;
- Acceptation of suggestions from the teacher;
- Independency level;
- Acceptation of his difficulties and acknowledgement of his own errors;
- Tolerance towards frustrations.

The only mention of adapted hardware present in the evaluation sheet, regarding the usage of an external and adapted mouse, was left blank.

### 5.2.3 Teachers and family

During my whole fieldwork experience, I met various people who were involved in the education of Ismael. I interviewed them for the first time in 2009, using a semi-structured track (described in Appendix A, section A.2), in order to find some useful information about the child and to depict a detailed profile of his particular case before starting to work with him. The interviewed people were:

- D.U., director of the School 200;
- P.M., teacher at the School 200, who worked directly with Ismael in 2009;
- L.M., teacher at the School 200, who worked directly with Ismael in 2006 and 2007;
- R.G., teacher at the School 50, who worked directly with Ismael in 2009;

During the fieldwork experience held in 2010, I re-interviewed the first three people and added interviews to the following:

- C. V., support teacher working for School 200;
- L.A., director of the School 50, where Ismael was integrated in a mainstream class;
- J.R., teacher at the School 50, who worked directly with Ismael in 2010.
- R.F., Ismael's father.

Ismael was described by who worked with him in the past years as a young 'dictator': when he entered the special school he was used to asking – *commanding* – all sort of things to the others, specially to the adults. His personal story of integration in the mainstream school started in 2008, and this attitude was evident also for the teachers of the School 50. His former teacher in

the School 200 doubted about the efficacy of the collaboration between the special and the mainstream school:

> *Lo que quizás no hicimos fue la preparación de la docente, para que supiera que él es un niño más en la clase, si no no sirve.*
>
> What we probably did not do was the teacher preparation, to let her know that he is one more child in the class, otherwise it is not useful.

As Ismael had complex impairment, both in mobility and in the sensorial area, the teachers reported of his difficulties in distinguishing figures from backgrounds, colors and shapes. Also concentration was a mayor issue for him. All these facts suggest that a mainstream school would be quite hard for him to attend.

The integration in the mainstream school was decided upon discussing it among the special school personnel and interviewing the parents. P.M., the teacher who introduced me to Ismael, described the project behind his integration as a process of 'strategy development', where the child and his family were counselled by the school for defining ways of defending him and compensating his limitations.

What emerged from my interviews with the School 200 personnel about the two levels of social and functional integration, as reported in 4.4.2, was quite clear:

> *Siempre va a ganar en el nivel social, siempre va a ganar en el estar en ese grupo de niños comunes. Porque hay que llevarlo siempre a la normalidad.*
>
> He will always win on the social level, he will always gain from being part of that group of mainstream children. Because he must always be brought to normality.

They saw the integration process as a good opportunity for developing social skills and relationships. They provided Ismael with the basic functional skills

he needed in order to be accepted in the class, but considered the social level as the most important and profitable one.

With respect to technology, in the special school it was seen as an important facilitator for the functional level: both P.M. and L.M. expressed their positive opinions towards it, highlighting the important impact that they expected the XO to have on his motivation and on his overall level of functioning.

When it came to the mainstream school, both the father and the class teacher seemed to be more interested in the social aspect of the integration process: Ismael was, in their words, very well accepted by his classmates. There seemed to be no problem with them, as the father repeatedly told me during our interview and also during our informal chats. This process of social inclusion was not straightforward. As a teacher in the School 200 stated:

> *Tanto la maestra de clase como el papá, estaban como medio resistentes a que fueran los compañeros los que se encargaran de Ismael en la hora del recreo. Pero ahora poco a poco lo fueron logrando.*
>
> The class teacher as well as the father were kind of resistant to the fact that it would be up to his classmates to take care of Ismael at break time. But now they accomplished it, little by little.

While every person involved in Ismael's integration process showed great expectations and even greater satisfaction for his social relationship with the classmates, they seemed to care less about his overall functional level: they were never directly asked about Ismael scores and grades, and they never mentioned the topic, but they neither seemed to care much about it. Their discourses suggested an implicit acceptance of his pathological difficulties in some areas of knowledge.

A role of motivator was recognized to the computer, but no apparent functional improvement was obtained through it. As his father, R.F., told me during my second stay in Montevideo, it sometimes proved to be of disturbance to the school activity:

> *... era un sacrificio para él, levantarse en la mañana y todo, con ganas de ir a estudiar y... que hiciste? Jugué en la computadora... Que hiciste? Jugué en la computadora... Deseando que terminara el año pasado porque no fuera más!*
>
> ... it was a sacrifice for him, to get up in the morning and everything, willing to study and... what did you do? I played with the computer... what did you do? I played with the computer... [We were] looking forward to the end of the year to stop it!

At the end of my second fieldwork experience I directly witnessed a case of *incident*, mainly due to communication problems between the special and the mainstream school. This episode is later described in section 5.2.6.

### 5.2.4 Direct observation and solutions adopted

I spent a quite large amount of time with Ismael, including 20 hours with him at the School 50 during the first fieldwork experience and other 6 hours during the second. During all this time, the child always showed great interest towards computers, and repeatedly told me how happy he was of the gift that CEIBAL was about to deliver. He was, among all the children I met, the one with the highest curiosity, capable of learning some non-basic commands and actions simply by carefully watching the movements of my hands on the keyboard. He adopted this modelling strategy (see [107]) successfully in many episodes, and this allowed him to learn how to enlarge the text in a web browser using the proper keyboard shortcuts, or how to start a program from the Linux command line.

As he had sufficient mobility only to press some keys with his left hand,

I proposed him to use an external numeric keypad in combination with the MouseKeys option. At the time we experimented this first, I was only able to invoke MouseKeys from the command line. Then I created a Sugar activity package which would apply it to any XO laptop, until MouseKeys was later included in the Sugar control panel by the CEIBAL technical staff.

Using the external keypad was kind of exciting for Ismael, who showed it proudly to his classmates of both the special and the mainstream school. He never hesitated in explaining to his classmates how the aid worked, thus autonomously complying with the first of the guidelines discussed at the beginning of section 3.1: "Every child in the class, disabled or not, should know how the assistive tool works, what it is useful for and what parts it is composed of".

In addition to the keypad, Ismael also took advantage of the Screen Magnifier, which was also included in Sugar by CEIBAL upon my recommendation. As this tool did not work smoothly on the XO laptop, mainly due to the limitations of the XO hardware, he tended to make use of this tool only from time to time.

When I went back to Uruguay in 2010, I found out that he was also using another adaptation introduced by the CEIBAL technical staff, which consisted in a virtual keyboard. As I was able to see directly one day while visiting Ismael in his mainstream class, this tool allowed him to write slowly but quite precisely. On the contrary, using the XO keyboard or an external one was problematic for him, as his hand's mobility control was limited to fingers, and not to the whole arm. Besides the slowness of this writing method, Ismael proved to be able to write entire sentences.

Observing the class activity in the mainstream school also lead me to notice an interesting fact, which did not emerge from the interviews and which was partially contradicting some of the statements of the teachers: Ismael used the XO laptop at school only when the other children did. This means one important thing: the AT solutions he was adopting were being useful only

to interact with the computer, and not to overcome issues which were not related with the computer. He was not using the computer as a writing tool, neither his concentration problems were being supported by the use of mental mapping software. He and his classmates were using the computer together, and in this communitarian use he was the one who used different software.

Among the various interesting episodes I annotated in my diaries, there are three which I consider particularly interesting:

> *21st May, 2009*
>
> Today I got to the School 50 with a delay of twenty minutes, due to a transportation problem. When I entered the class, which I was visiting for the third time, I was warmly welcomed by a collective cry from the children. I was then informed that Ismael did not go to school that day and that his classmates had been protesting: they thought that I was not coming because I only cared for Ismael. They expressly told me that they considered it unfair.

This episode suggested me that Ismael was, comprehensibly enough, considered as subject to privileges. He had his father always accompanying him, he had had the possibility to use an XO laptop before his classmates, he had now an external, foreign person assisting him. All these facts obviously put him under a different light: the classmates were probably used to consider him "different", "in need of help", "privileged".

> *18th June, 2009*
>
> [In this passage, the class was doing a group work activity, with small groups of children dedicating to distinct tasks. Ismael was assigned, together with three other classmates and me, to internet searches about vegetables.] Ismael constantly tried to take the full control of one of the two XO laptops we were using. He insisted, saying first "They don't know how to do it", "I know

> where to search". When the other children tried to turn the XO screen, he protested saying "I can't see! I can't see!". The other children looked at me and, as if I had ordered them to do it (even if I did not), they turned again the screen towards Ismael and then left him alone, concentrating on the other XO.

The fact that Ismael tended to command his peers and the adults had already been remarked by the interviews with his teachers. The classmates were used to this, and apparently considered his will as something not controvertible. He also seemed to be conscious of this effect. When I visited the class in 2010, I noticed that these kind of behaviours were not so evident: every child had received a computer and Ismael's father was no more staying in the classroom during the class time.

> *25th May, 2010*
>
> The teacher asked the class to read a story which had no conclusion. The children read one sentence at a time, some of them having serious difficulties. The teacher then asked the class if they had found something strange with the story, and almost immediately one of them answered correctly. Then the teacher asked them to turn on their XO laptops and to start writing an appropriate end for the story. Six of the fifteen present children did not have their computers. The others accomplished with the task and then, upon the teacher's request, exchanged their computers and started correcting the work of each others. At this point Ismael had a problem: the computer of his classmate, using which he was supposed to correct the story, did not provide him with the adaptations he needs.

This passage highlights two interesting aspects:

- the computer was being used as a substitute for pen and paper, but in restricted amounts of time, compared to the whole class hours; this was in conflict with OLPC recommendations;

- there was no consciousness either of the possibilities offered by the collaboration features of the XO, either of the importance of individualized AT.

One year after my arrival, Ismael had surely changed in his disposition towards the rest of his class. At the same time, more than half of the classmates and the teacher had changed. The XO, which in everybody's opinion was very useful for him, was not being used at the top of its functionality. Most important, it was not being used as a tool for overcoming his physical limitations: he still wrote, with considerable effort, using a pen, and was allowed to use the computer only when the classmates did.

As Ismael himself told me one of the last days:

> *A mi me encanta esta computadora. Quiero usarla para comunicarme contigo y con mis compañeros, y para escuchar música en mi casa.*
>
> I like this computer very much. I want to use it to communicate with you and with my classmates, and to listen to music at home.

### 5.2.5 Tests

**Ability assessment.** When I administered the ability assessment test to Ismael's class, 16 children participated. 15 used their own computers, one used mine with the official Sugar distribution from CEIBAL. The results obtained by the observed child compared with the rest of the class are shown in table 5.2.

Ismael totalized a number of successes which is inferior to the mean but with z score superior to -1. This suggests that his abilities in using the XO are comparable with the average student in his class, even if a bit lower. He also asked for more help than the average, which allowed him to complete

| | NS | AS | NF | MF |
|---|---|---|---|---|
| **Ismael** | 16 | 3 | 2 | 1 |
| **Total** | 278 | 31 | 19 | 24 |
| **Mean** | 17.38 | 1.94 | 1.19 | 1.50 |
| **Standard deviation** | 3.03 | 1.48 | 1.05 | 1.83 |
| **Ismael's *z scores*** | -0.45 | 0,72 | 0,78 | -0,27 |

**Table 5.2:** Ismael's results in the ability assessment test, compared to the rest of his class

the test with more AS results than NF. The amount of NF is still higher than the average. The only MF he scored was due to a problem with the internet connection, which is not uncommon with the XO laptop. The subtask involved by this item was "reach the CEIBAL plan homepage" and in the whole class, three children could not accomplish with it because of connectivity problems.

Looking at the difficulty scores attributed to each item by the application of the Rasch-type model, reported in table 5.1, Ismael failed in two items (q10: "Save your photo in the journal" and q13: "Draw a house") which were respectively relatively difficult and relatively easy.

Item q10 was the third most difficult item for this class, but looking at the original matrix it is easy to understand that this difficulty was mainly due to a problem in the machine: except for the case of Ismael, the other children failed for MF, because their journals were full and no more data could be saved. Ismael did not remember how to save, and he was the only one. He then failed in q13, a relatively easy task, probably because of his deficits in the perception and motion area discussed above. He got NS results on the two most difficult tasks, both involving activity sharing: we had been experimenting this feature together during my first research period, while testing the accessibility solutions, and Ismael showed to remember well the procedure, which was difficult for his peers.

The test results, besides their purely indicative and non-absolute value, seem

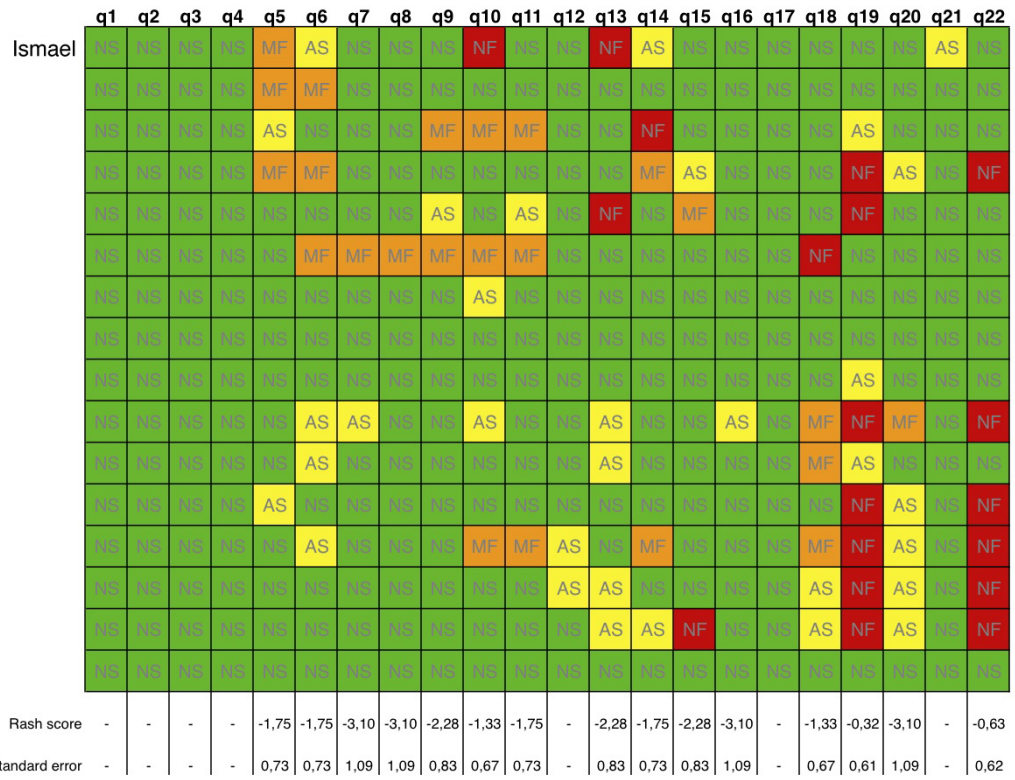


**Figure 5.1:** The total results of the class, with the difficulty coefficients of each item calculated using the Rasch function in R

to depict a child who is at the same level of his peers on an overall perspective, but has particular difficulties in well delimited areas. The adaptations he used proved to be effective at least in allowing him to finish the test in time with his classmates: during the test administration he relied on the MouseKeys solution, on a virtual keyboard and on the screen magnification tool included in the Uruguayan Sugar distribution.

**Sociograms.** The sociograms deriving from the administration of the questionnaire described in 5.1.3 display some interesting information about the class climate at the time of my second visit to Ismael's class.

Finding the "stars" and the "isolated" members of the class is the first objective of Moreno's sociogram. The two following diagrams (figures 5.2 and 5.3) show the total positive and negative preferences received by each child

in Ismael's class in the four analysed dimensions.

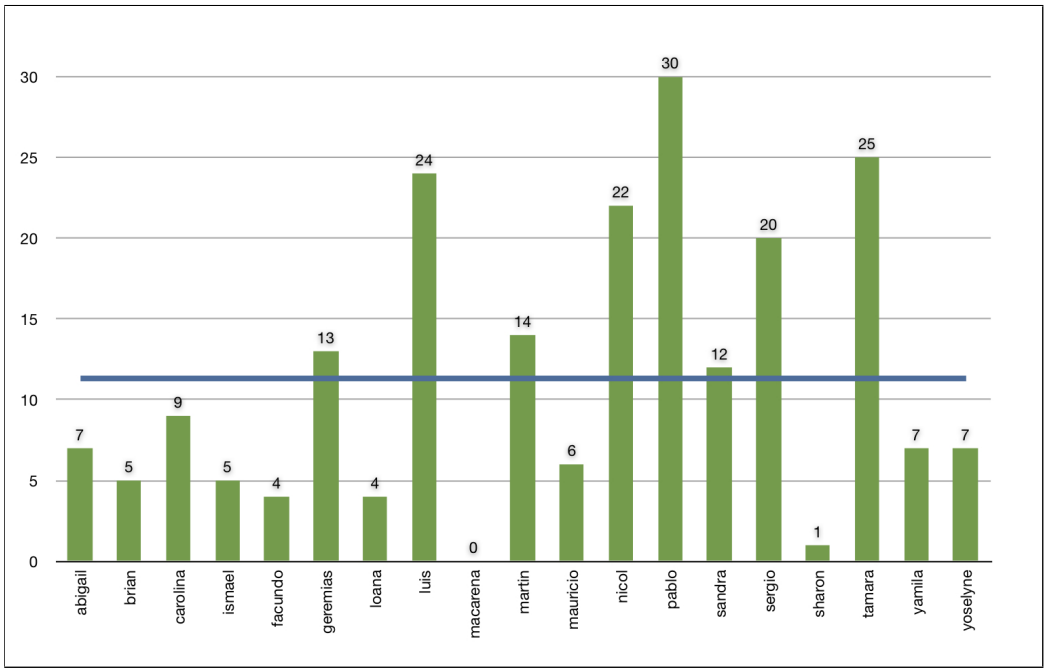


**Figure 5.2:** The total positive preferences in Ismael's class (the blue line marks the average).

The four couples of dimensions taken into consideration produced the following results:

The same results can be graphically represented as in figure 5.4, which is a reduction of the total class results.

The **social/analogical** result can be explained by looking at Ismael's normal position in the class: he must sit in the front row, on a special desk, higher than the others. This barrier did not facilitate his interactions with the other children: they did not refuse him, but they did not prefer him, either. He seemed not to be taken into consideration as a desk neighbour, a fact which classifies him as 'excluded'. He chose as preferred neighbours two classmates who he already knew and one who he did not. The same combination of choices was common to the other answers.

Under the **functional/analogical** point of view, Ismael was accepted but

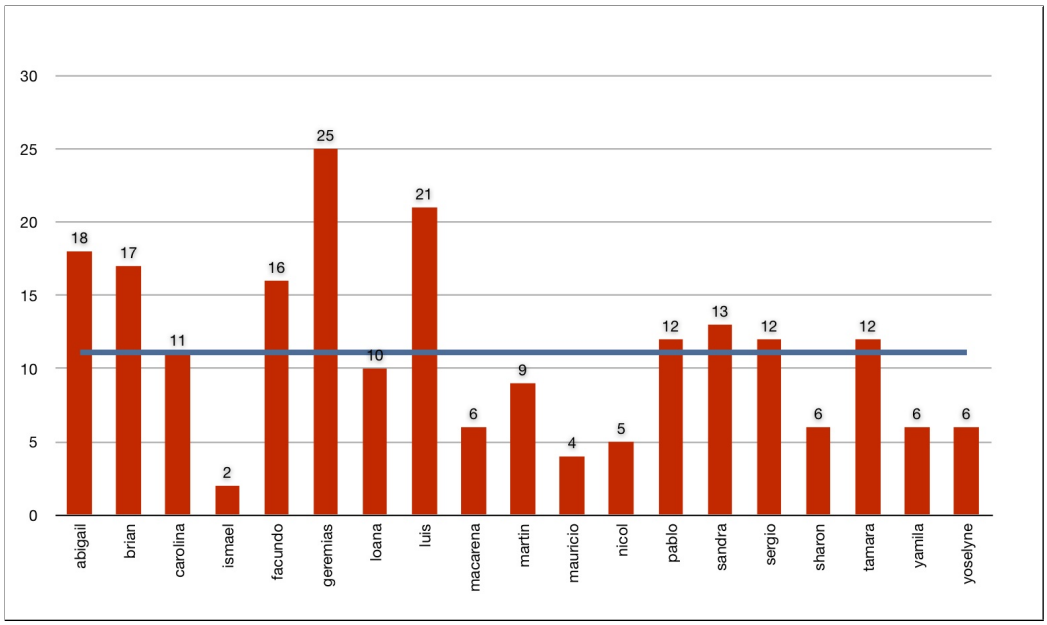


**Figure 5.3:** The total negative preferences in Ismael's class (the blue line marks the average).

also refused. This data, compared to the previously discussed social/analogical outcome, probably means that for Ismael's classmates it was easier to think of him as someone to work with, than as someone to spend time with. The same results were evident in the **functional/digital** dimension, a fact which could be read as a prove of the scarce influence that the adoption of the computer was having under the functional point of view. While Ismael chose the same people for the two functional areas, he was chosen by an old classmate and rejected by a new one for the analogical task. In the functional/digital aspect he had a bidirectional link with one of his favourite classmates (Sergio, who was new in the class) while was rejected by one of the old classmates.

It is finally interesting to see how much higher was the rate of acceptance Ismael obtained in the **social/digital** dimension: he gained 3 positive choices, which was slightly higher (0.16 points, *z-score* 0.07) than the average of the class. The maximum preferences were obtained by four "stars" (scoring 7, 7, 6, 6 preferences each) and 53% of the class obtained fewer preferences than

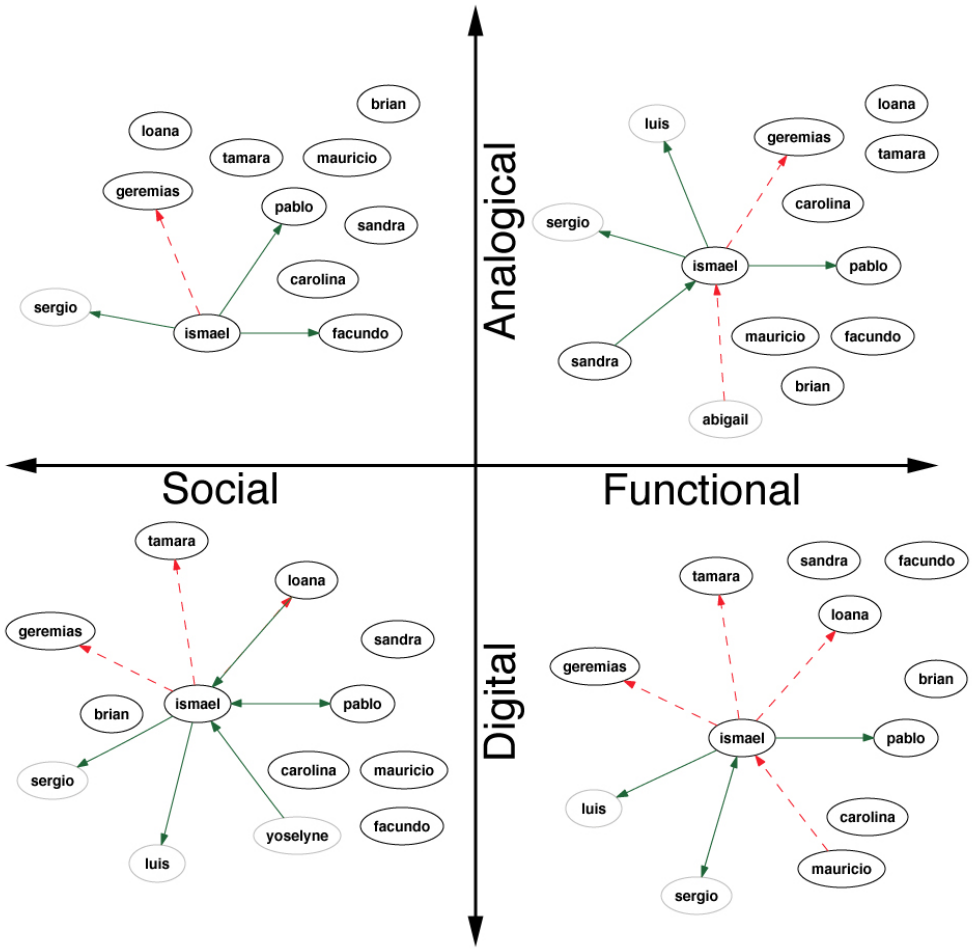


**Figure 5.4:** The sociograms of the four dimensions studied, relative to Ismael. Grey nodes represent children who were not in the same class during the preceding year.

| | **Social** | **Functional** |
|---|---|---|
| **Analogical** | 0 *(m. 2.84, s.d. 2.06)* positive | 1 *(m. 2.84, s.d. 2.41)* positive |
| | 0 *(m. 2.68, s.d. 2.11)* negative | 1 *(mean 2.74, s.d. 1.76)* negative |
| **Digital** | 3 *(m. 2.84, s.d. 2.32)* positive | 1 *(m. 2.79, s.d. 2.62)* positive |
| | 0 *(m. 2.84, s.d. 1.86)* negative | 1 *(m. 2.94, s.d. 1.89)* negative |

**Table 5.3:** Ismael's results in the classmates preferences declarations (average score of the class and standard deviations in parenthesis)

him. The relationships here were more interesting than in the three other areas for their complexity: Ismael chose two new classmates and was chosen by two who were old and one who was new. He had again a mutual choice with Sergio and a contradictory choice with Loana, a child choosing him and being rejected.

These results suggest that the XO laptop was being important to him primarily as a *social amplifier* and much less in its original function of *cognitive amplifier*.

### 5.2.6 A case of *incident*

During my second fieldwork experience in Uruguay, I went back to the School 50 in order to administer the above described tests to Ismael and to have an interview with his father. The day I got there, at the beginning of May 2010, lessons had already started since about two months. I had been recently informed of the full-time integration of Ismael by the School 200 director and I was curious of seeing if the child was at ease in his new condition.

I was first received by L.A., the director of the School 50, with whom I had an interview. She immediately told me they were having some serious problems with Ismael's family and that she was not really satisfied of how

his integration project was going on. The main problem was not the child, but his father: besides having problems with alcohol addiction, he was very protective towards the child and expected to assist him during the school time. As I mentioned above, he used to act like this during the previous year, but the teacher and the director wanted him to stop entering the classroom. The father's main motivation for acting like this was practical: the child had to be taken to the bathroom at least twice per afternoon and no other personal assistant was available. On the other side, the school personnel wanted the child to be more independent from adults, but at the same time they needed to provide him with an assistant for his physical needs.

At the beginning of the school year, the School 200 personnel suggested the family and the integrating school to let the father take the child at school and take him back after two hours, without staying in the class. This solution had the purpose of getting Ismael used to stay in the class without the support of the father, allowing him at the same time to be taken to the bathroom by the father, once at the beginning of the lessons and once during the break, after two hours. The father did not like this solution, but had to accept it. The result was that Ismael participated only to half of the classes, and then went home with his father.

The described solution was intended to be a temporary one, but at the beginning of May (and at least until the end of the month, when I left the Country) it was still being adopted. This produced two effects: Ismael was actually getting used to be independent from the father during the school time, but he was missing half of it. The father considered this an injustice towards the son, but he did not agree with the proposal of taking him to the school, visiting him during the break and then taking him home at the end of the afternoon class. The school could not find another person to assist Ismael.

When I asked for some explanations to the director of the school, she confirmed me that the solution was a temporary one, decided together with the

School 200 personnel. The fact that the School 200 director and the assistant teacher had counselled such a solution sounded a bit strange to me, because their declared position towards the integration projects favoured full-time integration to part-time.

I then asked for joint interview with them and met them at the School 200 on 14th May, 2010. I first asked them how was Ismael's integration project structured and they first confirmed me he was intended to attend mainstream classes during the whole afternoon turn. After receiving their confirmation, I explained them that the child was only attending classes for half of the school time. This information surprised them, as if they did not know of it at all. As they explained, the two hour solution was actually suggested by them *for the first week only*:

> *Lo acordamos en la primera semana, en que nosotros fuimos y el viernes empiezaban las clases, eran los primeros días, hasta que se hablara con el padre y se fuera acomodando la situación, esplicandole a Ismael que no iba a ir más el padre, que él iba a tener que empiezar a controlar también... y mientras tantos empiezar a buscar otras opciones, verdad... pero no era algo que iba a quedar fijo para... digo yo... para claro, sabes lo que pasa? Nosotros lo tenemos tan claro que nos parece que todo el mundo lo tiene claro. Nosostros tenemos la vision de lo que es y de lo que debe ser, y nos parece que ni bien se habla, que se entiende, y que y... y que se va logrando... el objectivo era que Ismael permaneciera, verdad? Independiente del padre totalmente.*
>
> We agreed on it during the first week, when we visited them and the classes were starting on Friday, it was in the first days, until we would have the opportunity to talk to the father and to solve the situation, explaining to Ismael that his father was no more staying with him during classes, that he also had to start controlling... and meanwhile to begin looking for other solutions...

> it was not something which had to remain unchanged for... I say... that's clear, you know how it goes? For us it is so clear that we think that everybody should understand it. We have the vision of what is and what should be, and it seems to us that it is something not to be said, something understandable, and... and something which is gradually achieved... the objective was that Ismael remained, totally independent from the father.

This means that during the first two months of school (actually three, as far as I was directly able to know) there had been no direct communication between the special and the mainstream school. Meetings were supposed to be held on a monthly basis, as the assistant teacher, C.V., told me in a direct interview.

Together with the case described in 5.5.3, this incident highlighted one of the true problems of the scholar system: the lack of communication between the parts composing it. This was probably due to the fact that the personnel dedicated to assisting integration projects was too reduced in number, and the communication between schools was still based on face-to-face interviews, rather than on regular transmission of data from point to point.

## 5.3 Micaela

The second case study focuses upon a little girl, born in 2001, called Micaela. She could walk with the aid of two sticks and had quite good manual control. Her hands were sensibly larger and stronger than those of her classmates mainly because of the fact she used them to balance on the sticks. Besides that, she had some problems in using pens and pencils. She could write using her right hand and could also use a computer keyboard. Trackpads were difficult to operate for her, hence she preferred using an ordinary mouse. The mouse was the only sort of adaptation she physically needed on the XO in order to use it.

As in the case of Ismael, who used to be a classmate of hers at the School 200, she was integrated in a mainstream school class. She attended the afternoon classes at School 166, where she was introduced in 2009, at the age of 8. She could also count on the support of a team of experts at a local private clinic.

### 5.3.1 First meeting and initial impressions

After receiving some information about her, I was introduced to Micaela two weeks after my arrival at the School 200. That day I was accompanied by another Italian student, who was visiting the school. She entered the class with me and with the class teacher, P.M.. The teacher introduced us and then left the room. Micaela was there with Pablo, a classmate who was the main character of the case study described in the next section.

The interest Micaela showed towards the XO was high, even if lower than that of her male classmates. She seemed more fascinated by the fact she was being introduced to two strangers and was eager to tell us about how much she liked the school, especially the other, mainstream one.

She already had a computer at home, used by her older sister. When I turned my XO laptop on, she showed moderate interest in it. She accepted entering a multiplayer memory game with Pablo, winning it, but her enthusiasm was sensibly higher when I showed them the Record activity, which allowed them to take photos and videos. She seemed to like it very much. In general, she proved to be lively and curious, even if more concerned about school matters than her classmates of the School 200.

### 5.3.2 Previous diagnosis and teachers' evaluations

Micaela's diagnosis was of Cerebral Palsy causing spastic diplegia, which determined both physical and intellectual consequences on her. As described

at the beginning of this section, she was able to walk only with the aid of two sticks. This was a quite recent achievement, as until little time before we met she used to rely on a walker of the "Zimmer frame" kind. Her manual skills were good and her arm muscles were well developed: she had only lesser manipulation problems and she could use pens, pencils and computer keyboards almost like any other child. Her cognitive potential was also very high, even if her medical condition determined a delay in some specific cognitive processes (consequences of cerebral palsy are classified in [11] and discussed in [124]).

An evaluation written at the end of the 2008 school year by the teacher working with Micaela at the School 200 gave a very positive portrait of her personal and social conduct:

> *Niña totalmente integrada al grupo y a la escuela. Se desenvuelve con suma confianza en sí misma demostrando mucha madurez. Se desenvuelve sin dificultad, va al baño sola.*
> *Tiene muy buena relación con sus pares y con los adultos.*
>
> A child totally integrated in the class and in the school. She can manage herself with utmost confidence in herself, demonstrating high maturity. She manages herself without difficulties, she can go to the bathroom alone.
> She maintains very good relationship with her peers and with adults.

The same document reports of Micaela's passion for writing: she was described as very interested in both poems and tales, to the point of hypothesizing the publication of a collection of her works in a book. Her Mathematical and Geometrical competences were also positively described: the teacher reported of her ability in the four operations and of her understanding of concepts such as quantity and relative values, but then generically adding that she needed *"un apoyo concreto"*, concrete support. Even though, the majority of the evaluation charts released by the School 200 teachers and by

other specialists pointed out the fact that Micaela had poor spatial conceptualization skills and, surprisingly enough, the most recent document about her highlighted some critical points:

> *Resuelve situaciones problemáticas concretas y vivenciales, pero le cuesta realizar las distintas operaciones, así como la memorización de las tablas de multiplicación. [...] Le cuesta organizar los datos, pero luego de organizados puede resolver el problema sin dificultad.*
>
> She can solve concrete and everyday-living problems, but she encounters some difficulties in the distinct operations and in the memorization of multiplication tables. [...] She has difficulties in organizing data, but after organizing them she can solve a problem without difficulties.

As in Ismael's case, the 2009 report about Micaela included a section about her computer related abilities. The evaluation certified that she could use the computer very well, with no particular problem. The specific XO usage evaluation sheet attached to the document stated that Micaela, three months after the delivery of the computers, had totally achieved all the objectives set by the teachers both in usage and in the socio-emotional area. She did not demonstrate any anxiety nor any dependence from other people when the computer was involved. The sheet also stated that Micaela needed an ordinary external mouse in order to use the XO laptop properly.

### 5.3.3 Teachers and family

Among the people involved in Micaela's education and integration process, I interviewed a total of six, using the same tracks described above (see appendix A from page 231). The interviewed people during the 2009 school year were:

- D.U., director of the School 200;

- P.M., teacher at the School 200, who worked directly with Micaela in 2009;
- A.A., teacher at the School 166, who worked directly with Micaela in 2009.

When I got back to Uruguay in 2010, I also met:

- C.V., support teacher working for School 200;
- V.L., teacher at the School 166, who worked directly with Micaela in 2010;
- G.A., Micaela's mother.

Micaela was described by both the teachers and by her mother as completely aware of her limitations, of her impairments and of the effects that her condition had on the way the other people related with her. The best synthesis of such awareness was probably the one offered to me by her mother during the interview we had in May 2010:

> *Tiene claro quien es, tiene claro... yo varias veces me he puesto a pensar y dije nunca, o sea, no se si nunca, pero pocos niños tienen claro la discapacidad que tienen y lo asumen. Ella lo tiene totalmente asumido. No se en la adolescencia que pasará, pero ahora de niñez son pocas las cosas que ella se priva de hacer... [...] "sabes maestra que yo tengo problemas en matemáticas?". Y ella le dijo "Ah sí?", "Sí, es por mi patología."*
>
> It is clear for her who she is, it is clear... I have been thinking about this many times, but I believe that never, I do not know if never, but there are very few children who understand their disability so clearly. She completely understands it. I do not know how it will be in the adolescence, but now, in her childhood, there is few things she deprives herself of doing... [...] "Do you know, teacher, that I have problems in Maths?". And she answered: "Really?", "Yes, it is because of my pathology".

She was also considered on her way to developing strategies for becoming completely independent and for ruling over the complex network of her interpersonal relationships. Everybody, Micaela included, pointed to mathematical and logical abilities as the most problematic areas for her cognitive development. On the other side, her linguistic and social skills were considered outstanding.

Every time I asked about her integration process, I received two kind of answers, involving respectively the social and functional aspects of it:

- socially, Micaela was highly participant in the class, she had many friends and many children were willing to spend time with her (this was confirmed by both A.A. and V.L., who were teachers at the mainstream School 166 during the two years interested by this research);
- functionally, Micaela showed problems in Maths and, obviously, in movement. She had a perfect understanding of this situation and the other children were aware, too. In this area, the XO represented an important advantage in A.A. opinion, and V.L. substantially agreed. The mother seemed less optimistic.

According to the School 200 personnel, she was integrated in a mainstream school mainly because of her high level of functioning. When I interviewed the director and the support teacher at the School 200, they had no doubt:

> *Yo pienso que de todos la que está funcionando mejor es Micaela, ya era distinta...*
>
> I believe that the one who is doing better is Micaela, she was already different...

> *Yo la vi, en distintas instancias y estaba... era una más del grupo...*
>
> I saw her, in distinct instances and she was... she was one more in the group...

Her main impairment was in walking and this fact provoked a problematic situation at the beginning of her integration experience, as the Grade Three teacher reported to me:

> *Me propusieron integrarla a mi clase, nosotros estabamos en el nivel superior, en el primer piso y para ellos era todo una noveleria estar allí, porque los dos primeros años se hacen en planta baja, ya en tercero suben y para ellos era sentirse mayores, más grandes [...]. Estuvimos un mes y me hicieron esta propuesta y bueno yo enseguida dije que si ellos consideraban que iba a estar mejor en mi clase y bueno así fue. [...] Me sorprende la forma en la que la han integrado, la quieren muchisimo a Micaela y ellos reconocen que hay ciertas tareas que Micaela no las puede hacer al mismo ritmo que las hacen ellos.*
>
> They proposed me to integrate her in my class group, we were at the first floor, for them [the classmates] it was all a novelty to be there, because they had been at the ground floor for the first two years and they went upstairs for third grade, they felt like they had grown up [...] We stayed upstairs for one month, then they proposed this to me, and I said that if they were sure she would be better in my class group... and then we did it. [...] I am surprised by the way she was integrated, they like Micaela very much and they know there are some tasks that Micaela cannot accomplish with at the same pace of them.

The fact that the other children in the class accepted a change in their habits in order to accept Micaela was hence described as *surprising* and *impressing*, also because she had been previously integrated in another class group and had reported very bad results. She was more than once described as a centre of attention, an element of the group who the other children wanted to help continuously. The mother also told me that Micaela herself disposed that her classmates had to respect turns to help her: some of them were allowed to

carry her school bag on a weekly basis. One of her former teachers used to say that other people threw 'flowers on her path'. This kind of attitude was not something Micaela totally accepted: according to her mother, who reported to me what the other children's parents observed at her arrival at school everyday, she did not like to be helped and preferred to do by herself.

As I outlined before, the general sensation of good social integration was often in contrast with a series of functional limitations. The mainstream school teacher I met the first year thought that the XO would be an effective instrument for overcoming those limitations:

> *Se va a ver muchísimo los logros. Se va a poder ver y lucir más y expresar más.*
>
> Her progresses will be evident. She will be able to see herself, and she will shine more, and she will express herself more.

During the second year, I received a slightly different view. While the new teacher recognized the high abilities Micaela was demonstrating in the XO laptop use, she did not seem to consider technology as relevant for her integration process. On the same topic, G.A. suggested that the introduction of the computer had raised some new difficulties, which Micaela was gradually overcoming:

> *En la clase se que ella trae la computadora todos los días pero no todos los días trabajan, y sí, necesita como... o sea no es rápido como otros chicos, ella le cuesta todo más, entonces no quiere decir que no se destaque en otras áreas. Digo sabe manejar todos los programas que hay pero si obviamente le cuesta, es más lenta... yo creo que ella si aprendiera a usar bien el teclado y pudiera escribir en la XO sería mucho mejor, porque ella escribe mucho más lento de los demás... Capáz le pueda servir un teclado más grande...*
>
> I know that she brings the computer to school every day, but they do not use it every day, and yes, she needs... I mean, she

> is not as fast as the others, everything is more difficult for her, hence this does not mean that she cannot be better in other areas. I mean, she can use every program, but obviously it is difficult for her, she is slower... I believe that if she learned how to use the keyboard well and if she could write using the XO it would be better, because she is very much slower than the majority... Perhaps a lager keyboard would be useful for her...

By superimposing the two levels of work with and without the computer, the mother introduced a critical point: Micaela could use the computer, but this instrument was not apparently solving her main problem: she was slower, and she could not be at the same level of the other. When everybody had a computer, she was still slower: anybody in the classroom could be faster, even if she had a better understanding of what she was doing. As in the case of Ismael, Micaela uses the computer only when the rest of her class used it.

### 5.3.4 Direct observation

Among the three case studies I was able to complete across my two fieldwork experiences, Micaela was the one with which I spent less time at the mainstream school (8 hours in 2009 and 6 hours in 2010). During this time, she showed moderate interest towards the XO laptop per se: she seemed mostly excited by the novelty (as the majority of the children was) rather than by the fact of owning a computer. The most striking thing in her relationship with school was the high commitment: I mostly remember her as willing to complete every task she was given successfully and tenaciously. She encountered no critical problems in learning how to use an XO laptop, except for her already mentioned slowness.

She had good control over her hands and the only adaptation I suggested her to use was an external mouse, as she proved to be in trouble when using

the XO trackpad. This required no software adaptations for her, hence the machine was accessible for her quite 'out of the box'. This adaptation was actually a common one among *every* child: as the standard XO trackpad was tricky and often had stability problems, many parents agreed in buying an external mouse. Also in this case, there was compliance with the first of the guidelines discussed at the beginning of section 3.1.

As I told above, when I returned to Montevideo in 2010, Micaela's mother reported me of some problems that the girl was having with the XO keyboard: she felt that her fingers were growing too big for those small keys and she asked me about the possibility to add an external, enlarged keyboard. The school took charge of it.

Working with analogical tools like pen and paper seemed not to be a real problem for her: she was slower and less accurate, but very determined at doing her best. She often remarked her difficulties in the Maths area.

By examining her XO laptop diary in May 2010 I was able to obtain a quite interesting picture of what she was doing at school with her computer: the most used activities were 'Labyrinth', a tool for creating conceptual maps, and 'Implode', a logic game based on the combination of blocks. The first activity was one of the teacher's favourites, hence it was no surprise finding it to be used extensively for producing conceptual maps or other graphs: a family tree was also stored in Micaela's diary, result of an homework assignment.

The consistent presence of 'Implode' games in the diary surprised me a bit, as the game was associated with the spatial abilities Micaela seemed to lack, according to all her teachers. Among the instances of the 'Browse' activity I found in the diary, many ended up in music related pages, which was a quite common use of the browser in the majority of the schools and classrooms I visited.

While I was observing Micaela at the School 200 during my first fieldwork

experience, I annotated some facts which I was later able to interpret as signs of her level of inclusion in the mainstream school:

> *May 18th, 2009*
>
> I visited Micaela's mainstream class for the first time today. P.M. from the School 200 took me there and introduced me to the director and to Micaela's teacher. I entered the class and met all the children together. Micaela was sitting among them, in the same desks as the others, in a corner position where she could extend her legs freely. Some of her classmates were sitting in isolated desks. She was surrounded by girls and later the teacher explained to me that she was part of a very united group of friends.

Since my first visit to the School 166 I noticed that there was more in Micaela's relationship with her classmates than in the other cases I had examined: she had developed a form of deeper link with a group of friends which went beyond functional assistance. While she was sitting among them, she was undistinguishable from the others, not only for the absence of special aids: she spoke to the neighbours while the teacher was talking, she raised her hand to ask questions, she laughed with her friends.

Later on I noticed something else:

> *June 8th, 2009*
>
> The XO laptops were delivered to Micaela's class last week. All the children were excited for the novelty and when I entered the class everybody started asking me how to do a variety of things. Micaela did not seem to be very much excited: she had already used the computer many times with me at the School 200, after all. When I started explaining to the class group how to connect the computers and how to enter a shared chat activity, I noticed that she had started doing the same with her friends. When I got closer to them, I saw that she had been effective: two

of her classmates were already connected to her.

Micaela never showed too much interest in the XO laptop, but she learned how to use it quite fast. She was also able to transmit her knowledge to the others.

> *May 25, 2010*
>
> I arrived at the School 166 before the afternoon classes had started, hence I met Micaela getting down from the small school bus. She said hello to me and one of her female classmates appeared, saying that it was her turn to carry Micaela's school bag inside. She was warmly welcomed by almost every person who encountered her in the short distance between the school main door and her class.

This last passage was a confirmation for me of what the mother and one of the mainstream school teachers had told me: Micaela was a centre of attention, her classmates were eager about helping her and the whole school was completely aware of her presence. She was an accepted and beloved girl, other people cared for her but that did not mean that she depended too much on the others, neither that she put pressure on them in order to be helped.

### 5.3.5 Tests

**Ability assessment.** Of the 22 children composing Micaela's class in May 2010, only 15 were able to participate in the ability assessment I administered at their school. Among the 15 children, 3 used an XO which was not their own, lent by older or younger brothers who were in the same school. Table 5.4 shows the results obtained by Micaela compared with the scores of the rest of her class.

Micaela totalized more natural successes than the average of her class, even

| | NS | AS | NF | MF |
|---|---|---|---|---|
| **Micaela** | 18 | 3 | 1 | 0 |
| **Total** | 259 | 34 | 32 | 5 |
| **Mean** | 17.27 | 2.27 | 2.13 | 0.33 |
| **Standard deviation** | 4.40 | 1.98 | 2.67 | 0.62 |
| **Micaela's *z scores*** | 0.17 | 0.37 | -0.42 | -0.54 |

**Table 5.4:** Micaela's results in the ability assessment test, compared to the rest of her class

if with a low z-score (0.17). This, together with the high standard deviation of the class, suggests that the group was highly varied and her abilities were very near to an average which was not common: there were many cases of children scoring very high (8 with 20+ natural successes), and many other cases of children scoring very low (4 children scoring 11 or lower). She asked for more help than the average, but the z-score was low also for this aspect: she fell into the standard deviation span. She completed the test with more AS results than NF. Finally, Micaela scored only one NF (in the "take a picture" sub-task), which suggested that her abilities in using the laptop were very high. Grouping NS and AS, she obtained 21 successes over 22 items, which can be considered a satisfying result.

The class was able to answer correctly to 10 of the 22 items: this means that nearly half of the points were easy for them. There is a sensible difference in the test results only in the four final items: a consistent part of the group (up to 46.6%) failed in one of the network and collaboration related sub-tasks. Of the 24 failures of the class in this final part of the test, only 2 were due to a technical problem with the machine.

Micaela obtained four successes in this relatively problematic part of the test, but two of them (on items 21 and 22, respectively 'Start a chat activity' and 'Share the chat activity with one classmate') required her to ask for help.

The only Natural Failure she scored was in item 18, 'insert your picture in

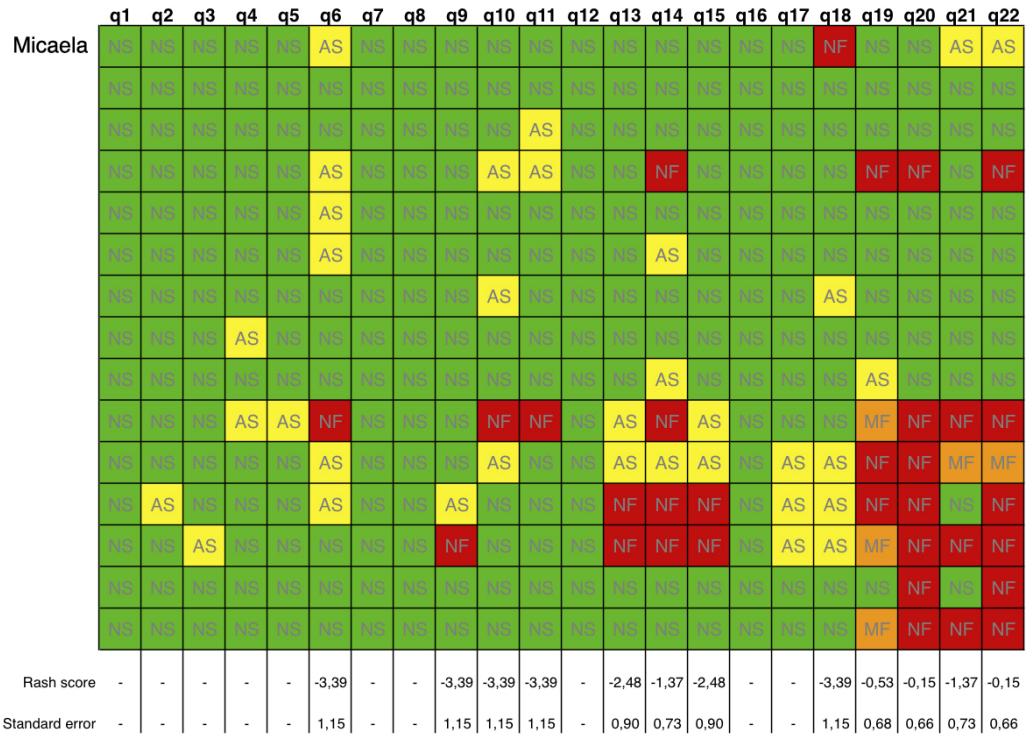


**Figure 5.5:** The total results of the class, with the difficulty coefficients of each item calculated using the Rasch function in R

the created document'. Even if helped with the suggestion of looking into the 'Write' activity toolbars, Micaela was not able to find the 'insert image' function on her computer.

The general results of this test suggested that the class group had an high level of competence in using the XO laptop as a single user device. The very low error rate in the test could be interpreted as a result of the extra technical training the teacher had received from CEIBAL: she was a *maestra dinamizadora* (dynamizing teacher), hence she was a reference for the other teachers in the school and was very confident with the machine use. The network and collaboration possibilities had not been explored during the class activity so far. Micaela demonstrated to be above the average of the class: even if she was not one of the most skilled, she proved to be independent and competent.

**Sociograms.** The sociogram test administered to Micaela's class in May 2010 gave some interesting results about the overall class climate and about the girl's position in the social network of the group.

The class counts many "stars" and "isolated" members and the two following diagrams (figures 5.6 and 5.7) show the total positive and negative elections received by each child.

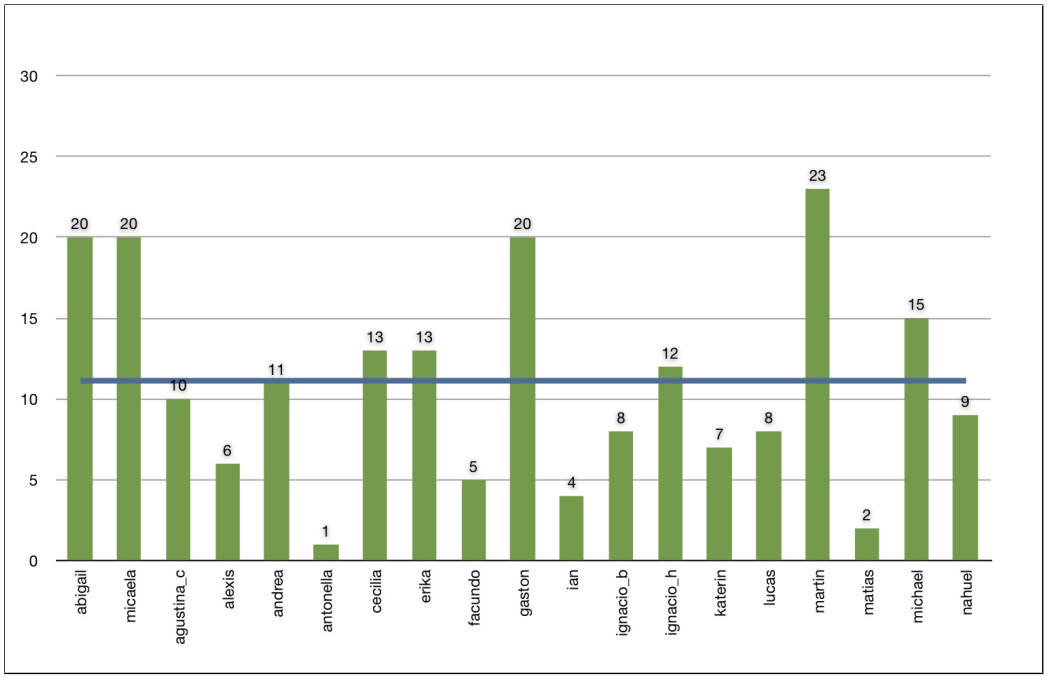


**Figure 5.6:** The total positive preferences in Micaela's class (the blue line marks the average).

The four couples of dimensions taken into consideration produced the following results:

The same results are represented in figure 5.8, which is a reduction of the total class results. The image offers a focus on Micaela, the children she chose and the children she was chosen by, positively and negatively.

Micaela's positive elections were all highly above the average of the class, with the only exception of the functional/digital area (*z-score* -0.29 for positive elections, -0.31 for rejections). She was rejected a number of time which

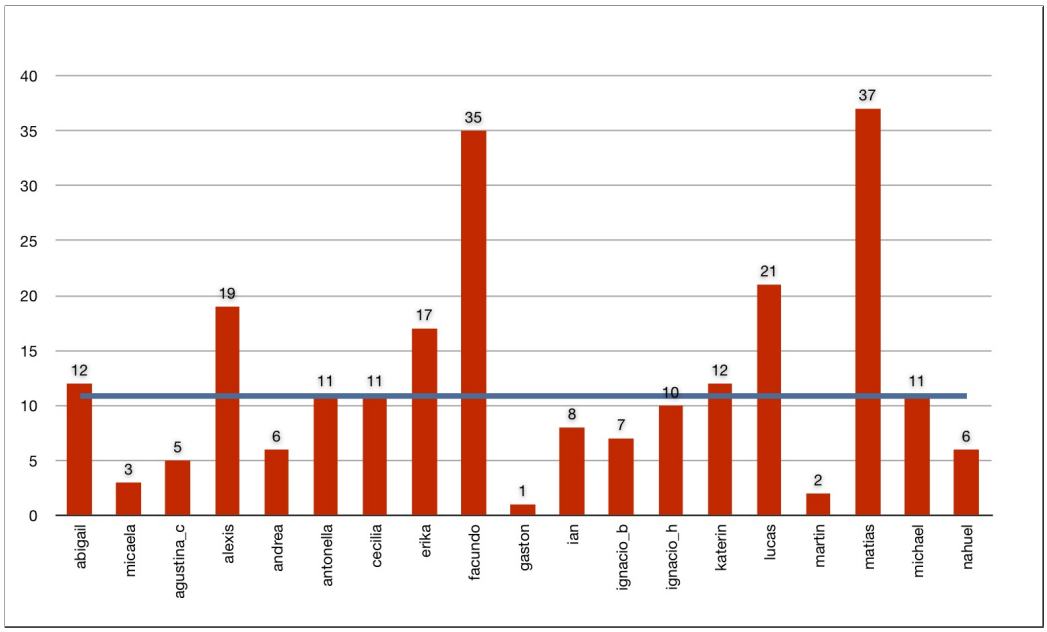


**Figure 5.7:** The total negative preferences in Micaela's class (the blue line marks the average).

was sensibly lower than the average, again with the exception of the functional/digital area. She was probably underestimated in this dimension because of the high number of very skilled classmates she had: as seen above while discussing the results of the ability assessment test, there was a consistent group of children in the class who could use the computer very proficiently.

The high results in both the social and functional dimensions obtained in the 'analogical' area were in accord with the impressions received from direct observation and from the interviews: Micaela was considered as an important member of her class and was able to build significant relationship links with her classmates, even with those she had in her class for few months, as can be clearly seen by the diagrams. Besides receiving few rejections, she was linked to five other children by mutual positive elections, also in more than one area (as in the case of Abigail). In three cases she rejected someone who in turn chose her. Among her classmates, she tended to refuse two of the children who were in her same class during the 2009 school year in all the

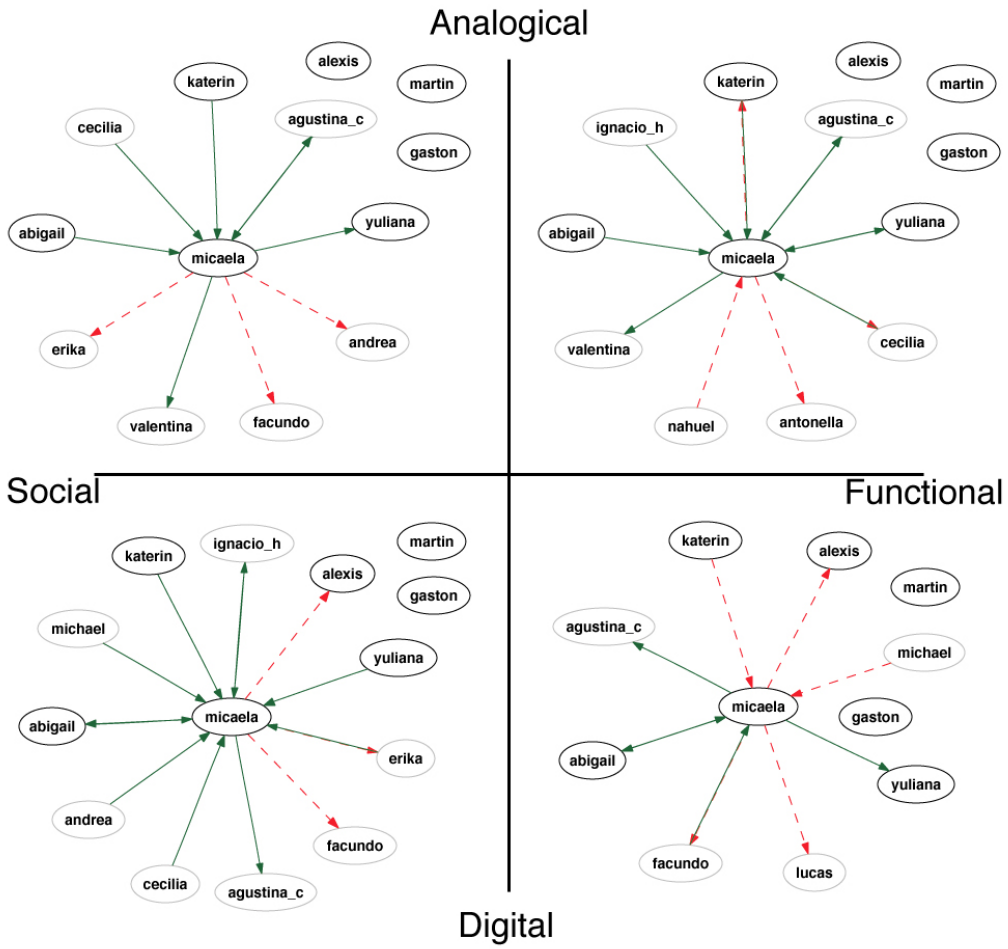


**Figure 5.8:** The sociograms of the four dimensions studied, relative to Micaela. Grey nodes represent children who were not in the same class during the preceding year.

| | **Social** | **Functional** |
|---|---|---|
| **Analogical** | 4 *(m. 2.83, s.d. 1.47)* positive<br>0 *(m. 2.74, s.d. 2.70)* negative | 6 *(m. 2.83, s.d. 1.85)* positive<br>1 *(m. 2.74, s.d. 2.68)* negative |
| **Digital** | 8 *(m. 2.78, s.d. 1.88)* positive<br>0 *(m. 2.74, s.d. 2.68)* negative | 2 *(m. 2.70, s.d. 2.44)* positive<br>2 *(m. 2.65, s.d. 2.10)* negative |

**Table 5.5:** Micaela's results in the classmates preferences declarations (average score of the class and standard deviations in parenthesis)

areas.

It is quite interesting that Micaela received the majority of positive elections from the social/digital area. She learned how to use the XO before her classmates and this probably influenced the results, but this data could also be read in a different perspective: Communicating with her was either perceived as easier when there is a computer in the middle, or considered harder in direct interaction situations, even if the difference is very narrow.

The XO laptop, which was being used by Micaela as a *social amplifier*, seemed to constitute for her a less favourable ground for building relationships when a functional issue arised. She was a positive 'star' in her class, but technology did not always act as a facilitator for her.

## 5.4 Pablo

Pablo was the centre of the third case study. He was born in 2000, and like Ismael he sat in a wheelchair. He had little limitation in the use of both his hands. He could write with his right hand and could operate the mouse and the keyboard of his laptop only with consistent effort. He could use the XO laptop without adaptations, but it was very difficult for him, and he also had problems in reading from the screen at standard text size configuration. He

was lively and exuberant, liked joking and laughing at other people. He was also perceived by the teachers as lazy and cunning.

Like Ismael and Micaela, he left the School 200 at the end of 2009 to be fully integrated in a mainstream class of the School 62. He had been attending that mainstream school since 2008. He is still under the observation of the experts of a private clinic.

### 5.4.1 First meeting and initial impressions

I first met Pablo together with Micaela two weeks after the beginning of my experience at the School 200. They were in the same classroom as Ismael and I met them together with a colleague who was visiting the school. The class teacher, P.M., introduced us and then left us alone with the two children. Pablo immediately showed great interest towards the XO laptop but also distinguished himself for his interest in our foreign origin. He asked many questions, of which only a small amount involved the XO. He seemed more interested in where we were from, how long were we staying and how much time would we spend in his class, but that was quite reasonable at the beginning.

At the time we met, he had no computer at home and was about to receive his XO. He was, like his classmates, curious towards the computer he would receive. He wanted it mainly for games and what he had already seen from the teacher did not completely interest him. He seemed to be more attracted by mobile phones than from other technological devices.

As I told while describing Micaela's case, when I showed him the XO for the first time I started explaining how the system was organized and then started a game (the Memorize activity). I connected the two machines via wifi network and allowed them to play a multiplayer game, which they enjoyed. After the game I showed them how to take photographs and videos, activities they both enjoyed a lot.

### 5.4.2 Previous diagnosis and teachers' evaluations

According to the evaluation sheet produced by the personnel of the School 200 in 2005, when he was 5 years old, Pablo's medical diagnosis was of *non progressive encephalopathy*. A later report of Fundación Teletón describes his case as *Cerebral Palsy*, and in particular of *spastic quadriplegia* with predominance of the lower limbs. He had no control of his legs and sat in a wheelchair. His hands mobility was also limited: he could write using a pen or a pencil, but the task was very difficult for him. He wore glasses, but still could not read very small texts. An evaluation sheet signed by the School 200 psychologist in July 2007 described him as a child with good learning potential, capable of concepts elaboration, of associative thinking and of verbal abstraction. The main difficulties accounted were in the ability of perceptive organization and in the manipulation of numerical concepts.

In 2007 the psychologist of the School 200 described him as a child with average intellectual level, but also remarked:

> *Su potencial intelectual sería superior al rendimiento alcanzado en las pruebas. Lo que incide en este resultado es su dificultad en el área perceptiva - motriz, la que deberá trabajarse con un Plan Individual Específico.*
>
> His intellectual potential could be higher than the results of the tests. What affects this outcome is his difficulty in the perceptive - motor area, which must be developed with a Specific Individual Plan.

The same report also mentioned the high level of involvement that the family maintained in assisting Pablo in his school experience. This aspect also lead to some interesting discussions I had with his mother and which will be reported in the following paragraphs.

The most recent document about Pablo I was able to access dated back to 2008. His personal and social conduct was there described as "very socia-

ble":

> *Si bien tiene muy buena relación con sus pares y con los adultos, necesita mucha contención y límites porque le gusta llamar la atención (se ríe y no para), presentándose a veces muy conflictivo.*
> *Es muy cariñoso y querido.*
>
> Even if he maintains very good relationships with his peers and with the adults, he needs a lot of attention and limits because he likes attracting attention on himself (laughing without stopping), sometimes resulting very difficult.
> He is very sweet and loving.

Another critical point was attention: he was described as problematic in the sense that he was easily distracted and he could not continue working on the same task continuously and independently. He relied a lot on the help of the teachers and other adults. The document also reported the fact that Pablo was integrated at the School 62, in which he attended first grade in 2007, obtaining a promotion to second grade with the need of extra training in Maths (surprisingly, the evaluation of the Mathematical and Geometrical area at the School 200 for the same year was very good).

Even if no evaluation was available of the level reached by Pablo in using the XO laptop, I was directly able to observe that he needed some adaptations: specifically, he had serious problems in using both the laptop's trackpad and an external ordinary mouse. His vision was not optimal, hence the screen magnification system was also useful.

### 5.4.3 Teachers and family

I had the possibility to interview five adults related to Pablo's case. During the year 2009 I met:

- D.U., director of the School 200;
- P.M., teacher at the School 200, who worked directly with Pablo in 2009;
- C.C., teacher at the School 62, who worked directly with Micaela in 2009.

When I got back to Uruguay in 2010, I visited again both the special and the mainstream school, interviewing again the first person and then meeting also:

- C.V., support teacher working for School 200;
- A.E., Pablo's mother.

I also arranged an interview with Pablo's teacher at the mainstream school but due to various problems our private meeting was cancelled. There was no other possibility for a direct meeting with her.

The mainstream school teacher integrating Pablo in her class during 2009 gave me a very clear explanation of the process he was undergoing:

> *Pablo era.. quiero que me arrimen la silla que me saquen la mochila era todo en función de Pablo. [...] Esto ha cambiado. Sí ha cambiado, ha costado muchísimo, por lo que hablé con la mama el año pasado fue todo el año así. [...] En realidad lo he hablado con la mamá y ella dice que se va contento y con ganas de hacer las cosas y bueno me parece que voy por el buen camino.*
>
> Pablo was... I want you to help me with my chair, to take that from my bag, everything depended on him. [...] This changed. Yes, it did, and it cost much, as according to what his mother told me about the preceding year, it was always like this. [...] Actually I conversed about this with the mother and she says that he is happy and eager to participate, and well, I believe to be following the right path.

Such view of him was also shared by the teacher at the special school. He was then described as potentially independent under many points of view, but still demanding. Even if recognizing his improvements, the teacher still felt that he was depending on his classmates and on adults, especially on his mother. She also remarked more than once that compassion and sympathy were not the correct feelings towards him. This attitude did not clear the path from all doubts:

> *Pero a veces me pregunto estoy haciendo bien o le estoy agregando un fracaso más. Algo que a él le haga sentir mal.*
>
> But sometimes I ask to myself: am I doing it right or am I adding one more problem to him? Something which could make him feel bad.

The same teacher saw a positive potential in the upcoming change introduced by the laptops. She was confident with the fact that the XO would create an egalitarian condition, also in the level of functioning of the children in the class. Analogical ways of teaching were very tiring for Pablo, as his limited sight did not allow him to read from the blackboard with ease and his difficulties in writing made him slow. Technology was hence welcomed as an optimal aid for his functioning.

Besides mere functioning, the XO was seen as useful for enhancing Pablo's independence. This was postulated as necessary for his future, sometimes considering it as the main priority of his educational career:

> *Cuando sea un adulto va a tener las mismas exigencias y responsabilidades que cualquier otro adulto. Entonces me parece que esta bueno que vaya aprendiendo que lo que él quiere y lo puede hacer lo haga y no depender del resto.*
>
> When he will be an adult he will have the same exigences and responsibilities of any other adult. Then I think that it is good that he learns that he can do what he wants and what he can, without depending on others.

One of the teachers at the special school was also very positive about the impact that the introduction of the XO laptop would have on his integration, mainly because of the time I spent with him during 2009:

> *Yo creo que la XO va a ser un medio más equitativo, respecto a las XO en este momento va a estar Pablo como en un nivel más alto que el de sus compañeros porque Pablo ya viene trabajando con todo lo que es el conocimiento. Ellos van a empezar de cero y él ya tiene una base de lo que es el conocimiento de lo que es la XO.*
>
> I believe that the XO will be a more egalitarian media, with respect to it Pablo in this moment will be as on an higher level than his classmates because he already worked with it, with an expert support. The others will start from zero and he already has basic knowledge of the XO.

The relationship with the family, limited to the mother, was described as good by the same teacher. Also the mother confirmed me that she was quite satisfied by the way Pablo was being treated in 2009 at the School 62. The same was not to be said the following year, when things seemed to have got worse.

When I returned to Montevideo in 2010 Pablo's mother accepted to have an interview with me, which turned out to be one of the longest of my whole work: she told me that she felt mostly abandoned from the school institution, especially since the day when her son had been integrated totally in the mainstream school. She thought the child to be still in need of special assistance and had started taking him to a private clinic. She plainly explained me that she disagreed with the methods of Pablo's new teacher at the school 62, especially, with the fact that she was very tolerant when the child did not do his homework.

She described the son as a very passive child, with no initiative and apparently no interest in improving his own condition. She also said that she would

prefer him to adapt to a negative situation (citing the present teacher of the mainstream school as an example) rather than helping him directly. Besides that, she felt that the introduction of the XO had not really influenced her son's school activity. She saw a lack of proper usage, but did not attribute it to the instrument *per se*:

> *Al principio la usaba mucho, ahora no... pero Ãl'l es asÃŋ, no es la XO: el le impacta la cosa del momento, pero despuÃl's se aburre, lo hace un ratito y nada lo entretiene demasiado. Ese es uno de los temas que yo siempre vi en Pablo.*
>
> At the beginning he used it a lot, now no... but he is like this, it is not the XO: he is enthusiast for the novelty of the moment, but after a while he gets bored, he does it just for a little moment and nothing entertains him too much. That is one of the things I have always noticed in Pablo.

She strongly disagreed with the School 200 personnel about the fact that Pablo would abandon traditional writing after the adoption of the XO laptop at school, and she motivated this with the urge for the child to maintain every single muscle of his body trained enough as not to loose any residual mobility. Contextually, she also remarked that the computer was not being used at school as it had been announced before: actually, it was used only as a side activity during the week.

The mother also pointed out some episodes in Pablo's integration experience which helped me understand how the environment of the mainstream school could be problematic: not only the building presented some architectural barriers, the personnel had also proven to be quite inadequate for his special needs. When, as an example, she asked for a modified desk for her son, she was offered one which was less adequate than the ordinary ones, being too high for Pablo to sit in a normal chair and too low for using it with the wheelchair.

### 5.4.4 Direct observation

During my two fieldwork experiences I spent a total of 22 hours with Pablo (16 hours in 2009 and 6 hours in 2010) in the mainstream school called "School 62". Since the day I met him at the School 200, he demonstrated a considerable interest in the XO laptop, mainly because of the novelty and the playful perspective he saw in it. As I was also told many times by the adults I interviewed, the child was a live wire, and he had problems in keeping focused on what he was doing or asked to do. His physical limitations consisted mainly in the total lack of movement in the lower limbs and in severe difficulties in controlling his hands. He also had problems in articulating his speech correctly, which made him quite difficult to understand for me but also for his classmates.

An important thing I noticed was about his relationship with the mother: the woman, who I met in both my visits to Montevideo, always showed great interest in the school activity of her son, to the point she once visited the class at the School 200 while I was testing some accessibility solutions with Pablo. As the teachers reported to me, she was always present and involved in his son's integration process and demanded him lots of efforts. As I annotated the first time I met her:

> *2nd June, 2009*
>
> Pablo's mother came to the school this morning. I was not informed about this visit until she appeared at the door of the classroom, with her youngest daughter in her arms. She asked to sit in the class to observe what I was doing with her son. I accepted this, in order to show her that Pablo was learning how to use the MouseKeys technique to move the mouse pointer. She asked me why I was not trying a regular mouse with him, and said to me that at home Pablo was used to it. As I answered that mine was a trial aiming to explore new possibilities, she

seemed satisfied. She asked me some counselling about her home computer and expressed great interest towards my work there.

The teachers also reported to me that Pablo's mother had been quite sceptical in the past months about the work that the special school teacher was doing with her son: she believed that the potential of the child was being underestimated. Actually, the child himself confirmed me that he felt the special school activity to be "too easy for him"

***Question.*** *Las cosas que haces acá [en la escuela especial] son parecidas a las que haces en la otra escuela?*
***Answer.*** *No, allá son cosas más complicadas, con matemáticas...*
***Q.*** *Y que te gusta hacer?*
***A.*** *Me gusta juntarme con mis amigos, estar con mis amigos, y jugar con el dinero, con la plata, la moneda...*
***Q.*** *Y cuantos amigos tienes?*
***A.*** *Tengo como veinte amigos...*

**Q.** Are the things you do here [in the special school] similar to those you do in the other school?
**A.** No, there they are more difficult things, with Maths...
**Q.** And what do you like to do?
**A.** I like meeting with my friends, staying with my friends, and playing with money, cash, coins...
**Q.** And how many friends do you have?
**A.** I have about twenty...

Pablo tended to value the social interaction with his peers above the academical results. What I could also see from him was a really frightened expression as a response to threats like "I will tell this to your mother": apparently, she was very hard towards him at home and demanded him extra efforts to compensate what the School 200 was not giving him in her opinion.

My first visits at the School 62 in 2009 revealed me a situation which could

not be called "easy": Pablo was integrated in a school not marked as "critical context", but it was still a problematic school. The infrastructures were not optimal (and not totally accessible for him), the number of his classmates was over 30, and, most important, he was the only one sitting alone in a desk. All the other children were sitting around low square tables, in groups of 6 to 8. When I asked the teacher why he was sitting there, she answered that it was because of his short sight. Besides these unfavourable conditions, Pablo remarked to me more than once that he preferred the mainstream school to the special one, giving me mainly two explanations: it was for the presence of so many other children and for the most interesting lessons.

My visits to the School 62 were always welcomed with great enthusiasm by Pablo's classmates, who formed the most undisciplined class I met during my fieldwork: many of them seemed not to care about the teacher and had the habit of walking through the classroom during class time, as well as they had very low respect of speaking turns. This "relaxed" atmosphere seemed to have a strong effect on Pablo, who let out his vivid nature with very few limitations: this provoked more than once hilarious reactions in his classmates, and it was quite easy to understand that the role of "jester" was not something Pablo rejected.

The class group did not seem to care much about his presence, until he asked to be taken to the bathroom: at that point, I saw more than once that the other children raced to help the teacher in taking Pablo there. Also during my first visits, when my presence was strongly linked to the upcoming arrival of the XO laptops for the children, Pablo's classmates turned to him to ask about the device, which he fiercely showcased to them, also telling about what we did at the special school.

When I left Uruguay at the end of my fieldwork experience, Pablo had not received his XO laptop yet, due to logistical problems. I had counselled him to use the MouseKeys functionality, for which he received an external numeric keypad, and I had also asked the CEIBAL technicians to activate

Sticky Keys on his machine. When I went back to Montevideo for my second experience, I found that he was not using the external keypad any more. His school was one of those receiving the accessibility updates from CEIBAL (see page 132), but nobody had been able to set up the XO properly for him at school.

During this second fieldwork period I also examined Pablo's laptop: among the most used Activities appeared Library, used to access two ebooks about Uruguayan historical characters, the games Implode and Memorize, the Record activity. Also the Physics activity, which allows to play with a simulation of gravity, had been used many times. The Write activity appeared a lot of times, but it seemed to be always about the same document, repeatedly saved. There were also a lot of Browse sessions and sporadic uses of Labyrinth, the conceptual mapping activity.

**Anecdote: bathroom policies**

One day, while I was administering one of the below described tests in Pablo's class, I was left alone with the whole group, as the teacher was urgently called outside the school for family problems. While I was there, at one point Pablo asked my the permission to go to the bathroom. Suddenly, three of his classmates raced towards his desk and started transferring him from the chair he was sitting in to his wheelchair. They told me that they were used to do this: when I forbid them to take Pablo outside the class, they looked at me with surprise. They said it was normal for them to take him there. I waited until one of the janitors passed by and asked her to take Pablo to the bathroom: she answered me that the other children did it, normally. Curiously enough, what seemed to be an insurmountable problem in Ismael's case, in the School 62 was being left *to the children*.

### 5.4.5 Tests

**Ability assessment.** When I administered the ability assessment test in Pablo's classroom at the School 62, 24 out of 29 children had their XO laptop working. I gave my own XO laptop to one of them, hence collecting a total of 25 test results. Table 5.6 compares the results obtained by Pablo with the scores of the rest of her class.

| | **NS** | **AS** | **NF** | **MF** |
|---|---|---|---|---|
| **Pablo** | 11 | 3 | 7 | 1 |
| **Total** | 417 | 21 | 96 | 16 |
| **Mean** | 16.68 | 0.84 | 3.84 | 0.64 |
| **Standard deviation** | 3.50 | 0.99 | 2.79 | 1.25 |
| **Pablo's *z scores*** | -1.62 | 2.19 | 1.13 | 0.29 |

**Table 5.6:** Pablo's results in the ability assessment test, compared to the rest of his class

Pablo's results, compared to those of the rest of his class group, were evidently less satisfactory. His Natural Successes score was half of the total number of items covered by the test and was significantly lower than the average of his class. His Natural Failure rate was nearly double than the mean, while the Assisted Successes were highly above it. His only Machine-related Failure fell into the standard deviation.

As I mentioned above, when Pablo received his XO it was not configured correctly for him: it lacked the Assistive Technology solutions that I had been using with him during the preceding year. This most likely influenced the results, as in the case of sub-items 13 and 14 ("Draw a house" and "Use at least two geometrical shapes") I was directly able to observe that he could neither use the trackpad nor the MouseKeys controller, with which he had lost his familiarity.

His seven NF results were allocated in the items which were the most difficult for the whole class, hence his low ability could probably be associated to a low stimulus from the surrounding environment (e.g., scarce attention from

the teacher, low peer teaching activity among the children). Those items, as can be seen from figure 5.9, where q6, q13, q14, q18, q19, q20 and q22.

The class was quite compact: outside those critical items, both Failures and Assisted Successes were rare, except for item q5 ("Connect to CEIBAL website") where the most common mistake consisted in not being able to go past the research results received by Google (the default search engine for the XO).

Pablo required my help for items q10 and q11 ("Save your picture in the Journal" and "Find your saved picture in the Journal"): he had partially forgotten how to do something we had been doing quite a lot of times during the preceding year.

According to the general conclusions which could be drawn from those results, Pablo was one of the less able children in his class with the XO laptop. He did not master its basic functionalities, but neither the rest of the class did: only the first items were completed successfully by the whole group and the high error rate detected can be related to the low sistematic use of the XO declared by the teacher. In fact, she told me that even if the children took the laptop to school every day, they used it under her direct control only once per week. The answers I received about the usage she did of it were not really convincing, as she only mentioned generic information retrieval on the web and writing.

This resulted in a very bad relationship with the technological aid from Pablo's part, and was probably one of the causes of the abandonment of the Assistive Technology solutions he had tried during 2009.

**Sociograms.** The data collected through the administration of the sociogram test to Pablo's class allowed to catch an interesting snapshot of the climate of his class.

The two following diagrams (figures 5.10 and 5.11) show the distribution of positive and negative preferences in the class group. As can be easily

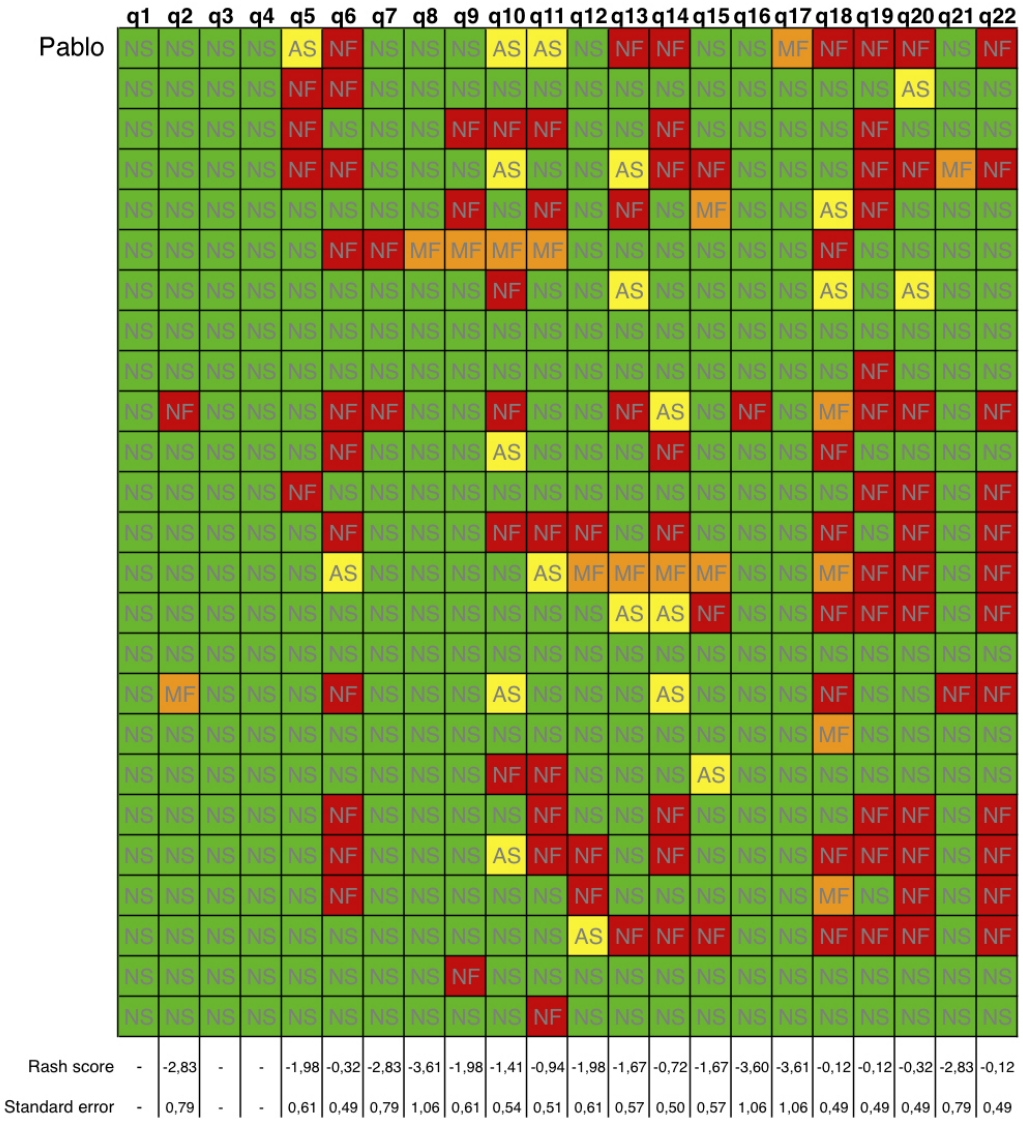


**Figure 5.9:** The total results of the class, with the difficulty coefficients of each item calculated using the Rasch function in R

noticed, Pablo obtained a result which was lower than the average in both macro-areas, a fact which suggests a low level of interaction with his classmates.

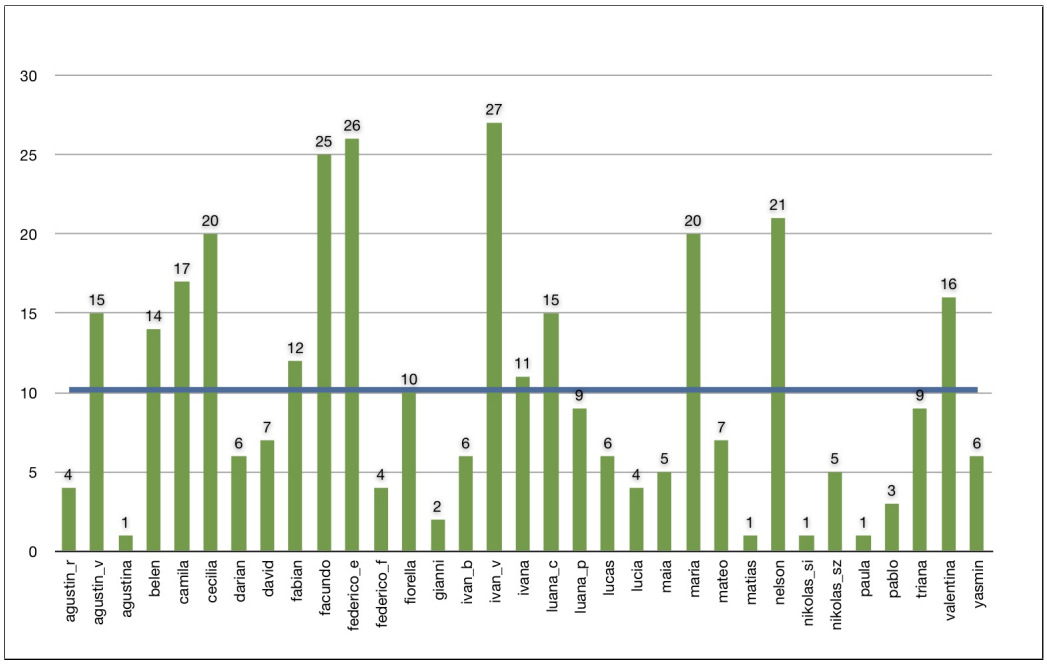


**Figure 5.10:** The total positive preferences in Pablo's class (the blue line marks the average).

The class group, which was the largest examined in this work, counted three super-stars (children with 25+ preferences in all the four areas) and nine other children who received more positive preferences than the average. The negative choices concentrated on four children (two of which obtained 40 or more nominations) who also obtained low positive scores. Pablo's positive elections were less than half the negative ones. If we take a look at table 5.7 it is evident that also his positive results are scattered among three distinct areas and there is a slightly higher concentration of negative elections in the functional/analogical area.

The same results are clarified by figure 5.12: his former classmates tended to ignore him or to point him out as one they would not want be related to. The positive preferences he received came twice from new classmates,

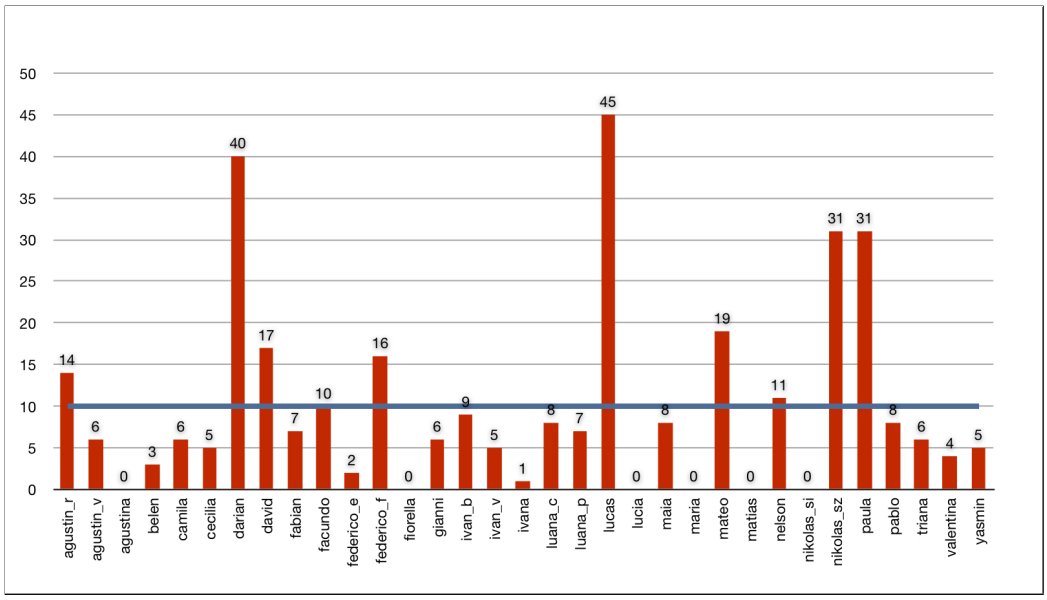


**Figure 5.11:** The total negative preferences in Pablo's class (the blue line marks the average).

on a total of three. The only former classmate who chose him did it for the functional/digital area.

Pablo received a number of nominations which was sensibly lower than the average of the class in all areas, except for the negative functional/analogical preferences. The time spent with him allows me to comment on those scores and to try to find an explanation for those results:

- nobody in the class wanted to sit next to him: Pablo needs to sit in the first row, he requires help from time to time, especially for going to the bathroom;
- the majority of rejections received by Pablo concentrates in the functional/analogical area: it is problematic to understand what he says and he cannot write properly. This lack of communication ability, together with the "laziness" witnessed by the mother, could be enough for making him undesirable as a partner in group works;
- computer mediated communication was not something Pablo was fa-

| | **Social** | **Functional** |
|---|---|---|
| **Analogical** | 0 *(m. 2.71, s.d. 2.16)* positive<br>2 *(m. 2.71, s.d. 3.33)* negative | 1 *(m. 2.71, s.d. 2.13)* positive<br>3 *(m. 2.68, s.d. 3.38)* negative |
| **Digital** | 1 *(m. 2.71, s.d. 1.90)* positive<br>2 *(m. 2.71, s.d. 2.37)* negative | 1 *(m. 2.71, s.d. 2.37)* positive<br>1 *(m. 2.65, s.d. 2.69)* negative |

**Table 5.7:** Pablo's results in the classmates preferences declarations (average score of the class and standard deviations in parenthesis)

miliar with: the absence of adaptations I noticed in 2010, together with his low ability in the use of the XO laptop demonstrated by the ability test, certainly did not favour the development of social skills in the digital area, and did not encourage his classmates to turn to him for technical help, neither.

The XO laptop, which for Pablo was neither a *cognitive amplifier* nor a *social amplifier*, seemed to make no difference in his relational potential: the snapshot of his class network of relationship taken in May 2010 depicts him as excluded under all aspects.

## 5.5 Jorge

Jorge was one of the most interesting and most problematic children I met in my first fieldwork experience. Unlike the above described cases, he derived his disability from a car accident, which compromised his ability to walk and to speak. Formerly a mainstream school pupil, he started attending classes at the School 200 after recovering from the accident, in order to gradually regain possession of his speech and motor control. When I met him, he was able to walk with the aid of a stick and only rarely asked for being carried in a wheelchair. He showed, like the others, great interest towards the XO

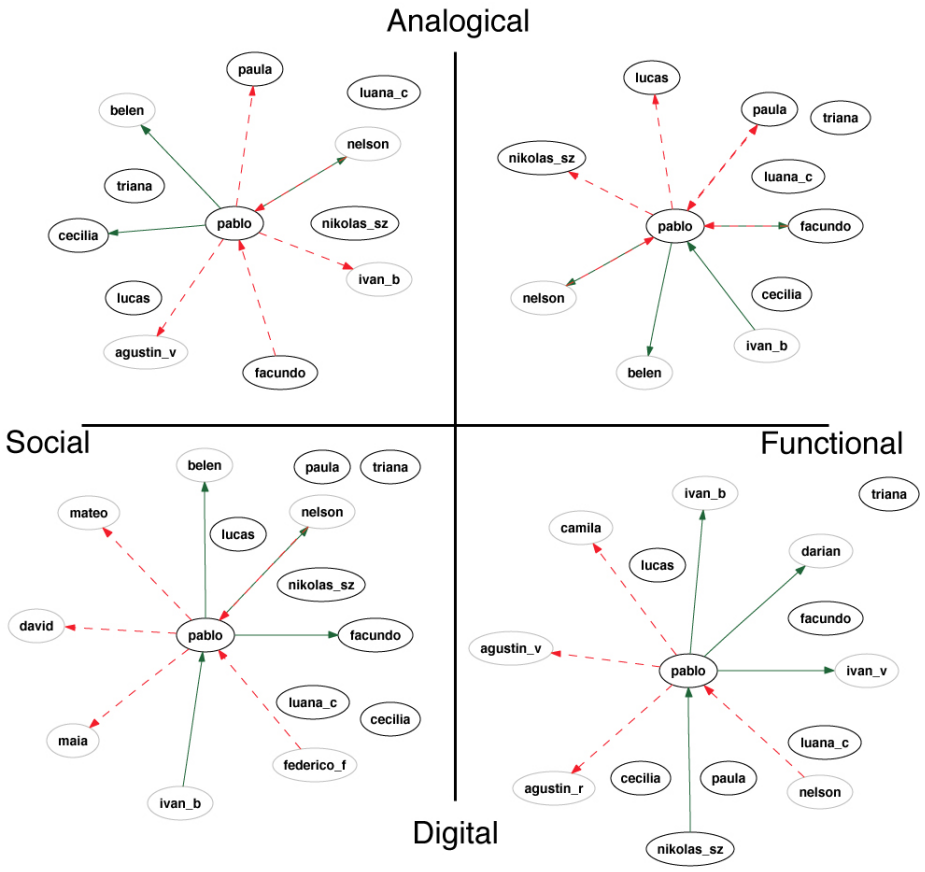


**Figure 5.12:** The sociograms of the four dimensions studied, relative to Pablo. Grey nodes represent children who were not in the same class during the preceding year.

laptop, which was accessible to him also without adaptations.

Besides attending classes at the School 200, as part of the most advanced group of the school, he was integrated in a sixth-degree class at the mainstream school number 52. The two schools are in two distinct neighbourhoods but are also quite near to each other.

This case study could not be completed: when I went back to Uruguay in 2010 I was not able to make contact with him, nor with his family. By the way, Jorge taught me some important lessons which, even if not directly related

with the role of technology, helped me in understanding what inclusion (and lack of it) meant for those children.

### 5.5.1 First meeting and initial impressions

I met Jorge only three weeks after my arrival at the School 200. He was sitting together with his classmates in the largest room of the school, in a class group populated by the oldest children. The class was very varied, ranging from severe motor impairments which also compromised communication abilities to mild physical impairment associated with mental retardation. The teacher (C.L.) was also present during our first meeting.

He immediately showed great interest and enthusiasm towards the XO laptop: he told me he did not have a computer at home, but that he had already used a desktop PC in one of the many cybercafes which were very common in the streets of Montevideo.

One thing in particular struck me since the first times I observed him in the classroom: he showed to be bored by the lessons, or simply not interested in them. Later I discovered some other details which made this initial impression clearer.

### 5.5.2 Teachers, family and direct observations

Among the people who supported Jorge in his educational activity, I interviewed four:

- D.U., director of the School 200;
- L.M., teacher at the School 200, who worked directly with Jorge in 2007;
- A.A., teacher at the School 200, who worked directly with Jorge in 2008;

- C.A., teacher at the School 52, who worked directly with Jorge in 2009.

I also had a joint interview with the latter of them, the director of the school 52 and C.L., Jorge's teacher at the School 200 in 2009.

Given the nature of Jorge's impairments, the tones assumed by the teachers who talked about him were mainly referring to a "personal tragedy" condition. They tended to consider him as an unfortunate child, who was still shaken by what happened to him. The fact was that he had completed the cycle of primary school education before the accident and then was sent to the special school for recovering. His class group at the School 200 was made up of children who had never attended a mainstream school and who needed personal curricular adaptations. According to the teachers there, he had lots of conduct problems related to the difficulties in relating with his new classmates: he apparently felt different from both the children in the special and the mainstream school.

> *Con el caso de Jorge es diferente, el aquí siente que sobra, que sabe más, que todo es fácil, el quiere parecerse a ese niño que era antes pero obviamente no se asemeja.*
>
> With the case of Jorge it is different, he feels that he is misplaced, that he knows more, that everything is easy, he wants to be similar to the child he was before but obviously he does not resemble him.

Being aware of this problematic state of mind, which was also going side by side with the phase of adolescence, the School 200 personnel had decided to start an integration project with him in the year 2009. Jorge was attending a mainstream school in his own neighbourhood and personally told me he was going there three mornings per week.

The child had no hesitation in telling me directly how uninterested he was in the special school activities: he remarked more than once that he preferred the mainstream school, even if he admitted not to have many friends

there:

> *Las cosas que hago en esta escuela ni le presto atención, porque yo ya se que yo se. [...] Allá no tengo muchos amigos, empiezé hace poco...*
>
> The things I do in this [special] school, I do not care for them, because I am already aware that I know. [...] There [in the mainstream school] I have not many friends, as I started short time ago...

His teacher at the mainstream school described him using the words *sumamente integrado*, extremely integrated: she based her statements mainly on the fact that the other children particularly appreciated his lack of 'filters' during lessons. Actually, Jorge tended to cut in on a lesson just to tell everybody something he was thinking about: this attitude provoked fun in his classmates. As C.A. explained me:

> *Toda la clase disfruta mucho de todo eso, porque tener un compañero que no tenga vergüenza ni inhibiciones es bárbaro.*
>
> All the class group enjoys this a lot, because having a classmate who has neither shame nor inhibitions is fantastic.

The family of Jorge was also quite problematic: the schools did not know very much about the father and the mother: they only saw them at the beginning of the school year and planned together the timings of the child's participation in the classes. After that initial moment, the school was not able to contact them again.

Under the technological point of view, Jorge required some intervention: it was true that he could operate the XO keyboard and trackpad directly, but this also cost a lot of efforts to him. Using an external mouse was also problematic for him, hence I proposed the adoption of MouseKeys. Jorge liked this solution, and preferred using it via the rocker controller seen in figure 4.5, page 114. The general opinion of his teachers was that he would

be able to use technology in order to enhance his functioning level and that was expected to help him in regaining self-confidence.

During one of my first visits to the mainstream School 52, at the end of May 2009, I had the possibility to meet Jorge's class teacher, the director of the school and the teacher of the School 200 who was directly working with him. This meeting turned out to be also the first one between them, which provoked the incident described in the following section.

### 5.5.3 A case of *incident*

Jorge was presented to me as a problematic child, but everybody seemed to agree about the positive effects that the integration in a mainstream school was having on him. When I met the School 52 personnel, my interview with the class teacher and the director started with a complaint about his scarce attendance to classes:

> ***Question.*** *En qué días viene?*
>
> ***Answer.*** *Los jueves y los lunes. Te dije primero los jueves porque es el día que tenemos educación musical. No vino ningún jueves todavía, no participó nunca de ninguna clase. Por eso ya te digo que de dos días de la semana, hay uno que no vino nunca, las veces que ha venido ha sido lunes. Yo te diría que él vino cuatro veces.*
>
> ***Q.*** *En todo este año?*
>
> ***A.*** *Sí en todo este año. La mamá me trajo un certificado en un momento como que había estado enfermo, un certificado por diez días...*
>
> **Question.** On what days does he come here?
>
> **Answer.** On Thursdays and on Mondays. I told you Thursdays at first because it is the day we have musical education. He did not come any Thursday by now, he never participated in any of

> those classes. That is way I say that of two days in a week, there is one he never came, and the times he actually came it was on Mondays. I would say he came four times.
> **Q.** During all this year?
> **A.** Yes, during all this year. His mother brought me a certificate once, saying he was sick, a certificate valid for ten days...

Evidently enough, the situation was not optimal, even if the child had been described to me as highly integrated. During the meeting it came also out that his family had never contacted the schools (both special and mainstream) since the beginning of the year. The most important fact was that the teacher representing the School 200 during that meeting was not aware of this, hence the incident: focusing on Jorge's integration allowed to shed light on what was not working not only in his particular situation, but also in the overall relationship between the special school and the integrating mainstream schools. As in the case of Ismael, which happened in 2010 but was described in before this case, my intervention allowed to highlight some basic problems which were not directly related with the topics of my research.

## 5.6 Main findings: Steps towards a grounded theory

As I explained in the previous chapter, the research question which drove this part of my study was:

[q3] *How does the laptop accessibility relate with the fact that it is distributed on a 1-to-1 basis?*

As of May 2010, the XO laptops had been changing the way teachers and pupils were living their everyday school experience, even if this change was not exactly what teachers, parents and children expected. As outlined in the conclusions of the preceding chapter, technology had been welcomed with

great expectations, but the project was having difficulties in advancing in the constructivist direction which was considered foundational by its developers. The use of the computers was still rudimentary, as a plain substitution of other supports. The opportunities offered by the laptops, at least those that the OLPC initiative points out as the most revolutionary, were not being totally exploited. In particular, a mix of technological wariness and of communication problems (as in the incident cases described above) made it really difficult to completely benefit of the introduction of Assistive Technology at school.

The three cases shed light on some interesting points which can be useful both for fostering a positive change in the environment studied and for new research ideas. Various aspects of their personal stories were different, but they also showed some similarities. The chart in figure 5.13 resumes the main aspects of their integration stories and of their relationship with technology.

With their own singularities, they impersonated distinct facets of mobility impaired people, which at first corresponded to **distinct ways of accessing and benefiting of technology**. Among them Ismael, aged 11, seemed to fit perfectly with Turkle's technological appropriation classification discussed here in section 2.3.1, page 25: he was in his *ability phase*, using the computer mainly for games and in shared activities with his peers. He did not master it perfectly, but the evaluation of his competence level showed he fell near the average of the class. Micaela, only 9, was living the same appropriation phase: she performed better than the others in the ability assessment test, as her class did in respect to the other two classes involved. The third child studied, Pablo, 10 years old, showed to have nearly the same interest in technology, but was one step back on the way towards a satisfactory use of the XO laptop. This could be attributed to various causes: personal lack of motivation, problematic class environment, lack of technical support. He scored among the lowest results in the ability assessment test.

| | Ismael | Micaela | Pablo | Jorge |
|---|---|---|---|---|
| **Overall perception of the integration process** | Positive, with some critical aspects | Positive | Problematic | Biased |
| **Role of the family in the integration process** | Involved, but problematic (logistics problems) | Involved and supporting | Involved, but problematic (disagreement on treatment) | Poorly involved |
| **Improvements in independence after the introduction of the XO** | Changed positively in his attitude | Consolidated her independence | No evident improvement | not observed |
| **Ways of accessing and benefiting of technology** | Low-skilled enthusiast | Skilled, not enthusiast | Low-skilled, non enthusiast | Skilled, enthusiast |
| **Perception of the skills level by teachers and parents** | Enthusiastic and skilled use | Problematic use (slower than pen and paper) | Problematic use (lack of adaptations) | not observed |
| **Perception of the skills level by classmates** | Very low | Low | Very low | not observed |
| **Enjoyment of the potential of Assistive Technology** | High | Incomplete | Low | not observed |
| **Laptop usage at school** | In collective activity, not as AT | In collective activity, not as AT | In collective activity, not as AT | not observed |
| **Assessed computer skills** | Average | High | Low | not observed |
| **Perceived computer skills (by peers)** | Low | Low | Low | not observed |
| **Level of computer mediated social interaction** | High | Very high | Very low | not observed |

**Figure 5.13:** A resume of the characteristics of the three case studies. Colors mark positive (green), problematic/uncertain (yellow) and negative (red) results.

As a second differencing aspect, their integration processes were considered all positive enough to allow them to stop attending classes at the special school at the same time: obviously enough, they were having totally **distinct** integration experiences, with particular relation to the **role of their families** in it. The case of Ismael was one of an excessive presence of the family (represented by the father at school), creating a sort of protective barrier around him. That generated not only a complication in the relationship between school and family, but also between special and mainstream school. Micaela could easily be pointed at as a perfect integration case: it would be very interesting to investigate how much her aspect, which was more similar to that of an able-bodied, influenced the process. In her case, I saw the less conflictual relationship between family and school. It was not the same with Pablo: his mother was evidently being very critical towards both the special

and the mainstream school, to the point that she told me more than once that she had to quarrel with them quite often.

As a third difference among them, I will compare their **improvements in independence and in overall social skills** (or lack of them): when I first met them, Ismael and Pablo were both described to me as used to command their peers and the adults around them, they used to be served and helped. After the introduction of technology at school this aspect seemed mitigated in Ismael: he was still demanding and commanding, but both the mainstream school teacher and the father agreed that he was gradually changing this attitude, gaining more independence. The same was not to be said about Pablo, who had not apparently improved in his personal independence as he did not in his technological skills, either. Micaela, who was already depicted to me as very independent during the 2009 school year, maintained her autonomy and showed me new facets of it in her ability to use the XO laptop with very few need of external help.

With regards to how much they were **enjoying the potential of Assistive Technology**, it must be said that Pablo was the only one I found totally unaware of the accessibility enhancements introduced by CEIBAL. This was mainly due to the scarce communication between special and mainstream schools that I witnessed more than once, as in the two incidents I described above involving Ismael and Jorge. The situation for Ismael was better but not optimal: he still had some problems in using the laptop and in understanding the usefulness of the AT adaptations; moreover, his father did not seem to consider the XO as a learning tool: to his eyes, the child had been using it mostly for gaming in the preceding months, with no interest in increasing his own productivity. In the case of Micaela, it was evident that she relied on her only adaptation (a regular USB mouse) in the same way she would rely on her walking sticks: she felt at ease with it and used it to be more productive. In the three cases, what seemed most important for the development of efficient strategies in the use of the computer was the technological competence of the

teacher: both Ismael and Micaela could rely on CEIBAL volunteers, while Pablo, during the year 2010, was assigned to a group with a teacher with low technological skills. In the constructivist perspective on which the whole OLPC project is based, peer teaching is highly valuable: accordingly, the class of Pablo had many poor performers in my ability assessment test, while the other two classes had an higher overall competence level. It is not among the objectives of this work to determine if teacher's competences influence the overall class abilities in a one-to-one computing setting, but the hypothesis seems worth to be considered for future work.

An aspect which was common among the three cases was the use of Assistive Technology to **access the laptop, rather than to access the environment**: Ismael, Micaela and Pablo were living their technological experience at school only during the "computer related activity", which means that they did not take advantage of it *in the way the teachers had dreamt of in 2009*: as I reported in section 4.4, the delivery of the laptops generated great expectations for the development of new skills and for the improvement of the functioning of mobility impaired children. But that meant using the computer as an alternative to pen and paper, a use which I never saw in practice. Especially in the cases of Pablo and Ismael, where handwriting was a real barrier, the laptop was being considered an activity to be proposed to the whole class at a time, rather than an instrument to improve the productivity of the children. In this sense, the meeting between special education and one-to-one computing, especially in the form OLPC proposes, was particularly problematic: the traditional way of introducing AT at school, based on the assumption that the disabled child was the only one with access to technology in the classroom, was kind of overwhelmed by the novelty of the constructivist approach. The teachers of mainstream schools seemed too much focused on dealing with the presence of computers in their classrooms to notice that the limitations on their use actually meant denying some children the possibility to enjoy the effects of Assistive Technology.

Finally, in the cases of Ismael and Micaela it was quite surprising to notice how much they were able **to benefit of the computer more socially than functionally**: even though they were using the laptop only once or twice per week, they seemed to have been able to develop more complex and consistent relationships with their classmates through it. This aspect suggests that, even in a regime of infrequent use of technology, the presence of computers on a one-to-one basis in their classrooms allowed them to develop social relationships. The case of Pablo, again, was less positive, but it was not a surprise: not being able to use his computer properly, also because of the lack of proper AT configuration, that environment was not favourable to him.

The social use of the computer is the most interesting outcome of this work: as hypothesized in section 5.1, the children I studied showed improvements in their social skills which were not directly connected to an improvement in their functioning. Ismael had not gone very far beyond his physical limitations, but had already found a powerful channel for his interaction with peers in the computer. Micaela was as good in the use of the computer as she was in the majority of the subjects, but there was a substantial difference in the way her classmates perceived her with respect to her social and functional possibilities. The case of Pablo proved that the lack of a very basic level of implementation of Assistive Technology simply turns the machine into a useless device. This reflection opens up the need of investigating in a wider and deeper way the benefits that Assistive Technology can bring especially on the social level.

# Chapter 6

# Conclusions

This work required a quite large amount of time, in which three main research questions were addressed adopting distinct research methodologies. I was able to propose answers to such questions by the means of:

1. an analysis of the environment, useful for individuating the gatekeepers and for reaching the real actors involved in the studied process;
2. the proposal of practical solutions to some of the most common accessibility issues;
3. a study of the local idea of integration, carried out with a series of interviews and two focus groups;
4. a series of case studies to observe the impact of Assistive Technology and one-to-one computing on mobility impaired children.

The environment in which I operated during the total time of six months I spent in Uruguay had many similarities with the school system of my own country, even if with particular respect to special education there was an important difference: Italy abandoned the model of special schools separated by mainstream schools forty years before, in favour of total integration. Moreover, the high percentage of people who inherited my same nationality from

their grandparents made Montevideo quite similar to my country under many aspects. But the similarities were mainly superficial: the story of the Country, together with the influences received by other cultures which had very few in common with my own, made Uruguay a quite fascinating place to discover and to live in. In addition to this, the technological revolution introduced by CEIBAL, the first one-to-one computing initiative carried out on a national basis, opened up totally unexplored possibilities.

The hypothesis I formulated during the fieldwork experience, which had been inspired by the literature about one-to-one computing outcomes as well as from evidence collected on the field, was that also in the case of mobility impaired people the major advantages carried by the horizontal diffusion of technology would be registered on a socio-motivational dimension. That proved to be true in the analysed case studies: this result partially negated the expectations of the teachers, which in many cases saw in (Assistive) Technology a possibility for enhancing the functioning abilities of those children, giving secondary importance to social outcomes.

All this work was done during a period of transition, in which Uruguayan special schools entered a plan which had been causing great interest and fervid debates during the two preceding years. Being this an action research project, it was meant to aid the local actors in reflecting upon their actions during this delicate period. This resulted in the creation of a quite vast network of contacts, varying from simple friendships, to collaborations in projects and in publications, to mutual advice.

The results I exposed at the end of chapters 4 and 5 allowed me to depict a more defined image of the environment I was studying and to reflect upon the traditional uses of Assistive Technology with a brand new perspective. The reflections generated by this study follow three main directions: first, some critical factors are highlighted which do not directly relate to the introduction of technology at school, but which are also necessary for it; second, technology is defined as a resource facilitating inclusion of disabled children

in mainstream schools; third, a new shade of meaning is given to the word accessibility, focusing on the fact that it is an environmental variable.

The three following sections will explore those paths, while the closing section will try to set up some further doubts, questions and topics which will be the basis for future research.

## 6.1 Basic Requirements for Integration and Inclusion

The inclusion of children with special needs in mainstream schools proved to be highly dependant on some key factors which played a fundamental role in this work. Among those I will concentrate on three:

- **communication and collaboration between special and mainstream schools**: both the incidents reported in sections 5.2.6 and 5.5.3 derived from a lack of communication between the two realities of special and mainstream education;
- **involvement of families**: parents demonstrated to be key decision-makers in the integration process, with the possibility of influencing it also negatively if not allowed to be active participants in it;
- **teachers training**: teachers felt and sometimes expressed the need of specialized training in order to deal with the needs raised by the distinct kinds of impairments they were working with.

That of communication between schools was probably the most pressing urge: my intervention, aiming to explore the personal stories of the children, revealed to be useful also for discovering inconsistencies in the whole integration system. Those inconsistencies influenced the children's integration experience in a very negative way, not allowing them to express their full potentials as human beings.

Family involvement was another core issue, and was again related to communication problems: parents repeatedly expressed their concerns about how the school (both special and mainstream) were dealing with their sons and daughters. They needed training, professional support and reassurance about their children, otherwise they could also cause serious trouble to the integration process.

Teachers, especially those of mainstream schools, did not know too much about their special pupils, a fact which was aggravated by the change in the class teacher happening every new school year: this proved to be an highly critical factor, as in two of the analysed case studies parents reported of not being able to understand why some problems did not emerge with former teachers but had appeared with newer ones.

## 6.2 Inclusion in the One-to-one Era

The introduction of computers in classrooms surely has an observable impact. The literature review exposed in chapters 2 and 3 showed that if on one side there is proof of the positive influence that it can have on both the functional and social aspects of an impaired child's learning experience, on the other hand one-to-one computing outcomes mainly involve social and motivational factors.

The combinatory effects of those influences were well reflected by the children of the schools I visited. The expectations of teachers about the role that technology would have on the inclusion of mobility impaired children were varied:

- when discussing about it in groups, they insisted on the social and motivational aspects of the integration/inclusion processes, both in the special and in the mainstream school environments;
- when personally interviewed, they tended to give more importance to

functioning and to learning outcomes, sometimes considering social skills as secondary and technology as a simple productivity support.

Since when I started talking directly to the children in the special school who were integrated in a mainstream one I noticed that they valued their social interaction with their peers above everything else. The arrival of the computers, besides making the *forbidden experiment* mentioned at page 13 possible, meant two other things for them:

- **being part of a community**: the XO was a generally diffused, egalitarian device; it was easily recognizable as 'the laptop' (not simply 'a laptop') and was available for everybody, beyond any belonging to a social group;
- **a new communication channel**: computer mediated communication offered new possibilities for those who had difficulties in turn-taking while speaking and allowed the development of a shared ground of interests among the children.

In the analysed case studies **the most relevant and interesting outcomes were registered in the social dimension**: even if it was true that the lack of technical support compromised both functional and social areas, as in the case of Pablo, the two stories of Ismael and Micaela demonstrated that the XO could be appreciated more for its ability to connect to classmates, creating new communication channels and opportunities, than for the expertise that the children could gain in using it.

This research, especially in the case studies part, does not claim to be representative of a large population. Actually, such a population is very hard to define, given the fact that disability is classifiable but can never be univocally defined: people with the same diagnosis can have very different needs, personal problems and social relationships. The validity of this work is mainly internal to the environment studied and produced knowledge valuable for immediate intervention. Besides these needed specifications, it remains the

fact that the panorama depicted by the analysed situations suggests that there are more things we need to know about the processes fostered by the introduction of (Assistive) Technology at school.

Augmented social interaction can also be read as a sign of the improved *inclusiveness* of the environment: as explained since the introduction of this work, I tried to distinguish *integration* practices from *inclusion*. These results highlight a positive change in the Uruguayan mainstream school environment, which in some sense is becoming more open towards children with special needs.

## 6.3 Ubiquitous Accessibility

Accessibility is commonly considered as something to be reached, or granted. The underlying fact is that the environment normal condition is of non-accessibility. The role of Assistive Technology in such a context is that of a 'personal facilitator': individuals using AT solutions enjoy the benefits of prostheses and aids which substitute or expand their lacking abilities. This view, which is indeed realistic and reasonable, as prostheses are in many cases something not only useful, but necessary, is strongly influenced by the dominant medical model of disability and by the tendency to consider rehabilitation as the cure for a personal tragedy.

The adoption of a one-to-one computing model, based on the diffusion of a well recognizable device, fostered in the environment studied the development of the sense of belonging to an horizontal community of users of the same technology. In this panorama, children with special accessibility needs are given the possibility to interact with their peers in new ways. The computer is an environment, more than a mere instrument: it is a facilitator for all of its users, and computer mediated interactions tend not to expose people (and their impairments) directly.

Being portable, laptops allow bringing AT solutions almost everywhere. This, in combination with the fact that accessibility improvements can be propagated in a sort of 'viral' fashion to all the machines of CEIBAL plan, is actually creating a landscape made of accessible terminals, where replication of AT solutions is made extremely easy and straightforward. This does not mean that all machines are accessible to everybody: some children will need external adaptations, some others will require special configuration. The advantages introduced by one-to-one computing in this sense are classifiable in two levels:

- **accessibility as a trait of the environment**: all the actors can be involved in the deployment of AT solutions, spreading not only technical competence but also knowledge of the needs of those with a physical impairment; access can then be seen as a possibility for all, rather than a privilege;
- **increased accessibility potential**: any machine is *potentially* accessible, and Assistive Technology costs are drastically reduced, increasing the availability of solutions also for those who would not commonly be considered disabled.

One-to-one computing initiatives as One Laptop Per Child provide the possibility for ubiquitous accessibility, extending ideas such as 'universal design' in a way which not only favours already known solutions, but also allows the creation of new ones. This would be easier with the diffusion of new competences and with the spreading of a renewed sensibility towards the needs of people with different kinds of impairment.

Besides the potential, however, OLPC demonstrated to have put very low attention towards accessibility issues: both the hardware device and the operating system did not enable users to access information in an easy and straightforward way: they simply were not compliant with the basic Universal Design principles. This work helped in the adaptation of software solutions in order to partially overcome such a lack of accessibility, but many other

measures should be adopted. Ubiquitous accessibility is still something far from the everyday experience of physically impaired children of Uruguay, even if without such an effort it would probably be impossible.

## 6.4 Further research ideas

The above described outcomes raise some new and interesting research questions. As discussed above, one of the most remarkable results was the improved social interaction opposed to poor functioning outcomes. This deserves further studying, as scientific literature about one-to-one computing is still limited, especially about the real impact that the model can have on overall learning. In particular, some questions should find an answer: do improved social skills and interactions positively influence learning outcomes? Are there other appreciable consequences? And what would happen in a one-to-one computing initiative where the adopted machines demonstrated higher performance and wider AT availability?

As a matter of fact, the XO hardware and software have many limitations if compared to mainstream computers: it is hard to find out how much they can act as obstacles to learning, but it can be safely assumed that their lack of accessibility is in some way limiting the possibilities of a part of its users. Further study will be carried out in order to form a more detailed picture of what is actually happening in OLPC and other one-to-one computing deployments, following a *grounded theory* approach. The research strategy, the mix of distinct methodologies which was proposed in here will be reapplied to as many other cases as possible in order to highlight those indicators which allow to determine:

- **the (un)successfulness of an integration process**, in both its digital and analogical dimensions;
- **the impact of technology on such processes**, with regard to both

social and functional improvements.

All future efforts will be inspired by the same Action Research paradigm which guided this one, in the belief that research is both a scientific activity and a form of social engagement.

# Appendices

# Appendix A

# Research instruments

## A.1 Checklist for Accessibility Needs Survey

## A.2 Interviews track for teachers - baseline year

After asking some general information about the teacher/expert's experience in the field of education, the following main questions were asked:

- What is the role you cover in the institution you work for?
- What is your experience with cases of integrated children?
  - How would you describe the level of integration of the child?
  - Do you have any experience in the adoption of AT devices?
- What are the main issues in integration processes?

| Niño | Grado | Uso PC previo | Uso mouse XO | Uso mouse externo | Uso teclado XO | Teclado XO con un dedo | Uso teclado externo | Lamenta no ver? | Notas |
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**Figure A.1:** The checklist used for the initial survey on accessibility needs at the School 200.

  - Have you experienced any serious or particularly interesting problem?
  - What kind of resources did you feel you needed more?

- What do you expect from the CEIBAL plan and from the introduction of the XO laptop at school?

## A.3 Interviews track for teachers - second year

- What were the main changes and novelties introduced by the implementation of Plan CEIBAL in the school where you work?
  - How did LATU and CEIBAL support the provision of AT solutions?

  - Did you receive any form of extraordinary technical assistance or training?
  - Did the organization of your school get changed after the arrival of the XO laptops?
  - Did you receive any form of support from volunteers and from external organizations?
- How did families react to such a process?
- Cuales fueron los principales factores de criticidad?

### A.3.1 Specific questions for the director of the School 200

- Can you explain me what were the motivations for the full inclusion of Ismael, Micaela y Pablo?
  - Who participated in the decision process?
  - How much did CEIBAL (and the availability of technology) influence such a decision?
  - Do you still support them from this school?
- Did you start any new integration project since last year?
  - How much did CEIBAL (and the availability of technology) influence such a decision?
  - Are they still attending also this school?

## A.4 Interviews track for parents

- How would you describe the integration process of your son/daughter?

  - Does he or she have any particular problem in following the regular curriculum?
  - Does he or she have friends? Is he or she accepted by his or her classmates?

- Did you notice any particularly interesting change in your son/daughter since the introduction of CEIBAL plan at school?
  - What do you think of the CEIBAL initiative?
  - Do you think your son/daughter has everything he/she needs for accessing the machine?
  - Do you think the machine has been a good support for his or her motivation?
  - Do you still receive support from the special school?

## A.5 Ability level test

Figures A.2 and A.3 show the complete list of the items included in the ability assessment test described in section 5.1.3, in the format presented to teachers. Figure A.4 shows the data collection sheet used by me and by an assistant for annotating the test results.

## A.6 Sociogram test

Figures A.5 and A.6 show the data collection sheet distributed to each child in the studied classes.

## Test de competencia en el uso de la Laptop XO

El objetivo de este test es averiguar cual sea el nivel de competencia y de autonomia en el uso de la laptop XO. La prueba está piensada para ser suministrada en el salón de clase, proponendo a los niños algunas acciones, desde la más simple hasta la más compleja. Cada tarea está dividida en puntos que serán marcados en una planilla y tiene un tiempo limite marcado al lado del título.
Los niños pueden levantar una mano para llamar al investigador y pedirle ayuda.

El orden en que aparecen las varias Actividades de Sugar sigue el criterio de popularidad que se puede encontrar acá:
http://www.ceibal.org.uy/docs/evaluacion_educativa_plan_ceibal_resumen.pdf

Antes de empiezar la prueba, hay que contar la cantidad de niños y máquinas presentes.

**PARTE 1 - Preparación del entorno - tiempo 5'**

Tarea: Encender la computadora, conectarrse a internet y ponerse en el “Hogar”

1.1 Encender la computadora
1.2 Conectarse a la red de la Escuela
1.3 Tornare alla schermata Home

**PARTE 2 - Navegación - tiempo 10'**

Tarea: Ir a jugar con el juego “Sonrisas sanas” que se encuentra en el portal Ceibal

2.1 Iniciar la actividad "Navegar"
2.2 Ir a la página de plan Ceibal
2.3 Abrir el juego "Sonrisas sanas"
2.4 Cerrar la actividad "Navegar"

**PARTE 3 - Fotos y video - tiempo 10'**

Tarea: Sacarse una foto sonriendo y guardarla con el nombre “Sonrisa”. Buscar la foto "Sonrisa" en el Diario

3.1 Iniciar la actividad "Grabar"
3.2 Sacarse una foto solos, sonriendo en la camara
3.3 Guardar la foto con el nombre "Sonrisa"
3.4 Buscar la foto "Sonrisa" en el diario

**PARTE 4 - Dibujo - tiempo 10'**

Tarea: Dibujar una casa usando por lo menos dos formas geometricas de distinto color (triangulos, cuadrados, rectangulos)

4.1 Abrir la actividad "Pintar" u otra que sirva para dibujar
4.2 Dibujar una casita
4.3 Poner en el dibujo por los menos dos formas, con colores distintos
4.4 Guardar la actividad con el nombre “La casa que quiero”

**Figure A.2:** Ability level test, page 1

**PARTE 5 (opcionál) - Escritura - tiempo 10'**

Tarea: Crear un documento, escribir “hola, yo me llamo” y mi proprio nombre y agregar la foto guardada como "Sonrisa". Compartir el documento con el vecindario.

5.1 Abrir la actividad "Escribir"
5.2 Escribir la frase "Hola, yo me llamo" y su proprio nombre
5.3 Agregar la foto guardada como "Sonrisa" en la página
5.4 Compartir la actividad de escritura con el vecindario

**PARTE 6 (opcionál) - Funcionalidades de Sugar - tiempo 10'**

Tarea: Entrar a una actividad compartida y iniciar un chat con alguien.

6.1 Ir al vecindario y participar a una actividad compartida por otro niño
6.2 Abrir la actividad "Chat"
6.3 Invitar otro niño a la actividad "Chat"

**Figure A.3:** Ability level test, page 2

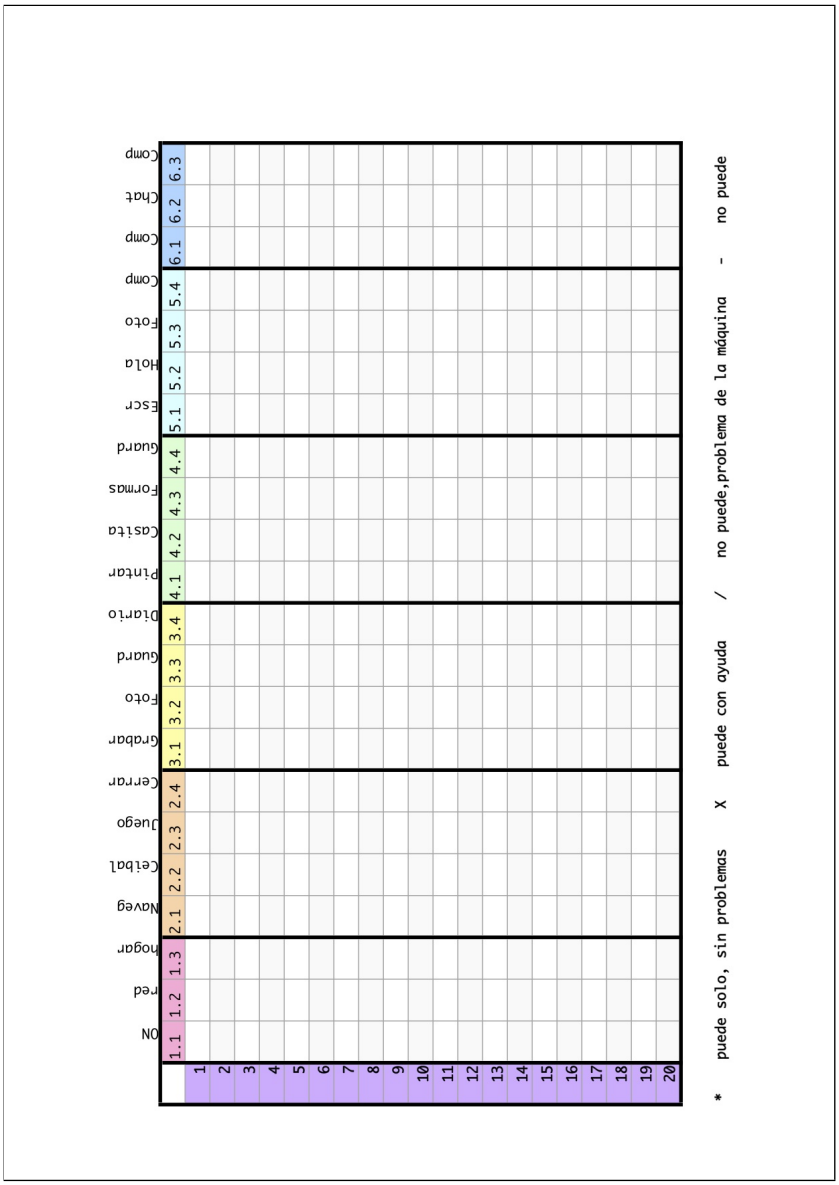
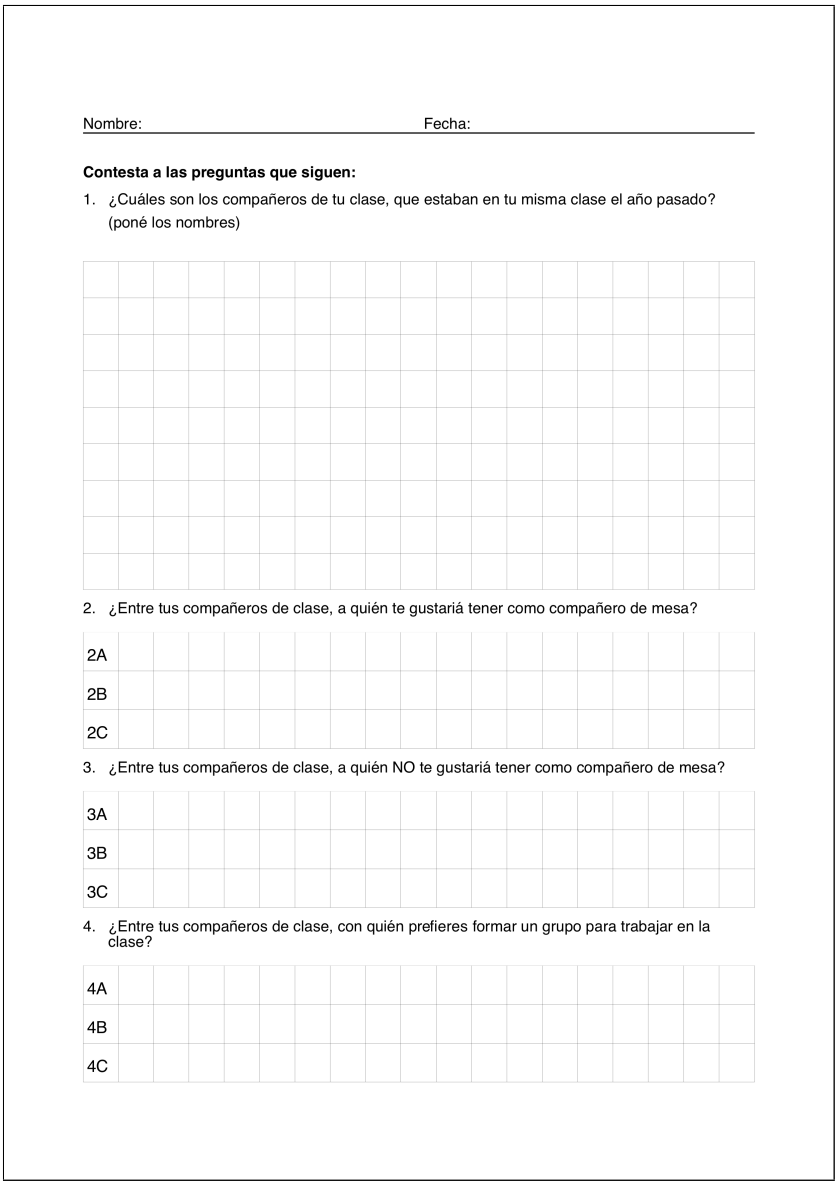



**Figure A.4:** Data collection grid



Nombre: Fecha:

**Contesta a las preguntas que siguen:**

1. ¿Cuáles son los compañeros de tu clase, que estaban en tu misma clase el año pasado? (poné los nombres)

2. ¿Entre tus compañeros de clase, a quién te gustariá tener como compañero de mesa?

2A
2B
2C

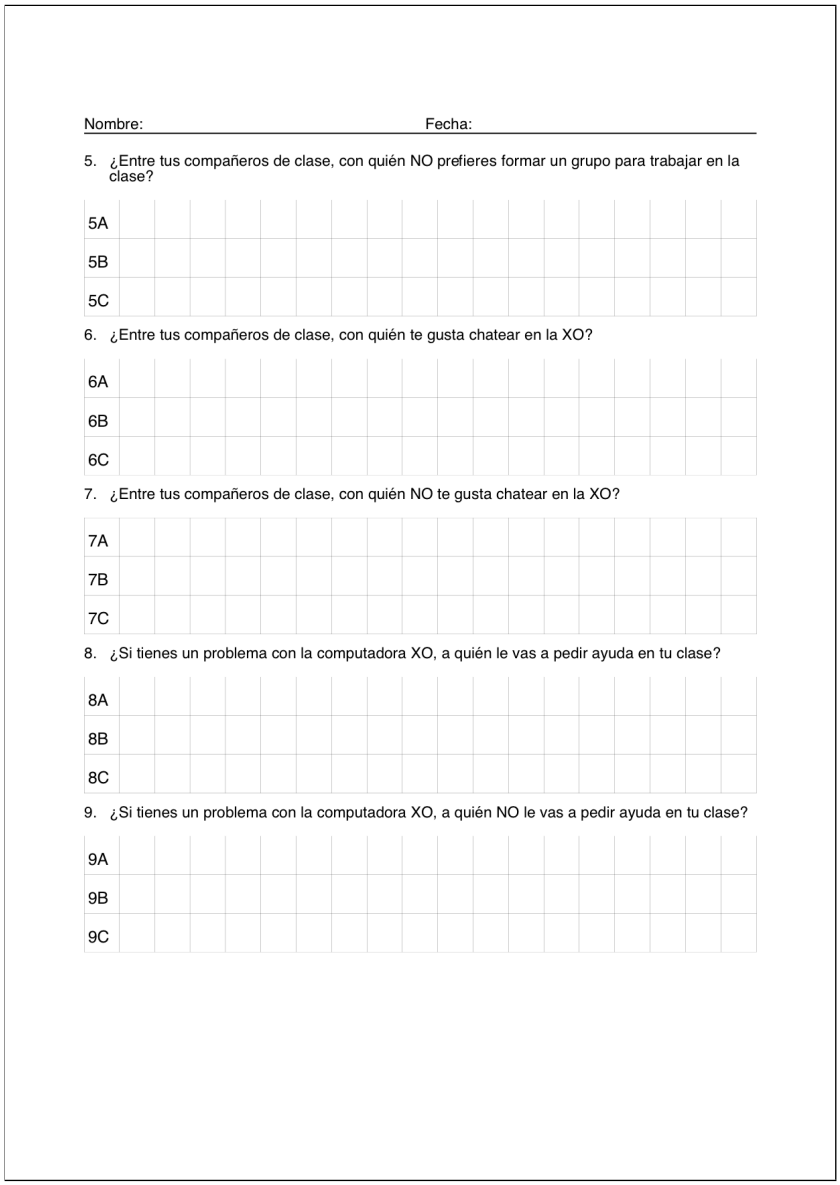
3. ¿Entre tus compañeros de clase, a quién NO te gustariá tener como compañero de mesa?

3A
3B
3C

4. ¿Entre tus compañeros de clase, con quién prefieres formar un grupo para trabajar en la clase?

4A
4B
4C

**Figure A.5:** Sociogram test, page 1



Nombre: Fecha:

5. ¿Entre tus compañeros de clase, con quién NO prefieres formar un grupo para trabajar en la clase?

5A

5B

5C

6. ¿Entre tus compañeros de clase, con quién te gusta chatear en la XO?

6A

6B

6C

7. ¿Entre tus compañeros de clase, con quién NO te gusta chatear en la XO?

7A

7B

7C

8. ¿Si tienes un problema con la computadora XO, a quién le vas a pedir ayuda en tu clase?

8A

8B

8C

9. ¿Si tienes un problema con la computadora XO, a quién NO le vas a pedir ayuda en tu clase?

9A

9B

9C

**Figure A.6:** Sociogram test, page 2

# Appendix B

# The Farfalla project

The Farfalla project started in late 2006 as a Master Degree project. The story of its development is not linear mainly because of the influence that the present work had on the mindset on which Farfalla is based. Basically, it consists of a web framework which allows the use and the integration of some software Assistive Technology solutions in web pages, without the need of installing any additional piece of desktop software.

The aim of this project has always been to integrate typical Assistive Technology functionalities inside a web application, in order to provide disabled people with easier access to the information on the web. As long as the solutions implemented in this framework were tested on the field during this research process, this appendix gives an overview of the project features and of the evolutions which have succeeded in its architecture. Actually, the software history can be split into two parts: an original one, when it was designed and a prototype was developed, and a new one, where the ideas emerged from the fieldwork were applied to a complete re-design of the software architecture.

## B.1 The origins of the project

As described in [103], the original idea of the project was to develop an interface allowing the users to write text documents and to save them using only a restricted number of keys. Later, this system turned out to be effective also for browsing web pages. This could improve the ability to retrieve information and to communicate, allowing the user to access the multitude of services and applications that the web makes available.

After developing this assisted writing method, the project adopted an architecture based on a virtual web browser. It allowed moving from element to element in a web page and filling forms using only five keys. The aim of the virtual browser was to make direct interventions on the contents by actually copying them locally and displaying only a sort of mirrored version of them.

As showed in figure B.1, the project adopted a modular structure, involving a database, a virtual web browser which could be accessed from the regular web browser, and input-output modules. Those modules would not interact directly with web pages, but with their representations provided by the virtual browser. This process, which was actually creating a man-in-the-middle environment, proved to be very hard to develop and maintain: complex web pages were very difficult to render in the virtual browser and asynchronous requests could not be properly implemented.

The input and output modules included a virtual keyboard, a scanning keyboard, text magnification, text-to-speech and a score based text prediction algorythm.

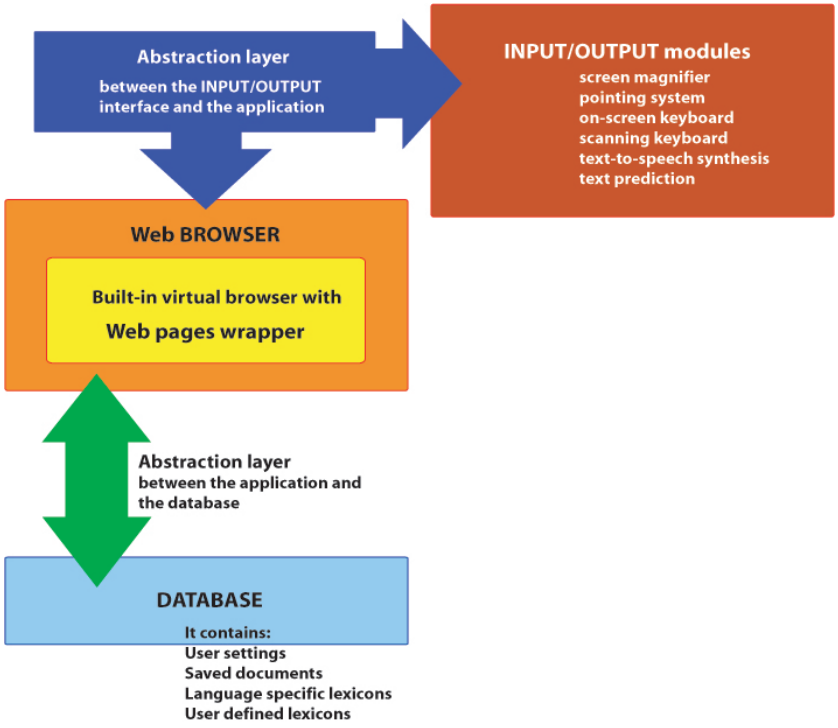



**Figure B.1:** Farfalla old scheme

## B.2 Actual state of the project

The model explained above in Section B.1 had one major flaw: it was designed as an application which was meant to replace another application. This has its obvious advantages but is also very expensive in terms of resources, both on the development side and on the user side. The reflection about "ubiquitous accessibility" exposed in Section 6.3 lead to completely re-think and re-design also the structure of this software.

The web is complex and ever-changing, with emerging technologies which have the potential to change the way websites are built in a relatively short amount of time. What remains the same is the basis: HTML is the language of the web since its beginning and CSS has become a standard for layouts. Javascript is also a technology which has been part of web development for years and is currently something very used for building rich web pages.

The idea is hence to start from the HTML, using various techniques to inject a small code fragment into a web page. This injection includes a remote Javascript file in the header of the page. The script relies on a remote database (communicating with it through AJAX and JSON techniques) to recall the user preferences and some plugins. Those pieces of software implement single functionalities, as the already mentioned virtual keyboard or text magnification, and can be combined in order to grant the user with the best experience, according to his/her needs.

In this case there is no need of replicating the browser functionalities: the 'real' browser does the browsing, while Farfalla only includes small standalone applications to the user's request. Those applications work on the client side, hence there is no need of a huge amount of resources on the server side: the actual load is distributed on the computers of the final users.

## B.3 Technical information

The software architecture is composed by a backend and a frontend interface. The backend is a database where the profiles of the users are stored. Profiles are simply made of the list of plugins that each user needs, together with plugin-specific preferences. The frontend is visually composed by a toolbar, generated by the Javascript file included into web pages, which allows the user's profile selection and activates the plugins.

The backend is based on a MySQL database and has a web based graphical interface written using the CakePHP framework[1]. It communicates with the frontend by producing a JSON output, including the list of plugins and options required by the logged in user. The frontend is mainly based on jQuery and jQuery-ui[2], two Javascript libraries which grant developers with

[1]CakePHP is a rapid development framework for PHP that provides an extensible architecture for developing, maintaining, and deploying applications. Documentation and source code are available at `http://cakephp.org/`

[2]See `http://jquery.com/` and `http://jqueryui.com/`

the possibility of abstracting from the web browser, by actually creating a compatibility layer between different rendering engines. Also the plugins are actually based on the same technologies, even if by the means of AJAX techniques it is possible to include almost any web-based application in the Farfalla plugin list.

The current plugin list includes

- a virtual keyboard, which appears when the user clicks on 'input' or 'textarea' HTML elements;
- a text-magnification method, which renders the elements under the mouse in a dedicated part of the screen, enlarging the text and setting its color to white on a black background, in order to make it easily readable;
- a contrast controller, which allows switching a web page appearance to white text on black background;
- a font-size controller, which allow to change the text size in the same way in any website.

### B.3.1 HTML injection methods

There are several techniques which allow to insert a piece of HTML code in a webpage. Among them, three are already available:

- *manual insertion*: the easiest, cheaper way of adding a piece of code to a web page depends on the webmaster work. Hence the Farfalla project primarily asks webmasters to adopt its solutions by adding a link to a Javascript library in the header of their web pages. The piece of code they simply need to paste is:

```
<script type="text/javascript" src="http://code.
    farfalla-project.org/farfalla.js"></script>
```

The advantage for using this technique is that users are provided with the advantages coming from Farfalla from every web browser they could use, without the need of installing anything.

- *bookmarklet*: a bookmarklet is a piece of javascript code saved as a bookmark in a web browser. It allows a client-side code injection and installing it is as easy as adding a bookmark to a browser. The downside of this technique is that it is only useful for the page which the user is viewing when he or she activates the bookmarklet. After visiting another page, the bookmarklet effect vanishes and needs to be reactivated.

  The stable version of the bookmarklet is available at this URL:

  `http://farfalla-project.org/bookmarklet/`

- *userscript*: userscripts[3] are Javascript files which can be semi-automatically installed in a web browser. Among the major web browsers, userscripts can be interpreted natively by Google Chrome, while Mozilla Firefox, Apple Safari and Microsoft Internet Explorer need a plugin application (respectively GreaseMonkey[4], GreaseKit[5] and Greasemonkey for IE[6]) in order to apply them to web pages. The major advantage of this approach is that, once installed, the userscript is automatically run on any web page. The user still has the possibility to mark some pages or entire domains to be excluded, which is useful in case of conflicts with other scripts. The major disadvantage of this technique is that the user depends on one particular browser. The bookmarklet technique is still available in case of necessity.

  The stable version of the userscript is available at this URL:

[3] The largest collection of userscripts on the web is available at `http://userscripts.org/`

[4] http://www.greasespot.net/

[5] http://8-p.info/greasekit/

[6] http://www.gm4ie.com/

`http://farfalla-project.org/farfalla.user.js`

There are some other ways to inject a fragment of code which have not been implemented. Among those, the following two seem to be the most interesting:

- *CMS plugins*: many websites are built using Content Management Systems, such as Joomla[7], Wordpress[8] and Drupal[9]. Those software packages, as many others, allow expanding their functionalities by the installation of plugins. Those add-ons can be very complex and radically change the purpose of the original CMS system, but they can also be very simple. The idea, in this case, is to create a plugin for each of them which will allow webmasters to include the Farfalla script in their pages also without knowing HTML. This is a variant of the *'manual insertion'* method described above, which is quite easy to develop and which an reach a large number of users.

- *proxy server*: Proxy servers allow filtering the web traffic from a client to the rest of the internet. This can be done for security or network optimization purposes. An http proxy, such as Squid[10], which is completely open source, can also be extended in order to add some interesting functionalities. By the means of the Internet Content Adaptation Protocol (ICAP), which can be used with Squid or implemented in a brand new proxy, the Farfalla script string could be added, for example, to all the computers of a LAN. This would allow institutions like universities, schools and actually any network using a common gateway to provide all the local users with the possibility of using the resources offered by Farfalla.

[7] `http://www.joomla.org/`
[8] `http://www.wordpress.org/`
[9] `http://www.drupal.org/`
[10] Squid is a caching proxy for the Web supporting HTTP, HTTPS, FTP, and more. It reduces bandwidth and improves response times by caching and reusing frequently-requested web pages.Documentation and downloads are available at `http://www.squid-cache.org/`

These two solutions will be developed after the framework core software will be released as stable. The source code of the whole Farfalla project is open and accessible from this repository:

`gitclonegit://gitorious.org/farfalla/farfalla.git`

while the website `http://www.farfalla-project.org/` hosts all the available information about the project.

## B.4 Final considerations

The present version of the Farfalla software design puts flexibility and accessibility together. Accessibility solutions protrude from the environment of the web on demand, in an ecological perspective. Among the above mentioned injection techniques, the first, human based one is to be preferred: the main idea behind this architecture is that everybody can participate in transforming the web into an accessible environment. If accessibility shifts from being a solution to being an environmental trait, the concept of disability itself can be rediscussed.

# Appendix C

# Orca installation guide for the XO[1]

This guide shows the necessary steps for installing the open source Orca screen reader and accessibility suite on Sugar, build 767 (the same version of Sugar used by plan CEIBAL in March 2009). This document is intended as a reference for the CEIBAL staff at LATU, Montevideo, Uruguay, but can be useful for people trying to install this suite on XO laptops all around the world. Some steps could be simplified, please feel free to contribute and/or translate it into other languages.

## C.1 Step one: install required packages

First, we need to open up the terminal activity and type:

```
su
init 3
```

[1]The original title of this document was "Orca on Sugar - Installation guide - version 0.1" and was delivered it to the CEIBAL technical area on March 6th, 2009.

to switch to console mode only (this frees memory and gives more stability to the process, as we need to download a lot of packages). You can now login as root by simply pressing ENTER (if the XO uses the official Sugar release or has root access. It is not possible to follow this guide on children machines without root access).

As direct installation of Orca through YUM should fail for an error in the libglade2 version check, we need to get an updated version of it:

```
yum --enablerepo=* install libglade2
```

If this doesn't work either, try downloading the rpm directly from a mirror. This one worked for me:

```
wget ftp://ftp.pbone.net/mirror/download.fedora.redhat.com/pub/
fedora/linux/updates/9/i386.newkey/libglade2-2.6.2-6.fc9.i386.rpm
rpm -Uvh libglade2-2.6.2-6.fc9.i386.rpm
```

Now we can install the Orca package. Note that this will also download a lot of dependencies which we would never want on Sugar, such as additional Gnome themes.

```
yum install orca
```

We're done, now we need to reboot to make it work in Sugar:

```
reboot
```

## C.2 Step two: add required packages which are not listed as dependencies

Unfortunately, installing Orca in this distribution does not provide all the required packages (I suppose that some of them are normally present in any Gnome based distribution). As we are not Gnome users, we need to install/update some more packages.

```
yum install gnome-python2-gnome pyorbit gnome-python2-bonobo
gnome-terminal gnome-speech gnome-speech-espeak
gnome-speech-festival
```

That's it. Now Orca can be run using this command (as normal user):

```
orca -n &
```

## C.3 Step three: install Festival Text-to-Speech and enable it

Sugar comes with eSpeak, which is a lightweight, open source speech synthesis system. Some voices are very bad. We can use Festival instead, which has a better Spanish voice. First, we need to enable OSS emulation for the ALSA sound system. We can do it by simply loading a kernel module:

```
modprobe snd-pcm-oss
```

Then we need to install Festival and configure it:

```
yum install festival
```

To get the Spanish voice working we have to download it separtely as a tar.gz archive and configure the program to use it.

```
cd /home/olpc
wget http://festvox.org/packed/festival/1.95/festvox_ellpc11k.tar.gz
su
cd /usr/share
tar -xvf /home/olpc/festvox_ellpc11k.tar.gz
```

We can now enable Festival with Spanish voice from the Orca preference pane. I set velocity to 66 to make it sound a bit more vivid.

## C.4 Step four: enabling voice in Firefox

To enable voice in Firefox we only need to download this activity from `http://wiki.laptop.org/go/Firefox`, then we can follow the instructions in `http://firevox.clcworld.net/installation_linux_orca.html` starting from point 3.

## C.5 Step five: installing other voicing applications

The Orca project website at `http://live.gnome.org/Orca` shows a list of applications working well with the Orca engine. Unfortunately they are not Sugar Activities, but we can still use them on an XO laptop.

Try installing a text editor:

```
# yum install gedit
```

To start it we need to use the Terminal Activity, unless someone writes an activity package for it. I did not try anything else by now.

# Appendix D

# *Prestame tu voz*

## D.1 Introduction

*Prestame tu voz* (Lend Me Your Voice) is an Augmentative Communication aid designed to run on a XO-1 laptop. It is open source software and its development started in May 2009 during one of the developers meetings promoted by CEIBAL Jam (see note on page 93). The following paragraphs explain the idea and illustrate the software structure.

### D.1.1 Augmentative and Alternative Communication with Voice Output Communication Aids

Augmentative and Alternative Communication [65] is a multimodal form of communication which substitutes, integrates and augments the oral verbal language. It is a branch of the clinical practice and it primarily aims to empower existing resources rather than at substituting them. Persons using AAC can communicate in an efficient way, translating their thoughts into something which is intelligible for other people. In this field images and sound

are very important because they are more intuitive and direct communication channels than written or oral language.

Among the variety of tools used in AAC interventions are the Voice Ouput Communication Aids (VOCAs). These particular tools are normally computer-independent and can resemble large keyboards with pictures on every key. They allow to use different collections of images organized in tables and to associate every image with a sound, generally a digitally recorded spoken word or group of words.

## D.2 The idea

The idea behind "Lend me your voice" (*Prestame tu voz*, in Spanish) is to create a Sugar activity that is both a program and a stimulus for cooperative work in a class.

The inspiration for this activity comes from the VOCAs described above. These tools use series of images and symbols organized in tables to reinforce communicational skills. They are particularly useful for people with autism, cerebral palsy or other syndromes involving difficulties in comprehension and/or expression of language. The images are also associated with sounds and speech, which can be recorded or generated automatically by a speech synthesis system.

The XO laptop hardware includes a microphone, a camera and two speakers. It is also robust, lightweight and energy-efficient. Sugar allows easy access to the XO hardware through various software libraries.

### D.2.1 The program: concept and overall design

The activity design includes a double interface: one is for editing tables by importing pictures and recording new sounds, the other grants easy access

to the tables themselves.

The "editing mode" is intended to give the possibility to the users to create their own tables by adding new elements or by selecting existing ones. New images would be available from a library, from the web and from the camera which is included in the XO laptop. Sounds could be recorded by the XO microphone or produced by the text-to-speech software eSpeak, which is included within any Sugar distribution.

The "table mode" will allow selection of symbols and images in various ways: with the direct click of the mouse, with the aid of an automated scanning cursor or with a selector guided using arrow keys.

### D.2.2 The didactic activity in the classroom

The idea behind this proposal is to create a tool which is useful both for teachers and for children. Among the guidelines described in 3.1 about the usage of technology for inclusion at school, there is the need for making the children prepare the class environment for their disabled classmates. The ideal scenario for this activity is a class which has an active inclusion project involving a child with communication restrictions.

The teacher should be able to use "Lend me your voice" to prepare a lesson plan which has the objective of setting up communication tables together with the children. The rest of the class, while being involved in this process, could lend their voice to a disabled classmate, in terms of recording it, or help in finding pictures for a table.

Students with communication impairments or restrictions will then be able to use a tool with which they can communicate easily and independently with their colleagues, family, etc.

## D.3 State of the project and further ideas

The "Lend me your voice" project started in Uruguay, under the CEIBAL plan, during the third CEIBAL Jam meeting. The team working on it was made up of developers, teachers and experts of the area of Assistive Technology.

The project source code is available for download at `http://code.google.com/p/prestametuvoz/`. As of August 2010, no working demo of the software is available.

## D.4 Acknowledgments

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