Information and communication technologies for people with disabilities

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Abstract:

This paper describes ongoing research that is being conducted at the University of Algarve involving the design and utilization of information and communication technologies for special needed people.

We present a virtual keyboard project that interfaces with a text-to-speech synthesizer. The virtual keyboard contains a built-in dictionary and a simple algorithm that allows people with disabilities to write much faster than with a regular keyboard.

We also show how some educational technologies, largely inspired by Seymour Papert's theories, can be used to help people with disabilities. Among these technologies, we highlight a project involving the GoGoBoard, a small electronical device that can have sensors and actuators attached to it. The GoGoBoard was used by two students in their final undergraduate degree project, to build an intelligent bedroom. In this room, a person with physical disabilities, can control various things. As examples, the person can open/close the door, turn on/off the lights or turn on/off the air conditioning. All of that by simply pressing a touch button.

1 Introduction

People who are born with disabilities and cannot control their bodies need to suppress a very large number of obstacles. Unfortunately, these obstacles usually have their beginning at the school as was described in a paper about the academic life of a student with cerebral palsy [1]. The obstacles are caused by lack of technology but mainly because of society's misconceptions. We think that is fundamental to change our educative system to open the mind of our society to finish with those misconceptions. Seymour Papert defends a change in educative system and suggests a constructionist approach [5, 6]. Papert believes that children learn best when they can explore the surrounding world and that our traditional educative system is obsolete.

The constructionist approach isn't adopted by most public schools, but we can see similar learning environments in some private institutions. During our research we have visited the Associação Portuguesa de Paralisia Cerebral (APPC)[1] several times and we think that the

[1] The Portuguese Cerebral Palsy Association.

educational environment at APPC is like a constructionist environment. The majority of children in that institution doesn't frequent regular schools due their limitations, but at APPC they learn fundamental things with their educators. Children learn to read, to write, to do daily life activities such as cooking, among other things.

In the next section, we describe how technology is important to people with disabilities to suppress their limits and why finding cheaper technologies is an essential step. In section 3, we present a virtual keyboard project that interfaces with a text-to-speech synthesizer. Finally, we describe how a small board can be used to create new, and cheaper, technologies to help people with disabilities.

2 Technology can break limits

We have tested our ideas, and some technologies, with children with cerebral palsy at the regional nucleus of APPC in Faro. That is a private institution of social solidarity, without lucrative ends, created to help people with cerebral palsy.

The first time that we visited the institution to ask for assistance in our research we found an educator who had worked with the Logo programming language. That was very important to us, because we were to talk with someone that knew Papert's theories and that could understand the main objective of our research.

We were welcomed at APPC and our ideas were accepted easilly. When we talked about the hope of developing new technologies based on constructionist theories, the people at APPC were very happy. In Portugal, most educational institutions have lack of technology due their limited budgets, especially public institutions, but this problem is more pronounced when we are dealing with students with disabilities. Those students need additional technology to surpass their limitations. This problem is an important question in our research because the current technology for people with disabilities is expensive due to the limited number of consumers. To create low-cost hardware devices we were inspired by the work of Arnan Sipitakiat [8].

Usually, students with disabilities cannot easily learn things because their limitations hinder the world exploration, and not because they are retarded. Unfortunately, many times society makes the big mistake to think that people with disabilities are retarded. The majority of children with disabilities is not retarded, they simply don't have the opportunity to explore the world like the others kids do. Being able to explore the world is very important to develop children's capacities, in a constructionist learning environment, because children learn with their mistakes in a natural way. Papert has called *home-style learning* to this kind of exploratory learning that, we think, can mainly be observed in children at pre-school age.

In the following scheme (figure 1), we have tried to show in a simple way that a person with voice and movement control disabilities can have some difficulties to interact with the external world.

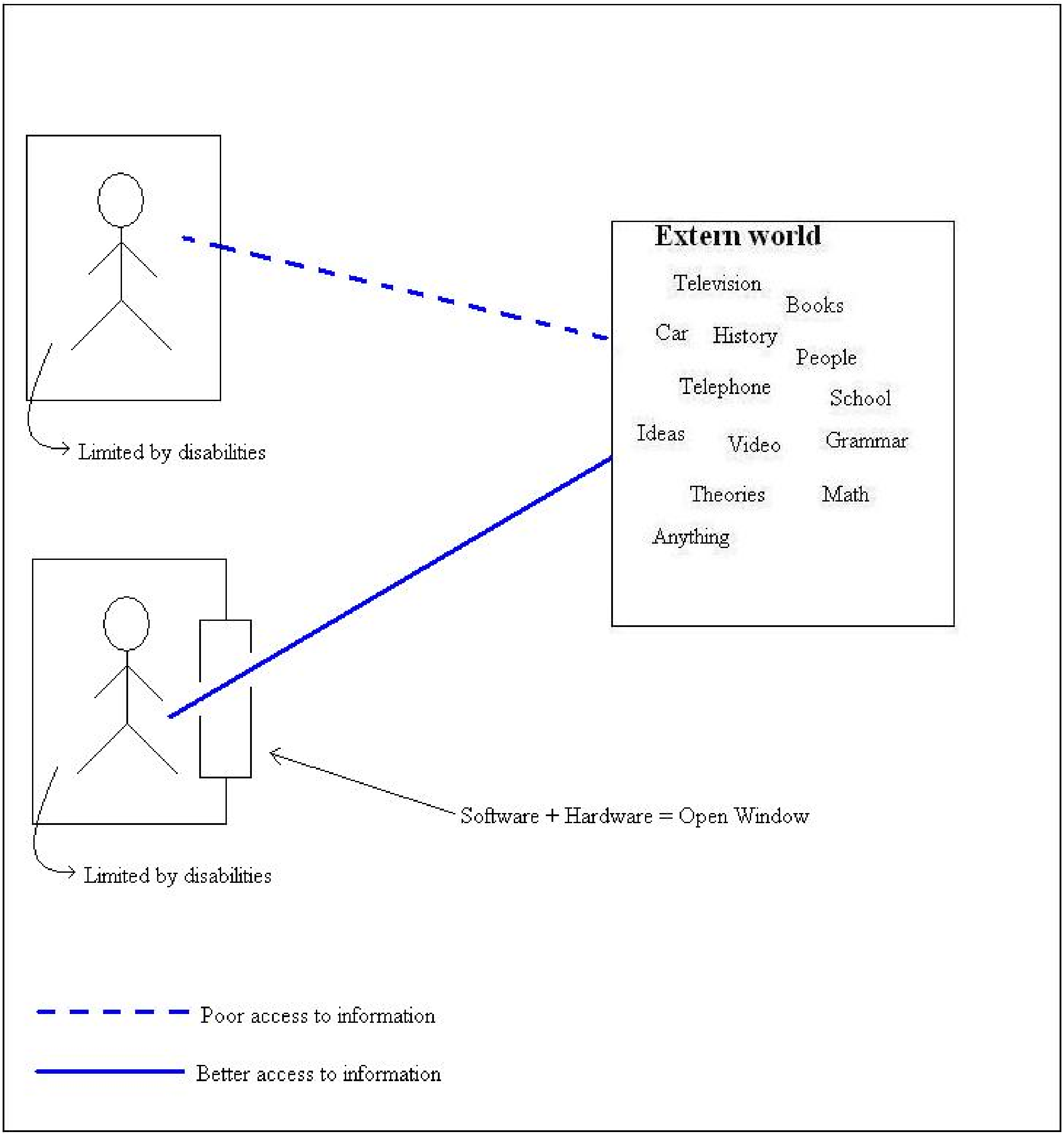

Figure 1: The scheme represents the person's difficulties to interact with the world caused by his physical limitations and how technology opens a new window for those people.

However, technology can open a window to the world and improve the quality of life of people with disabilities. Technology can be used as a body extension to provide new kind of experiments.

The Logo programming language invented by Seymour Papert is a good example of a technology that can be used to help children with disabilities. For example, "normal" children are able to learn various concepts by giving instructions to a virtual turtle in the Logo programming environment. Likewise, children with disabilities, especially those with severe physical limitations, can identify themselves with the turtle to learn and gain a better sense of orientation in the physical world.

Voice synthesis is another example of a technology that can help people with disabilities. When someone cannot speak in a perceptive way, voice synthesis technologies become essential tools.

In the next section, the paper describes research done at our University to improve a voice synthesis system for helping people with cerebral palsy.

3 Voice synthesis

Voice synthesis systems open a window for people with voice disabilities. With the aid of these systems, people with voice disabilities can have a more effective education because they can create a good communication channel with their teachers and colleagues. People using a voice system can show what they know to the class and they can participate with their ideas in classroom activities.

At the University of Algarve, and with objective to help an undergraduate student to present his final undergraduate degree project, one of his professors had the idea to use a text-to-speech system [1]. The system used by the student was based on the Mbrola project [2] with some modifications made in the input/output system interface to improve the quality of synthesis for the Portuguese language.

After that student concluded his degree, the research in this field didn't die at our University. Several modifications have been made on that system to obtain a better interface and one of them was the development of a virtual keyboard. Another student, Pedro, as his final undergraduate degree project developed this interface.

3.1 Virtual keyboard: A better user interface for people with physical disabilities

Many people with voice disabilities can also have other physical disabilities. For those people it is essential to have an easy-to-use interface to suppress their body limitations.

The text-to-speech virtual keyboard, called "Toque de voz"[2], tries to give an opportunity to people with severe physical disabilities to have an easy access to a text-to-speech system. This interface (see figure 2) was designed based on interviews conducted at APPC and took into account the needs of the people.

[2] Means Voice Touch in Portuguese

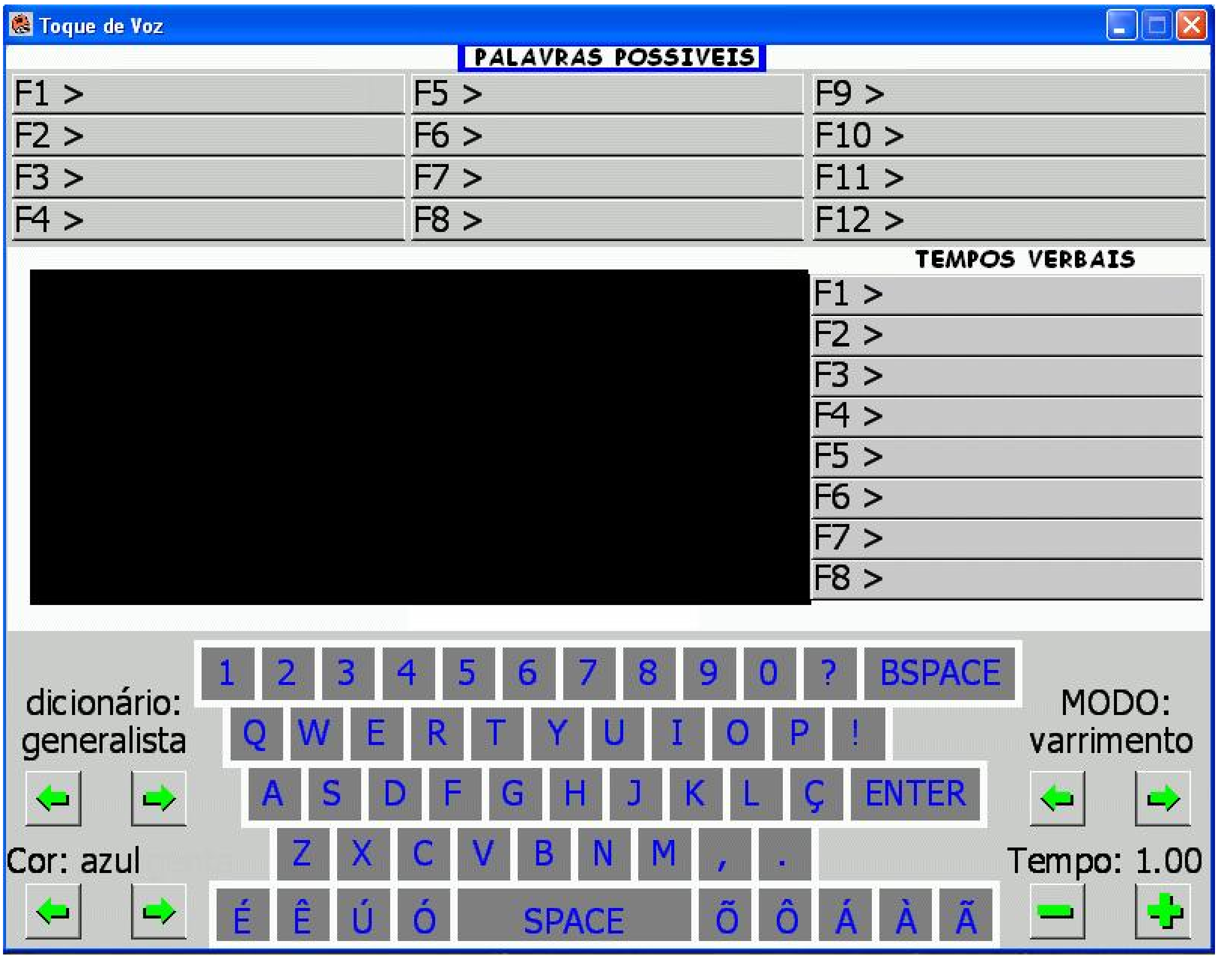

Figure 2: Screenshot of the “Toque de voz” application

The virtual keyboard contains a built-in dictionary and a simple algorithm that predicts the possible words that the user wants to write. This is a very important feature because it allows users with physical disabilities to write faster what they want to say. For example, if an user wants to write the word “viagem” (it means trip in Portuguese) then when he types the “v” letter, a list of possible words starting by “v” are shown on the screen. If the desired word doesn’t appear in the list then the user must type the next letter. This process is concluded when the desired word appears in the list to be selected by the user (see figure 3). Normally, an average of two or three keystrokes are sufficient to write a Portuguese word.

Figure 3: List of possible words

It is important to refer that the dictionary system can be used in the generalist mode or in a more formal mode. The generalist mode contains the words commonly used in daily life while the formal mode contains a more colloquial vocabulary.

Another important feature of this application is the keyboard group scanning function. This function offers the possibility to the user with severe physical disabilities to select the keys by pressing a single switch.

The scanning on the keyboard is made line-by-line. Once a line is selected, the scanning is made column-by-column and inside this group it is made key by key. This kind of scanning appears to be more efficient than the scanning key by key. With the group scanning it becomes much faster to write, and soon it provides a more natural and more effective communication.

That application has a QWERTY keyboard configuration. However other research teams have created optimised keyboard configurations [3].

3.2 Testing the text-to-speech virtual kerboard at APPC

The virtual keyboard is being tested at APPC and we already have interesting results about those tests.

Our first experiment involved a girl who didn't frequent a regular school. We were surprised with her capacity to explore the software, mainly her capacity for choosing words in the list. However, after we thought a little more, it is very natural because at APPC she learns things with the help of her educator from a way that resembles the constructionist approach. The girl had a kind of built-in capacity to explore the software, it was her usual way to learn things.

On a second experiment, we tested the application with a boy who frequents a regular school, and we knew beforehand that he was a good student. We were expecting that he wouldn't have any difficulty to use the application. But contrasting with the girl, he had more difficulties. He was having trouble to write his name. After some time we realized that his difficulty was because all the words on the list appeared with the first character uncapitalized. It was very confusing to him at the beginning because he knew a grammar rule that says: "People's names must begin by a capitalized letter". The girl didn't have this problem because she wasn't restricted by grammar rules and she didn't have fear of making mistakes. The boy could use the application but only explored it when we told him: "Now, grammar rules don't matter".

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This software continues in test at APPC and until now some improvements were made to the scanning system. An extended description of this work is available elsewhere in Portuguese [4].

We also have the APPC collaboration in other projects that are being developed to help people with cerebral palsy to interact with the physical world. These projects use a small electronic device called *GoGoBoard*.

4 The GoGoBoard's use to help people with physical disabilities

Others windows can be open to people with physical disabilities with small devices that help them to do things without external help. With these devices a person with disabilities becomes more independence to explore the world. When people can explore the world by themselves they can learn better because they become explorers of knowledge rather than being just receivers of knowledge. For instance, if a person knows that the sea is enormous (and beautiful) but that person never saw the sea, then that person cannot have an exact idea of what the sea is.

Unfortunately, the cost of equipments to help people with disabilities in their education is an obstacle because the educational institutions (at least in Portugal) have very limited budgets. However, some constructionist technology can be used to make low-cost equipments in an easy way. One of those technologies is the GoGoBoard.

The GoGoBoard [9, 10] (see figure 4) is a small and low-cost device that can have sensors and actuators attached to it. This device was invented by Arnan Sipitakiat and is a non-commercial version of a programmable brick [7] such as the Cricket or the LEGO Mindstorms RCX brick.

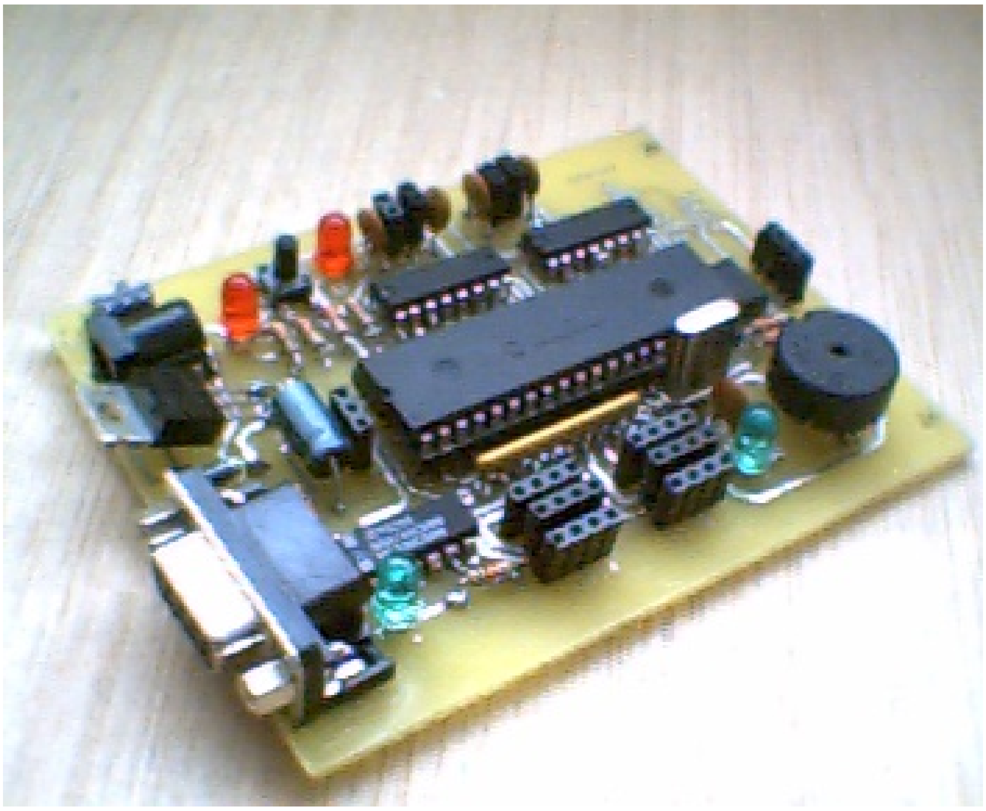

Figure 4: Image of a GoGoBoard

Sipitakiat has designed this board with the main goal to provide an economical solution to students in schools around the world to develop projects following Papert's educational theories.

When we saw that board's potentialities, we thought that it would be interesting to use it as a foundation to create new equipments for helping people with disabilities. The GoGoBoard can be used as a body extension for those people. So, we decided to make a board's replica at our university with some help from its inventor, Arnan Sipitakiat.

The work was largely done within another final undergraduate degree project and was performed by two students, Stéphane and Nuno.

4.1 Assembling the board

The first board that was assembled at our University didn't work due to a mistake when the components were soldered. This mistake was natural because the students had no experience at all with soldering and electronics.

The second attempt to assemble the board was successful and the following figures show some steps of the process.

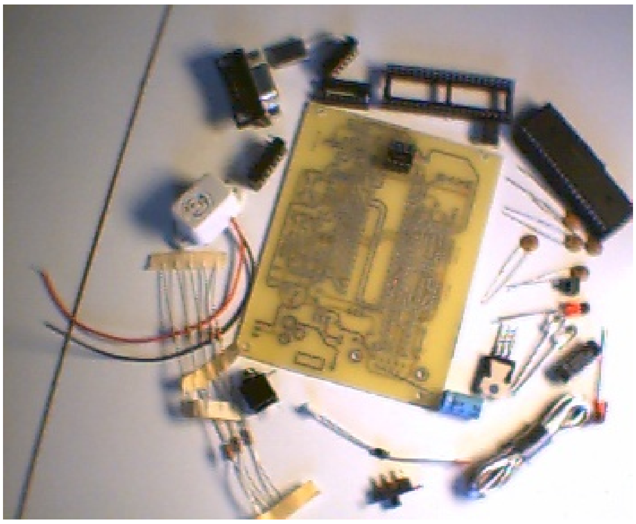

Figure 5: The board components

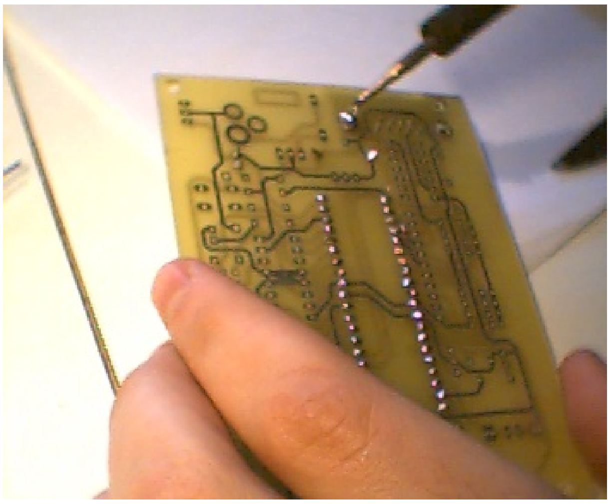

Figure 6: Assembling the board

The final result was shown previously on figure 4. However, this kind of board is very sensible to be used by people with disabilities. Therefore, the two students had an idea to protect it. The idea was very simple, they built a protection with external connections to the sensors and actuators from a box of swabs (see figure 7).

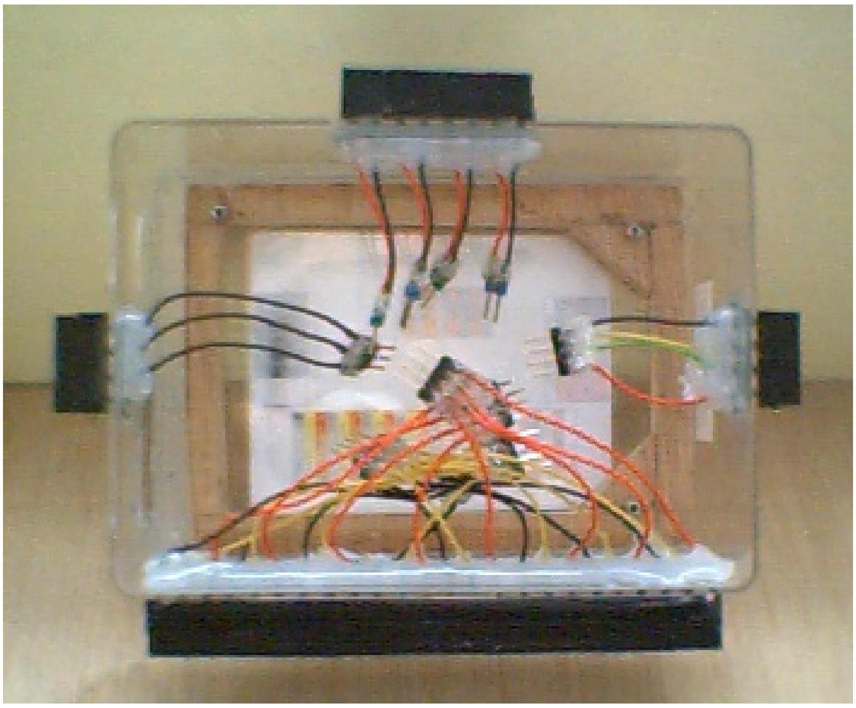

Figure 7: The board's protection

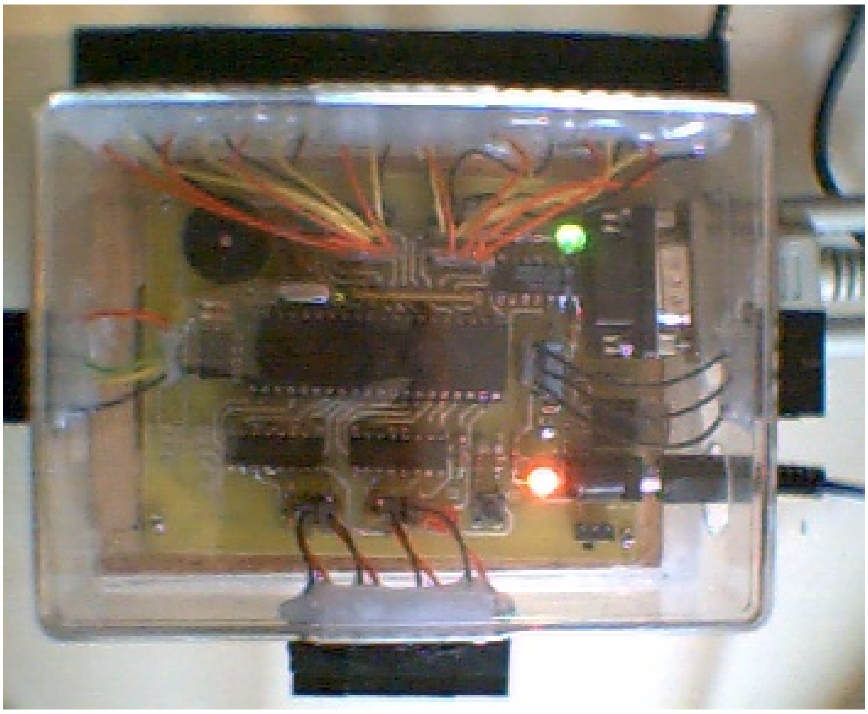

Figure 8: The final aspect of the board

After finishing the board's construction (see figure 8), the students wrote a software application programmed in Logo. This software, called ADM (Auxílio a Deficientes Motores[3]), was designed to interact with the board, allowing a person with disabilities to interact with the surrounding world by simply pressing a touch button (on a board's sensor) or just to ask for help (see figure 9). The ADM application uses a scanning system, similar to the one used in the virtual keyboard project, to help the user to select the desired options.

[3] Means helping people with physical disabilities in Portuguese

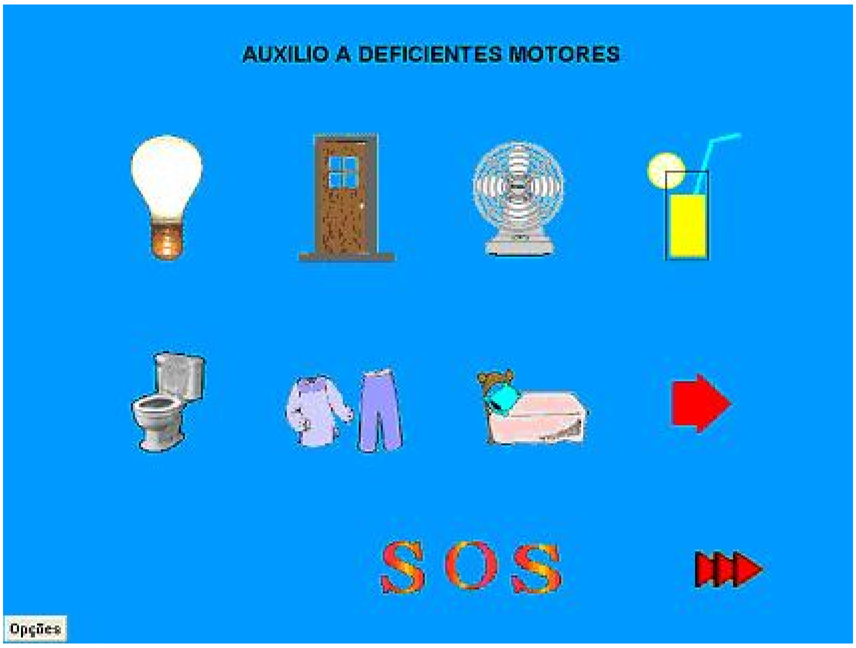

Figure 9: A screenshot of the ADM application

With the ADM application an user can ask for the assistance of another person. For instance, the user can ask to go sleep, to be dressed, to go to the bathroom, among other things. However, the users can also interact with the bedroom because this system allows to open/close the door, turn on/off the light, turn on/off the air-conditioning, among other things, converting the bedroom into an “intelligent” bedroom.

The interface to control the bedroom was tested on a small model (see figure 10). The bedroom model was designed to give an idea of the GoGoBoard’s capabilities in this field.

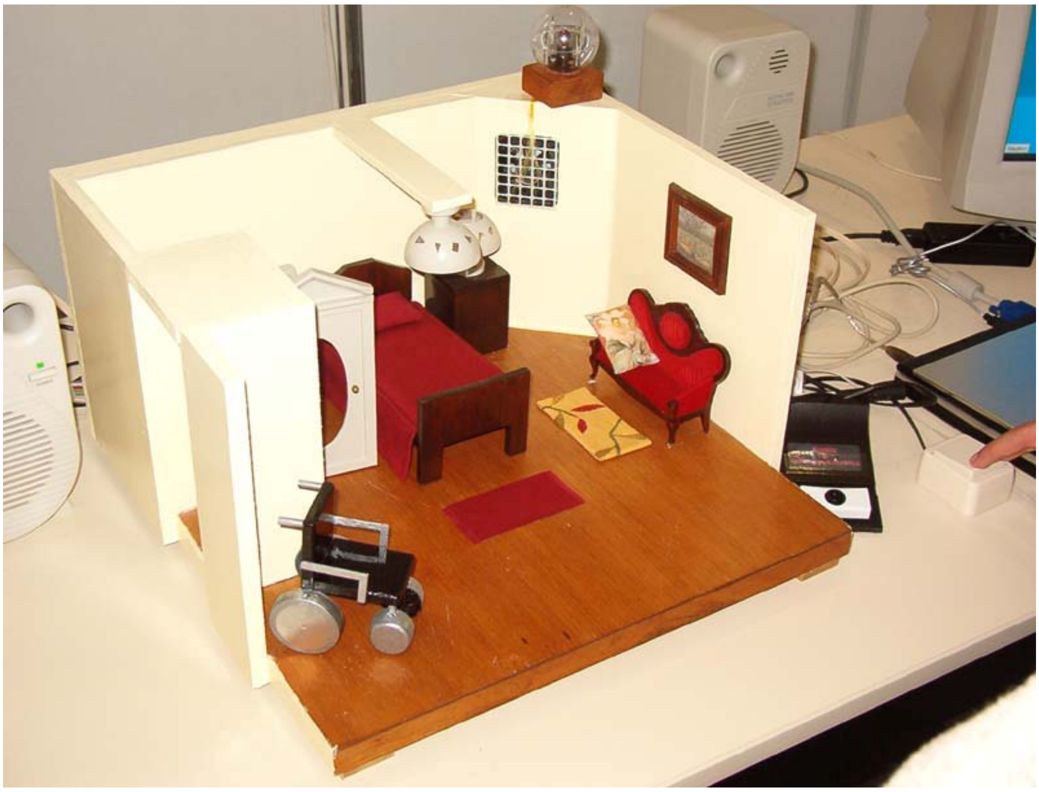
Figure 10: The intelligent bedroom

The system was shown at a science fair which was held in the south of Portugal. Visitors were very interested in it (see figure 11), and the project got the attention of the Portuguese media, both radio and the National TV.

Figure 11: The project in exhibition

At the moment, we are trying to implement the system in a real room and we are also studying new uses of this board for helping special needed people.

5 Summary and conclusions

This paper shows how information and communication technologies can open a new window for people with disabilities. Those people can have a regular education, and a normal life, when they are provided with appropriate technology. Unfortunately, some technologies are expensive but our University have tried to develop more, better, and cheaper technologies. For example, a copy of the text-to-speech virtual keyboard was given to APPC and it will be available to download soon.

We presented the idea to use constructionist technologies for building new (and cheaper) equipments to help people with disabilities in their education and in their daily life. We believe that the constructionist theory should be implemented on schools and that this will promote a better integration of students with disabilities in the educational system, and will improve the students's capacity to do research and learn things by themselves.

The tests that we conducted at APPC reveal that the constructionist approach for learning is very important. The girl had no trouble at all in exploring our software, and in our opinion, part of the explanation is because the girl was exposed to a constructionist way of learning from an early age.

As a final remark, we would like to say that our research work has been very rewarding. We feel that our research can be used to help to improve the education quality of many people, and their integration in society.

6 Acknowledgments

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