Inclusion of mobility impaired children in the one-to-one computing era: a case study.

Andrea Mangiatordi, University of Milano Bicocca, Italy

Abstract

While in some countries education systems contemplate both special and mainstream schools, in some other regions only mainstream schools exist, which provide specific facilities for children with special education needs. In both panoramas, technology has traditionally been considered a resource for empowering disabled children in their learning and communicating abilities.

Uruguay's education system, which has special schools, recently adopted the one-to-one model for distributing computers in classrooms. This means that new environments are created in which technology is no more a specific solution, but a matter of fact. In such a context, children from special schools who undergo integration projects and are introduced to mainstream schools can count on a computer technology which does not mark them as 'those who need some different tool'. This paper exposes the findings from a multiple case study action-research lead in the field.

1 Introduction

This paper tries to explore the key points and indicators of the relationship between 1-to-1 computing, Assistive Technology and education. A case study research is presented, with the objective of studying restricted units of analysis. The three case studies composing this work satisfy the general requirements of being well delimited, unique and specific. The final objective is to reflect upon 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.

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 physically took place.

1.1 One-to-one computing, OLPC and CEIBAL

One-to-one computing became very popular in the last few years. The "One Laptop per Child" project was started by Nicholas Negroponte in January 2005 at the Massachusetts Institute of Technology. The original idea was to produce a $100 laptop, a machine designed to follow the constructionist learning theory. The resulting computer, called "the XO laptop", is low cost and has a quite innovative interface, called the Sugar Learning Platform. 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.

When this research project started in 2009, the Sugar user interface did not present any of the accessibility solutions and preferences which are commonly available on mayor operating systems. This was quite interesting, also because of the fact that the population of developing countries presents higher taxes of people with disabilities compared to the rest of the world [1].

When in 2007 Uruguay started its own national deployment of OLPC XO laptops, called CEIBAL, teachers and pupils of all the primary schools of the Country started receiving their own computers. The machines were initially distributed alone and with a default configuration, which did not include any software or hardware Assistive Technology.

1.2 Related work

This paper is focused on the encounter between a quite common and well known practice – the use of computers to supports children with disabilities at school – and a relatively new computer

deployment model – known as 'one-to-one' computing. In many cases, computers allow children with various kinds of impairments 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 [2] described this use of computers at school as *'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 able-bodied children learn less about technology than their impaired peers. At the same time, technology can act as a marker of difference: the need for a computer aid to deal with common tasks is peculiar of those who are therefore considered 'different' or 'lacking' and who can also become objects of envy [19].

According to [17, 15], literature related to children using computers at school provides evidence that this practice facilitates the social interaction among children. This also applies to children with special needs. Assistive Technology has also been proved to have a positive impact on the social and emotional outcomes of students [13]. While working with computers, children tend to be more assistance-seeking from peers [4] and faculty and staff involvement is crucial in the implementation of Assistive Technologies [25].

Other studies [27] proved that students experiment distinct types of barriers, classified as:

1. Technical barriers (computer-related and knowledge-related);
2. Design barriers (readability level, ease of understanding, ease of navigation, etc.);
3. Interpersonal barriers (factors unique to a particular student).

On the other side, 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*: mean level of engagement for students in 1:1 classrooms was reported to be significantly higher compared to that of the shared classrooms [24];
2. *lowers conduct problems*: in the case studies described by the Maine Education Policy Research Institute in [20], decreased disciplinary problems are cited among the results;
3. *convinces teachers of the improvements in the skills of their students*: teachers' use of technology is related to their judgement of the benefits of particular technologies for their teaching and for their students' learning and engagement [7];
4. *improves writing skills*: giving students laptops increased the percentage of them who met performance standards by 22% over the course of one year [14]; significant improvements were found in writing and problem-solving performance for students given 24 hour access to laptops [18].

Critics of one-to-one computing programmes sustain the ideas that such initiatives have too high costs [21], especially if the returns on investment are considered [23]. Another common critique to one-to-one computing is linked to the higher problems in controlling the classroom for teachers [22, 16, 29], a heavier charge of work for teachers [16, 29]) and the difficulty of relating laptop usage and standard evaluation [22].

Other problems are documented, such as excessive weight and frailty of the machines, 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 [18, 8, 12].

2 Method

The instruments adopted in order to carry out this study were: 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*.

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, a set of semi-structured interviews allowed to portray each child and the context in which they respectively live, together with adults' expectations and opinions about the results generated by the introduction of the XO laptop. Direct observation sessions were used to elaborate on those expectations and beliefs, in order to verify them and to reveal interesting critical aspects. A competence level was 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, a modified version of Moreno's sociogram 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.

2.1 Participants

The three participants of this study will be referred to with the pseudonyms of Ismael, Micaela and Pablo, in order to protect their privacy. When the fieldwork started, they were all attending the same special school in Montevideo. They were met twice per week for three months in 2009 and for one month in 2010.

Ismael, born in 1999, 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.

Micaela, born in 2001, 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.

Pablo, born in 2000, 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.

2.2 Semi-structured Interviews

During the 2009 fieldwork period teachers from both the special and the mainstream schools were interviewed, defining a framework of themes to be explored. This included:

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

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

1. 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);
2. description of the active integration processes;
3. influence of the CEIBAL plan and of the XO laptop over the integration process;
4. changes in the child behaviour and independence after the introduction of the computer at school;
5. issues and positive effects emerged since the delivery of the laptops.

Such interview guidelines helped in focusing on the topics at hand without constraining them to a particular format.

2.3 Direct observation

The observations conducted for this study mainly followed the model of participant observation proposed in [5]: the observer was totally involved in the observed environment, becoming part of it. This allowed to spend time *with* the participants and in some cases to spend that time *like them*. The role assumed in the context of the classrooms allowed to operate a "resocialization" [10], learning the values, the norms and the precepts of the guest culture.

Notes were collected in the form of a field diary, from which some fragments will be reported here in order to clarify the most interesting points of the study.

2.4 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 mainstream school classes involved in the three case studies.

2.4.1 Ability assessment

The first test submitted to the children involved the direct usage of the XO laptop. They were asked to accomplish with six objectives, which were written 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[1];

• 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[2];

• Draw a house using at least two geometrical shapes of different colors (triangles, squares, rectangles);

---

[1] The "Home" screen is something typical of the Sugar UI. It is the representation of a virtual space where an avatar of the user is surrounded by the available "activities", the Sugar name for applications.

[2] The Journal is another peculiarity of the Sugar UI. It automatically lists all the activities performed by a user on an XO laptop and allows to retrieve them, actually replacing a traditional folder-based file manager.

• 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[3];

• Connect to a shared activity. Start a chat with one of your classmates.

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 [6]. 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 was 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. The readability score of the instructions was 67 on the Fernandez-Huerta [11] Spanish readability test scale, which marks them as “normal”. All tasks were explained to the children after being written on the blackboard. Each of them was subdivided into items (for a total of 22 items), splitting the action in smaller and more measurable objectives. The instructions given to the children were the following:

1. do what you are asked on the blackboard with your XO laptop, and do it alone;
2. if you do not know or do not understand how to do something, raise one hand and wait for my help;
3. if you cannot do something, simply wait for a new task, do not call your classmates or your teacher for help. The teacher was asked not to help them, even if they called for assistance.

For the data collection a printed table was used, where columns represented the items composing each task and lines represented the children. Successful and unsuccessful results were collected in the table during the test, together with the requests for help and the problems caused by an error or misconfiguration of the machine. A time limit was set for each task, and the children were asked to stop whatever they were doing when time ran out.

Each subtask was then associated to one of the following results:

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 failures due to the child only.

2.4.2 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.

The main purpose in adopting this particular data collection and representation technique was understanding if the introduction of the computers in the classroom activity had someway influenced the relations between the children. This was not intended as a longitudinal test: given the fact that Ismael’s mainstream class group had changed in the passage from 2009 and 2010 school year, it did not make much sense to compare data about two different groups. Hence a synchronous

[3] Sharing is among the most interesting features offered by the Sugar UI. Almost every activity can be shared and used as the basis for collaborative work over pont-to-point or infrastructure networks. The collaboration framework of sugar is based on the XMPP protocol.

snapshot was taken 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 1. The two dichotomies at the base of the sociogram and the resulting four diagrams

The test was made up of nine questions. The first one had the sole purpose of determining how many children already knew each other since the preceding school year 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 1. After collecting the data it was possible 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, it was possible at first to identify the leaders and the isolated children of the class. The main interest was still focused on Ismael, Micaela and Pablo, hence the analysis concentrated upon understanding in what kind of interactions they obtained the best results.

3 Results

The study was conducted following the same structure for the three case studies. What follows is a synthesis of the main results obtained for each child.

3.1 Interviews

The people having a significant role in Ismael, Maicaela and Pablo's education interviewed in 2009 were:

- the director of the special school;
- a teacher at the special school, who worked directly with all the three children in 2009;
- a teacher at the special school, who worked directly with Ismael and Pablo in 2006 and 2007;
- a teacher at the special school, who worked directly with Micaela in 2006 and 2007;
- the three teachers working in the integrating mainstream schools in 2009;

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

- a support teacher working for the special school;
- the director of the mainstream school where Ismael was integrated;
- the three teachers working in the integrating mainstream schools in 2010;
- Ismael's father;

- Micaela's mother;
- Pablo's mother.

The total number of interviews is 15, almost equally distributed. An interview with the director of the mainstream school integrating Ismael was necessary in order to understand the causes of some problems in which the child got involved, which will be discussed later.

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 who met him there. Pablo's description was interstingly similar:

> *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.*

On the other side, Agustina was always described as a very kind and friendly little girl. Their former teacher in the special school doubted about the efficacy of the collaboration between the special and the mainstream school:

> *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 and Pablo had complex impairment, both in mobility and in the sensor area, the teachers reported of their difficulties in distinguishing figures from backgrounds, colours and shapes. Concentration was also a mayor issue for them. All these facts suggest that a mainstream school would be quite hard for them to attend. Augstina's case, again, was normally described as less problematic: she had a very well delimited kind of learning difficulties, mainly involving Maths.

The integration in the mainstream school was decided upon discussing it among the special school personnel and interviewing the parents of the children. The special school teacher who had been working with the three children in 2009 described the project behind their integration as a process of 'strategy development', where the children and their families were counselled by the school for defining ways of defending them and compensating their limitations.

What emerged from the interviews with the special school personnel about the two levels of social and functional integration was quite clear:

> *He will always be advantaged 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.*[4]

They saw the integration process as a good opportunity for developing social skills and relationships. They provided the three children with the basic functional skills they needed in order to be accepted in the class, but considered the social level as the most important and profitable objective.

With respect to technology, in the special school it was seen as an important facilitator for the functional level: all the teachers who had been working directly with them expressed their positive opinions towards it, highlighting the important impact that they expected the XO would have on their motivation and on their overall level of functioning.

---

[4] This fragment is referred to Ismael.

When it came to the mainstream school, both the parents and the class teacher seemed to be more interested in the social aspect of the integration process: Ismael and Micaela were, in their words, very well accepted by his classmates. The exception here was Pablo, whose mother expressed some doubts about the efficacy of the integration process because she thought the child to be subject of discrimination. She plainly explained that she disagreed with the methods of Pablo's teacher at the mainstream school, especially with the fact that she was very tolerant when the child did not do his homework.

The mainstream school personnel seemed to care less about the overall functional level of the three examined children: they were never directly asked about their 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 their pathological difficulties in some areas of knowledge:

> *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".*[5]

A role of motivator was recognized to the computer, but no apparent functional improvement was obtained throug. In Ismael father's opinion, it sometimes proved even to be of disturbance to the school activity:

> *... 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!*

3.2 Direct observation and solutions adopted

Quite a large amount of time was spent with Ismael and Pablo, including 20 hours with each of them at the mainstream school during the first fieldwork experience and other 6 hours during the second. The visits at Micaela's mainstream school in 2009 were shorter (around 12 hours), but her case was studied with the same attention reserved to the others. During all this time, Ismael always showed great interest towards computers: he was, among all the children met, the one with the highest curiosity, capable of learning some non-basic commands and actions simply by carefully watching others' hands movements on the keyboard. He adopted this modelling strategy 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. It was not the same for the others: Pablo seemed to care less, and Micaela even fewer. Their interest towards the machines rapidly decreased after a few months.

The use of an external keypad to control the mouse pointer was proposed to Pablo and Ismael. Initially, they both showed it proudly to their classmates of both the special and the mainstream school. In addition to the keypad, Ismael also took advantage of a Screen Magnifier[6], which was also included in Sugar by CEIBAL after this study. 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 it only from time to time. Micaela only required an external mouse, as she could operate the XO keyboard without problems, but had some difficulties with the regular XO trackpad.

---

[5] This fragment is referred to Micaela.

[6] This functionality was added to Sugar by including the "Virtual Magnifying Glass" software package, which is open source and available at http://magnifier.sourceforge.net

In May 2010, Ismael also started using another adaptation introduced by the CEIBAL technical staff, which consisted in a virtual keyboard. 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. The same AT soution was proposed to Pablo, but at the first encounter with him in 2010 he was found completely uninterested in the computer: he had ceased using it during the summer because, as he decleared, he found it too difficult.

Observing the class activity in the mainstream schools also lead 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, Micaela and Pablo used the XO laptop at school only when the other children did. This means one important thing: the AT solutions they were adopting were being useful only *to interact with the computer*, and not to overcome issues which were not related with it. They were not using the computer as a writing tool, nor as a support for their Maths difficulties, as in the case of Micaela. They were using the computer together with their classmates, and in this communitarian use they were the ones who used different software or hardware.

Among the various interesting episodes annotated in the fieldwork journal, there is a particularly interesting one:

> *21st May, 2009*
>
> Today I got to the [mainstream school] 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 complaining: 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 that Ismael was, comprehensibly enough, considered as subject to privileges. He was accompanied by his father, 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". The same dynamic was visible in Pablo's case, even if with a slight variation: in his class he was more than once object of the classmates' attention in a distorted way. They tended to serve him, some of them were also the ones who took him to the bathroom, or who carried his schoolbag. Micaela was, in this sense, the most independent and the one with the less 'different' sort of treatment: she was very proud of being independent, capable of moving alone and never demanding extra help.

Going back to the role of technology in the integration process, in the three mainstream schools:

- 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 the beginning of this work, Ismael seemed to have changed in his disposition towards the rest of his class, while Pablo kept having a problematic relationship with his classmates. Micaela, on the other side, kept being the well-integrated, successful pupil she had always been. In 2010, for each of them, more than half of the classmates and the teacher had changed. The XO, which in everybody's opinion was very useful for them, was not being used at the top of its functionality. Most important, it was not being used as a tool for overcoming their physical or

intellectual limitations: they still wrote, in some cases with considerable effort, using a pen, and they were allowed to use the computer only when the classmates did.

In Ismael's own words, recorded in the last days of the fieldwork:

> *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.*

One important fact to notice is that when Pablo was visited again in the mainstream school in 2010 he had abandoned the use of the XO laptop. By observing the machine it was easy to notice that it had not been used for long and no accessibility options had been configured between 2009 and 2010, when the child received his laptop from CEIBAL.

3.3 Tests

The results of the two tests – ability assessment and Moreno's sociogram – are described in detail in the following sessions. Tables and graphs are used to clarify and visualize the results.

3.3.1 Ability assessment

When the ability assessment test was administered to Ismael's class, 16 children participated. The results obtained by the observed child compared with the rest of the class are shown in table 2.

	NS	AS	NF	MF
Ismael	16	3	2	1
Micaela	18	3	1	0
Pablo	11	3	7	1
Mean	17.04	1.54	2.63	0.8
Standard deviation	3.59	1.56	2.62	1.38

Table 2 – Ismael, Micaela and Pablo results in the ability assessment test, compared to the rest of their classes

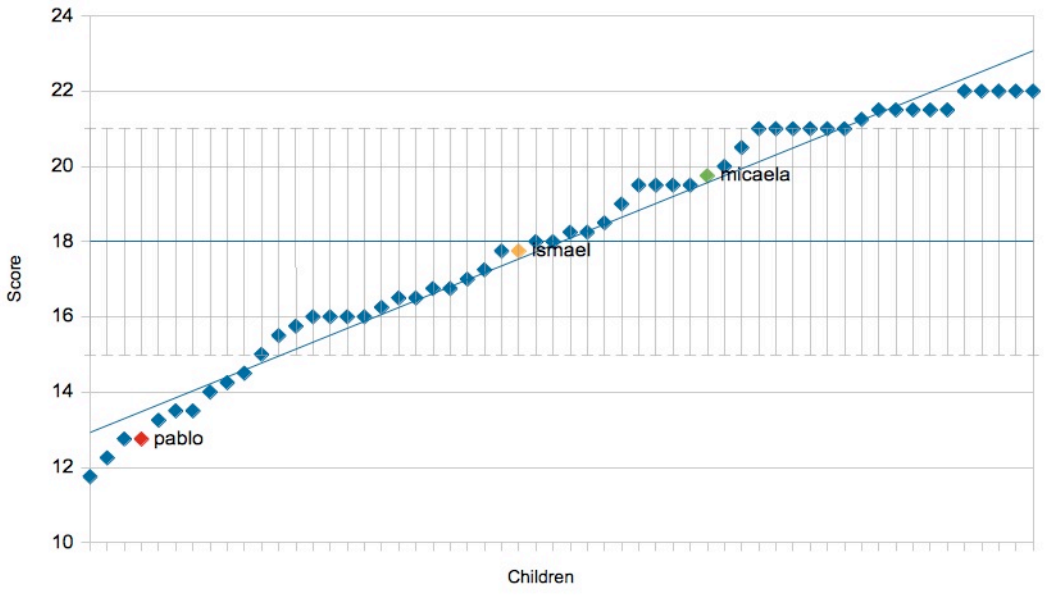

Figure 1 – Total scores obtained in the Competence Level Test: the horizontal line marks the mean of the three classes, while vertical segments show the Standard Deviation span

Ismael totalized a number of successes which is inferior to the mean but still falls in the standard deviation span. This suggests that his abilities in using the XO are comparable with the average student in his class, even if a bit lower. Micaela scored better, above the mean: even if she did not reach excellence, she was very confident with the instrument. On the other hand, Pablo scored among the lowest in the whole group, demonstrating that he had not been learning the use of the XO during the first year. He had, as the observation sessions already allowed to remark, gradually abandoned it.

Al three asked for more help than the average, while the amount of NF is higher than the mean value only for Pablo. The only MF he scored was due to a problem with the internet connection, which is not uncommon with the XO laptop.

The test results seem to depict Ismael as a cild at the same level of his peers on an overall perspective, but with 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. Micaela, who demonstrated the highest level of competence among the three cases, was also the one who did not need Assistive Technology to carry out the test. Pablo's case was completely different: since he abandoned the use of AT between 2009 and 2010, he had not learned the basics of the XO laptop, which was still unaccessible to him.

3.3.2 Sociograms

The sociograms deriving from the administration of the questionnaire described above display some interesting information about the class climate at the time of the second visit the mainstream classes.

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

The **social/analogical** result was low for Ismael and Pablo, probably due to normal position in the class: they must always sit in the front row, or on a special desk. This 'barrier' did not facilitate their interactions with the other children: they tended not refuse them, but they did not prefer them, either. They seemed not to be taken into consideration as a desk neighbour, a fact which classifies them as 'excluded'. Micaela, on the contrary, 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.

Under the **functional/analogical** point of view, Ismael was accepted but also refused. Pablo only obtained one positive election and three rejections, one from a girl he was choosing. 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, while there was no improvement for Pablo. Similar 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.

It was 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 than the average of the class. Pablo was still under the mean, keeping a difficult relationship with the classmates. Micaela obtained 8 preferences, which identified her as one of the 'stars' in her class group.

These results suggest that the XO laptop was being important to two of them primarily as a social amplifier and much less in its original function of cognitive amplifier. In the case of Pablo, abandoning the computer had meant rejecting a possibility to enter the class network of relationships.

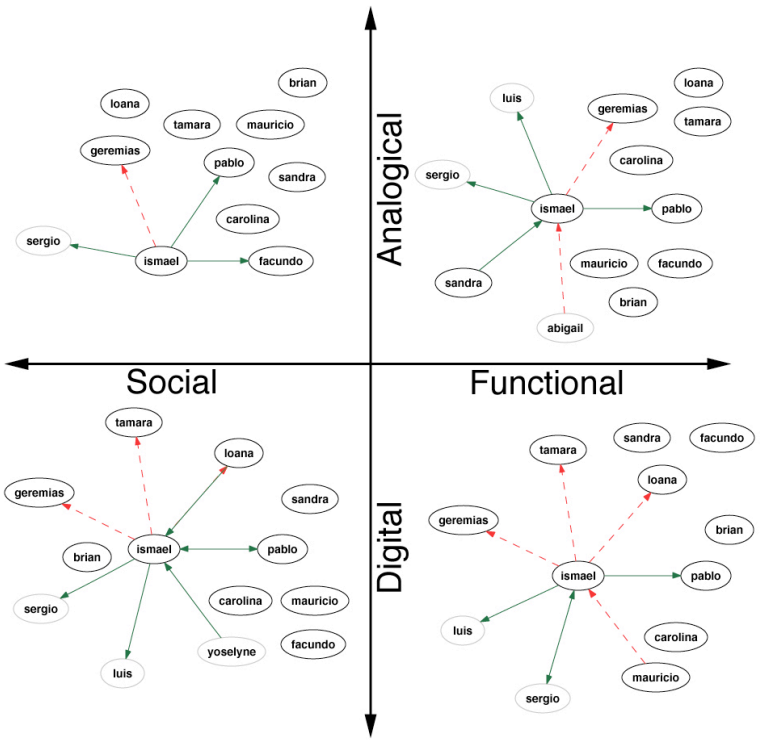

Figure 2 - Ismael's active and passive preferences

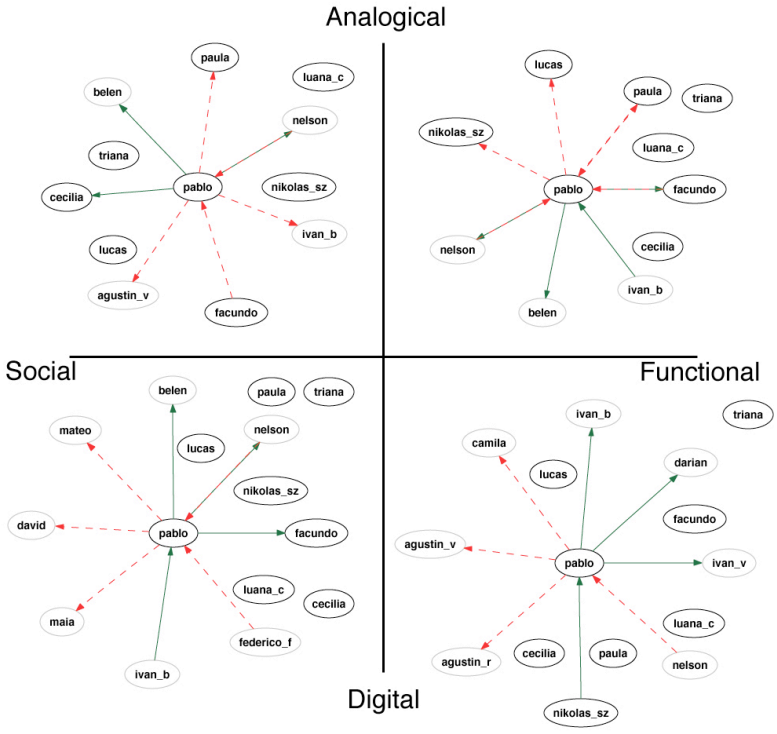

Figure 3 - Pablo's active and passive preferences

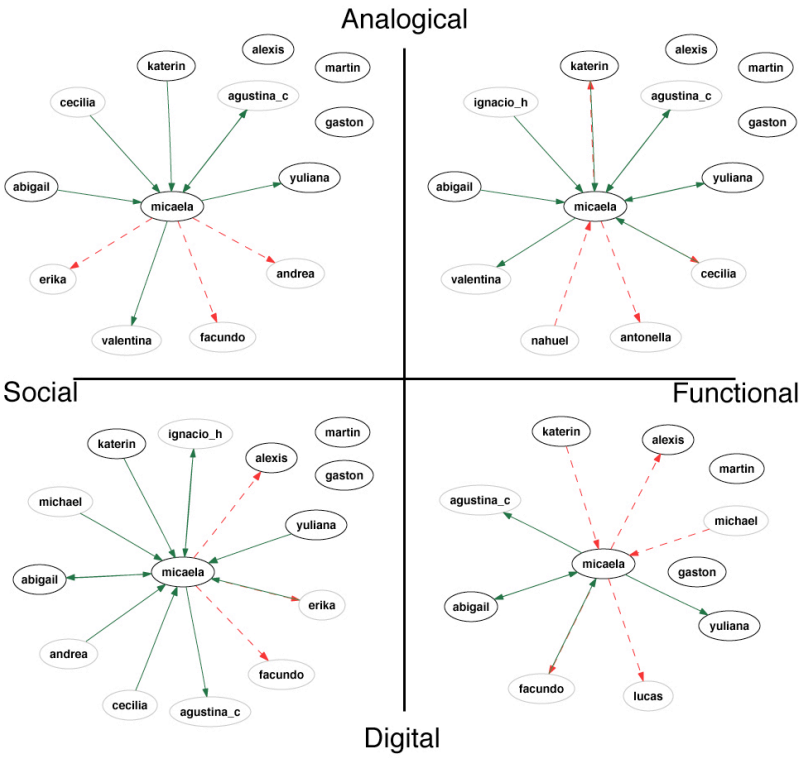

Figure 4 - Micaela's active and passive preferences

4 Conclusions

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 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 resumes the main aspects of their integration stories and of their relationship with technology.

	Ismael	Micaela	Pablo
Overall perception of the integration process	Positive, with some critical aspects	Positive	Problematic
Role of the family in the integration process	Involved, but problematic (logistics problems)	Involved and supporting	Involved, but problematic (disagreement on treatment)
Improvements in independence after the introduction of the XO	Changed positively in his attitude	Consolidated her independence	No evident improvement
Ways of accessing and benefiting of technology	Low-skilled enthusiast	Skilled, not enthusiast	Low-skilled, non 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)
Perception of the skills level by classmates	Very low	Low	Very low
Enjoyment of the potential of Assistive Technology	High	Incomplete	Low
Laptop usage at school	In collective activity, not as AT	In collective activity, not as AT	In collective activity, not as AT
Assessed computer skills	Average	High	Low
Perceived computer skills (by peers)	Low	Low	Low
Level of computer mediated social interaction	High	Very high	Very low

Figure 5 - A synopsis of the three case studies

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 initial 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.

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, 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, the less conflictual relationship between family and school was seen. 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 stated more than once that she had to quarrel with them quite often.

As a third difference among them, their improvements in independence and in overall social skills (or lack of them) will be compared: at the beginning of the project, Ismael and Pablo were both described 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 as very independent during the 2009 school year, maintained her autonomy and showed 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 who was found totally unaware of the accessibility enhancements introduced by CEIBAL. This was mainly due to a scarce communication between special and mainstream schools that was witnessed more than once. 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 the 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 teachers' 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: 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 was never seen 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: the studied children 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 confirmed 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.

5 References

[1] E. Ackermann. Piaget's Constructivism, Papert's Constructionism: What's the difference?, 2001.

[2] A. M. Battro and P. J. Denham. *Hacia una inteligencia digital*. Academia Nacional de Educación, Buenos Aires, 2007.

[3] J. Braithwaite and D. Mont. Disability and Poverty: A Survey of World Bank. Poverty Assessments and Implications. SP Discussion Paper No. 0805, 2008.

[4] A. Brett. Computers and social development of young children. *Dimensions of Early Childhood*, (Fall):10–13, 1994.

[5] M. Cardano. *Tecniche di ricerca qualitativa: percorsi di ricerca nelle scienze sociali*. Carocci, Roma, 2003.

[6] CEIBAL. Monitoreo y evaluación educativa del Plan Ceibal, 2009.

[7] B. Drayton, J. Falk, R. Stroud, K. Hobbs, and J. Hammerman. After Installation: Ubiquitous Computing and High School Science in Three Experienced, High-Technology Schools. *Journal of Technology, Learning, and Assessment*, 9(3), 2010.

[8] J. Efaw, S. Hampton, S. Martinez, and S. Smith. Teaching and learning with laptop computers in the classroom. *Educause Quarterly*, 3:10–18, 2004.

[9] A. Elwan. *Poverty and disability: A survey of the literature*. Number 9932. Social Protection Advisory Service, 1999.

[10] R. Emerson, R. Frents, and L. Shaw. *Writing Ethnographic Fieldnotes*. Chicago University Press, Chicago-London, 1995.

[11] J. Fernández Huerta. Medidas sencillas de lecturabilidad. *Consigna*, (214):29–32, 1959.

[12] N. Garas, D. Davis, P. Hopstock, A. Kellum, and T. Stephenson. Henrico County Public Schools Ibook Survey Report, 2005.

[13] P. Hutinger, J. Johanson, and R. Stoneburner. Assistive technology applications in educational program of children with multiple disabilities: A case study report on the state of practice. *Journal of Special Education Technology*, 13(1):16–35, 1996.

[14] S. Jerosky. Wireless Writing Project Research Report: Phase II, 2003.

[15] K. Johnson. Literature Review: Assistive Technology and its Educational Impact on Student Performance and Curriculum Development. 2008.

[16] K. Kerr, J. Pane, and H. Barney. Quaker Valley Digital School District: Early Effects and Plans for Future Evaluation, 2003.

[17] C. Lau, K. Higgins, J. Gelfer, E. Hong, and S. Miller. The Effects of Teacher Facilitation on the Social Interactions of Young Children During Computer Activities. *Topics in Early Childhood Special Education*, 25(4):208–217, Jan. 2005.

[18] D. L. Lowther, S. M. Ross, and G. M. Morrison. The Influences on Teaching Strategies and Student Achievement of Using Laptops in the Classroom. *Educational Technology Research and Development*, 51(3):23–44, 2003.

[19] D. Lupton and W. Seymour. Technology, selfhood and physical disability. *Social Science & Medicine*, 50:1851–1862, 2000.

[20] M. E. P. R. I. (MEPRI). The Maine Learning Technology Initiative: Teacher, Student, and School Perspectives Mid-Year Evaluation Report, 2003.

[21] G. Mowen. Adventures in laptop land. *School Administrator*, 60(4):14–16,18–19, 2003.

[22] P. Newhouse. A follow-up study of students using portable computers at a secondary school. *British Journal of Educational Technology*, 32:209–219, 2001.

[23] T. Oppenheimer. The computer delusion. *The Atlantic Monthly*, 280:45–62, 1997.

[24] M. Russell, D. Bebell, and J. Higgins. Laptop Learning: A Comparison of Teaching and Learning in Upper Elementary Classrooms Equipped With Shared Carts of Laptops and Permanent 1:1 Laptops. *Journal of Educational Computing Research*, 30(3), 2004.

[25] S. F. Shaw and L. L. Dukes. Program standards for disability services in higher education. *Journal of Postsecondary Education and Disability*, 14(2):81–90, 2001.

[26] S. Turkle. *Life on the Screen: Identity in the Age of Internet*. Simon \& Schuster, New York, 1995.

[27] L. Wimberly, N. Reed, and M. Morris. Postsecondary students with learning disabilities: Barriers to accessing education-based information technology. *Information Technology and Disabilities E-Journal*, 10(1):1–40, 2004.

[28] R. Yin. *Case study research. Design and methods*. Sage, Thousand Oaks, California, 1994.

[29] A. Zucker. A study of one-to-one computer use in mathematics and science instruction at the secondary level in Henrico County Public Schools. 2005.