

# Design and Evaluation of a pictographic board for people with inability to communicate verbally

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*Abstract:* In this project we present Symbolum a tool to aid communication of individuals with cerebral palsy and speech difficulties, facilitating the access to information and knowledge, thereby improving their living conditions. Although cerebral palsy manifest itself in different ways, affecting different parts of the body, there is usually a barrier that the majority of individuals have difficulty to overcome, which is its inability to communicate verbally and written. Thus, the main objective of this project was to create an alternative communication platform whose base settles in communication through graphic symbols, called pictographic boards. To validate the application like the one we describe, we used a User Centre Design methodology involving the main users of Symbolum, therapists and its students/patients, from an early stage. However, as we can only truly say that a system works after being tested by its users it is a primordial goal to make tests with their real users. In this document only the tests with the therapists will be reported, however in preparation there are tests with patients.

*Key-Words:* - Assistive Technologies, Pictographic Systems, Special Education, Alternative and Augmentative Communication

## 1 Introduction

The new Information and Communication Technologies (ICT) has had a great importance in communication and ease of access to information and knowledge, thereby improving the living conditions of people in general and certain groups in particular. In the context of this project the integration of ICT in supporting people with cerebral palsy will be shown. Despite the use of new technologies being able to offer recreational opportunities, in this project, they will be primarily used as a tool to aid communication for these individuals, since this is a barrier that they often have great difficulty to overcome due to their inability to communicate both in written and verbal form.

Communication is crucial for social interaction. Among other limitations the majority of people with cerebral palsy has verbal communication problems. Thus, professionals and researchers from the area of Special Education have been concerned with identifying and developing these children's communication abilities [3], [13], [6]. According to

Sameshima, Deliberato and others [16] it is important to identify the various communication possibilities of nonspeaking individuals, in order to select the best communication strategies for these people. In the case of nonspeaking individuals affected by cerebral palsy, their communication with the environment may be established through facial expressions, head movements and vocalizations. The literature has described different forms of communication of children and teenagers who are either nonspeaking or have communication problems [7, 11, 12]. There are several studies [1, 16, 12] calling the attention to the different forms of communication of nonspeaking people with cerebral palsy. The development of resources such as communication boards with pictorial symbols or vocalizers, computers with specific software, and other specific assistive tools, help to encourage the communication functionality of people with severe speech disorders, enabling them to increase their learning and social interaction [5]. Campbell et al. [2] identified 104 articles published on

Assistive Technology from 1980 to 2004, six of which focused on the use of a computer and just one focused on augmentative and alternative communication. Therefore the main objective of this project is to create an alternative communication platform, using new technologies where the base is the communication through graphic symbols. The platform aims to facilitate and improve the communication learning of a cerebral palsy carrier in society.

Due to be an alternative communication system, this project is essentially based on pictographic systems with the interface customization of the communication system, meeting the special needs of each user. It also includes the possibility of the system integration with some current social networks. Additionally the system would allow storing information about relevant user's actions, as a way to constitute a history of interaction that could later be queried or sent for processing in an external program. This stored information is related to communications made and the photos, videos, music or other media handled by each user. The ability to make notes on user interest subjects, using the alternative media, is another goal in processing. In addition to these general objectives, there was a set of generic concerns at the level of design and interaction, which were taken into account not only usability aspects but also specific accessibility issues in relation to the type of specific users. Finally, this project required some concerns related to the fact that the target users in general have mobility problems so it was created for use into mobile platforms such as Android tablets, as a way to enable a mobile interaction screen as large as possible.

There are well-known systems using pictographic symbols commonly used by people with cerebral palsy having difficulty in communication like Bliss symbols [18], Pictogram Ideogram Communication System (PIC) [10], Picture Communication Symbols (PCS) [8], Comunique [15], LMBrain [14], ImagoVox, ImagoAnaVox and ImagoDiAnaVox [4] and Plaphoon [9] are some examples. However, none has all the functionality and ease of use as Symbolum.

## 2 Symbolum: General Requirements

As indicated, the main users of Symbolum will be people with verbal communication disabilities. Among them, are those with cerebral palsy, to whom we payed special attention. Because these patients also show motor difficulties, the requirements related with

interaction, were discussed and defined. It was evident that due to its uncoordinated movements the main characteristic common to future users of this system is the difficulty they have to point and click. We have considered that the ease of use associated to the touch screens could help to surpass this problem, minimizing the difficulties that users with cerebral palsy can have. Although it is necessary to take some care in the positioning of interface elements and their spacing, we considered this type of interaction advantageous for our users. The option for touch screen allows us to choose some less expensive equipment, which can provide access to common communication systems, facilitating communication with others. For this, we feel that tablets were the most suitable equipment to implement this system, due to the screen size combined with the portability advantages. This system has a standard interface based on direct manipulation. The users tap on the mobile device screen to manipulate virtual objects and navigate through the system. The first version of Symbolum works only in the Android operating system.

In Symbolum we have two applications, one for people with cerebral palsy and another one for their therapists and administrators. In Symbolum it was considered that communication would include the symbols and appropriate categories of cognition for each user, which are set by the therapist. In the first part of the application, "Symbolum: student/patient", it was considered of interest the possibility to include the following functional requirements:

- Create messages displayed on a screen and be able to communicate with nearby people whenever necessary;
- Post these messages on Facebook;
- Create conversations ("chat") with other friends who use the same application by exchanging messages and keep a history of these messages;
- Edit the profile of the logged user to personalize/customize the form of interaction and personal information.

In the second part of the application "Symbolum: therapist", it was considered of interest the possibility to include the following functional requirements:

- Create, edit and delete students/patients;
- Manage groups of students, each group associated with a therapist;
- Manage students/patients' pictographic communication boards;

- Manage the global database of symbols used by the application;
- Edit user information and consult reports about the user actions.

Another aspect that we considered to promote the inclusion of these individuals in society is the possibility to publish their messages in a social network. Facebook is one of the best known and most used social networks currently available. Relations between the participants will be created through mutual acceptance of friendly relations (friends) or expressing interest to view other publications (followers). Facebook allows any person or entity to publish their interests or comments. These publications are available for discussion and can be commented on by all the "friends" or followers of the authors of the information. Facebook also allows direct communication between users via a chat system (Messenger). However, in this project, it is the publication and discussion of items that have a special interest, due to its asynchronous operation. This way of functioning can reduce the problem in how the amount of information available on a network like Facebook is managed, in terms of quantity and complexity, limiting the response by the target audience of this project in a timely manner. In this version of Symbolum, Facebook is used only to publish certain messages at the request of the user.

### 3 Symbolum: Therapists Configuration

The main goal of this paper is to demonstrate the tests with the therapists and the respective feedback. This way and to a better understanding of the analysed results, we will, in the first place, demonstrate the main features associated to these users. A more detailed explanation of the features associated to the students/patients, can be found in [17].

So, next some utilization examples are presented. Note that all the options are in Portuguese, however it is being prepared an update of Symbolum to have multinational version prepared to several languages.

The fig. 1 shows the initial screen, when the application is started, being possible the authentication in the system via a username and its password. It could be verified that 1 is a quick access to the last users authenticated in this device. When tapping on a picture, the name of the user will be automatically filled. For security reasons, the password will not be filled for the administrators and therapists users. 2

shows the button to exit the application. In 3 it could be seen the button to access the configurations of the application. Finally, the fields under 4 are the location where the username and password for authentication must be introduced.

Fig. 2, illustrates the main menu, where it is possible to access to the different sections of Symbolum, after the authentication as a therapist. In fig. 2, 1 marks the button to return to the previous screen, 2 signals the button to access the profile of the current user (this button is always present in all screens and allows to change user's information: username, password, full name, user's photo, ...) and 3 indicate the buttons to access various features available to therapists and administrators of the application: Institutions, User Accounts, Communication Boards, Categories and Symbols.



Fig. 1 – Authentication Menu

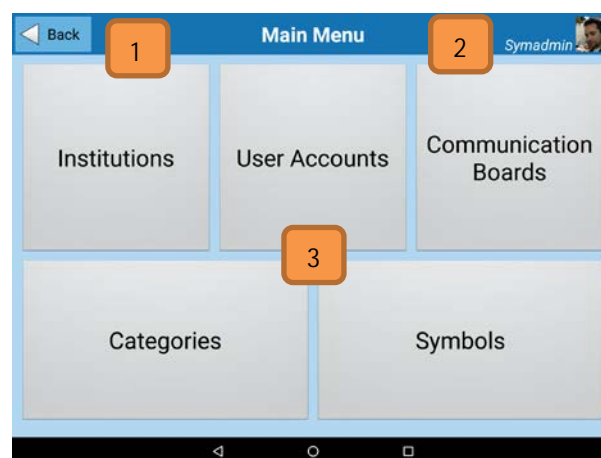


Fig. 2 – Main Menu

One of the Symbolum possibilities is the users be managed by therapists. Thus, in the "User Account" section, fig. 3, we can add, edit or delete users. To search for a user we need to write a name in the search field and then press the

search button. When pressing the search button on an empty search field all users will be displayed.

In fig. 3, in the area marked with 1 there is a list of the users existing in the system. This list is filled according to the type of authenticated user. If it is a Super Administrator, he has access to all the users in the System. In the event of being an administrator, it will only exhibit other administrators, therapists and students of your institution. Supposing it is a therapist, only the students/patients of your institution are presented. 2 – Button to force the update on the users list. 3 – Button to add a new user. The data are, afterwards, inserted in the section 7. 4 – Button to view the historic of the messages created by a selected student/patient. 5 – Button to save a new user or the changes made to the selected student/patient in the server. 6 – Button to eliminate a selected user or to cancel the addition of a new user. 7 – Zone of the fields of the selected user's data. If one is handling the addition of a new user, these fields will have to be filled. When tapping on the photo, it is possible to change it. This new photo can come directly from the device's camera or from the images gallery. If the new user to be added is a student/patient, there are some configurations of his account for which one must pay special attention.

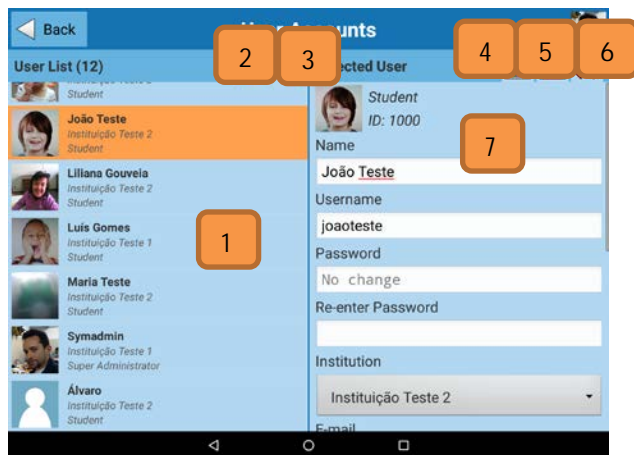


Fig. 3 – Section “User accounts”

Because the students/patients can have different difficulties of interaction, there were a number of concerns regarding the handling of the application, namely: Configuration of the buttons size: Small – all the buttons have 75% of their original size. Normal – all the buttons have their normal size. This is the size by default. Big – all the buttons are 50% bigger than their original size. Very big – all the buttons are 200% bigger than their original size. Configuration of the type of tapping: Normal tapping – the performed

tapping exhibits the usual interpretation. This is the kind of tapping by default. Tapping with Arrows – the scroll, on the several lists, is disabled and, in order to surf them, there are buttons that simulate the movement of sliding with the finger. This type of tapping is useful for those users who find it difficult to slide the finger. Long tapping – a tapping is only accepted, if the user has his finger touching the same point for, at least, 1 second. This kind of tapping is useful for users that, when trying to touch a specific spot of the screen, touch other spots, due to motor difficulties. Strong tapping – a touch is only accepted, if it is performed tightly. This kind of tapping is also useful for students/patients that, when trying to touch a specific spot of the screen, tap lightly, by mistake, in other spots. The algorithm determines, through all the performed taps, the values of the minimum and maximum pressure and, with these values, it is created a midpoint pressure that, if the student/patient over crosses it, it counts as a valid touch. This type of touch is subjected to the quality of the pressure sensor existing on the device display, but it may not work correctly, if the sensor returns inaccurate data. Automatic Synchronization: If active, whenever the student/patient authenticates himself/herself in the system, it is verified with the server if there is an updated version of his communication board. In case of a positive answer, that new version is transferred. Save Password: If active, it allows the password to be saved for when the student/patient logs in, tapping on his image, the password is automatically filled, along with the username. When data entry is complete, or their update, one must touch the button “Save” (signed by 5), so that information is sent to the server.

Fig. 4 shows a screen where one can view the history of the messages created by several students/patients. It is possible to change the student/patient without having to return to the previous screen. To do this, one must simply touch the student's name in the students list.

Fig. 4 shows a screen where one can view the history of the messages created by several students/patients. It is possible to change the student/patient without having to return to the previous screen. To do this, one must simply touch the student's name in the students list.

Another important feature that Symbolium has for therapists is to manage students' pictographic communication boards. It is then possible to edit all

the categories and the respective symbols of the system.



Fig. 4 – Section “Messages”

Fig. 5 shows all the categories in the system, allowing the editing, eliminating or adding new categories.



Fig. 5 – Section “Categories”

The screen to add and to edit a category could be seen in fig. 6. Here, 1 – Button to choose the language of the categories. Only the languages where there are categories will be displayed. 2 – Button to save, in the server, a new category or the alterations made to one of them. 3 – Button to remove a category or cancel the addition of a new one. 4 – When tapping on a photo, it is possible to add a new one directly from the camera or from the images gallery of the dispositive. 5 – In this zone, it is possible to specify if the category being created will be available to all the students/patients or uniquely to a specific student/patient. In case of editing a category, these fields are blocked because one cannot change the exclusivity of a category. 6 – Button only available when editing a category. It serves to add a new language to the selected category.

This way, the image is immediately added to the category with a new language and only translates the name and chooses the desired language in the section button 1. 7 – Button only available when editing a category. It removes the category in all the languages.

In fig. 7 it is presented the screen where all the symbols of the system are visible and, as such, likely to be added to the categories, where 1 marks the button to add a new symbol, 2 indicates the list of symbols of the selected category. When touching/selecting a category, all the symbols of that category will be displayed in the area marked with 2. When touching/selecting a certain symbol, the editing screen of that symbol will be displayed, where it is possible to make alterations to its data. 3 signs the list of categories in the system.



Fig. 6 – Edition of categories



Fig. 7 – Section “Symbols”

The following, fig. 8, shows the screen to add a symbol to a category. The screens to add and edit a symbol are identical.

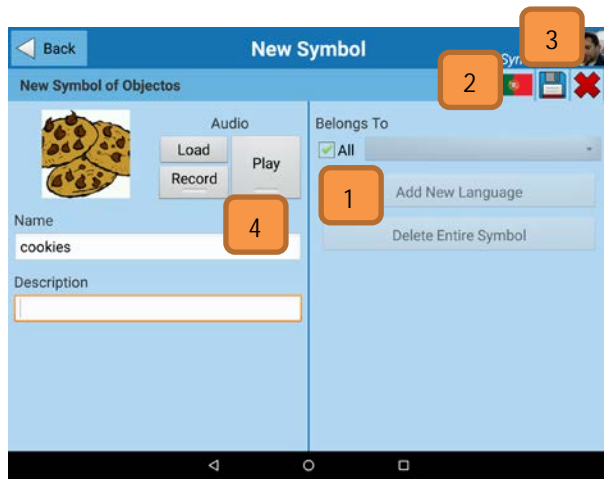


Fig. 8 – Creation of symbols

It must be emphasize that, when it comes to editing a symbol, it is possible to choose a new language since it exists a category in the desired language. When touching in the symbol image it is possible to add a new one directly from the camera or from the images gallery. 1 marks the zone where it is possible to specify if the symbol to be created will be available to all the students/patients or exclusively to a certain student/patient. To a unique symbol only that student/patient will have access. In the case of editing a symbol, these fields are blocked because one cannot change the exclusivity of a symbol. 2 signs the button only available when editing a symbol. It is used to add a new language to a selected symbol. This way, the image is immediately added to the symbol with a new language and it is only needed to translate the name and choose the desired language in the section “language”. 3 is the button, only available when editing a symbol, to remove the symbol in all the languages. The controls marked with 4 are used to associate an audio to the symbol. This audio can be uploaded through a file stored in the device, using, for this purpose, the button “Load”, or it can be recorded using the device’s microphone. When touching “Record”, it will change its name to “Recording” and the user has several seconds to say what he wants, preferably the name of the symbol. After this time or clicking in the same button again, the recording is finished. The button “Play” is, then, active and it is possible to listen to the audio allied, or being joined, to the symbol. If the user does not like, he can always repeat the steps of the recording. However, as referred, it is also possible to have customized communication boards per student/patient. Fig. 9 is a preparatory screen for further editing of the user’s communication boards. However, before editing the boards, the

students/patients that will have their boards changed must be chosen. In fig. 9, 1 shows the button to complete the selection, 2 marks the button to select all the submitted students/patients and 3 signs the button to deselect all the submitted students/patients. 4 indicates the zone where are shown the students/patients that were possible to select and which boards will be changed.

Fig. 10 shows a screen where it is possible to edit a communication board of one or various students/patients, depending on the selection made previously. Here, 1 is the button to select a different student/patient. Only available if previously only a student/patient had been chosen. 2 – Button to show the categories and symbols available in a different language. 3 – Button to select all the symbols of the selected category. 4 – Button to deselect all the symbols of the selected category. 5 – Button to force the update of the categories and symbols. 6 – Button to save the alterations made in the communication board. 7 – List of the symbols in the selected category. The symbols with an orange frame are the symbols that are available in the board of the selected student. In order to change them, it is enough to touch them. In the case of a multiple selection of students/patients, the selected symbols will be added or removed from those communication boards, according to the choice made when entering this screen.

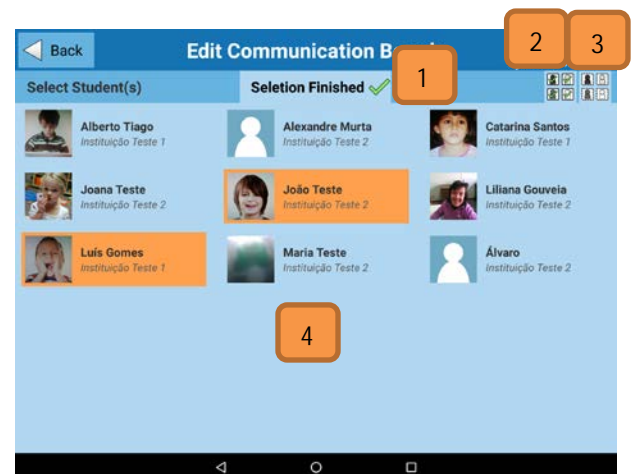


Fig. 9 – Edition of communication boards

There is no problem adding a symbol to a communication board where this symbol is already available (the communication board will not have repeated symbols). Similarly, it will not cause problems to remove a symbol from a communication board where it is not available. 8 – List of categories stored in the system. 9 – Number indicating how many

symbols of the selected category are available in the communication board of the selected student/patient and how many symbols there are in that communication board.



Fig. 10 – Communication boards

In “Chats”, fig. 11, it is possible to see the conversations between the student/patient and a friend. On the left side there is a list of all the friends and on the right side is shown the conversation with the selected friend.

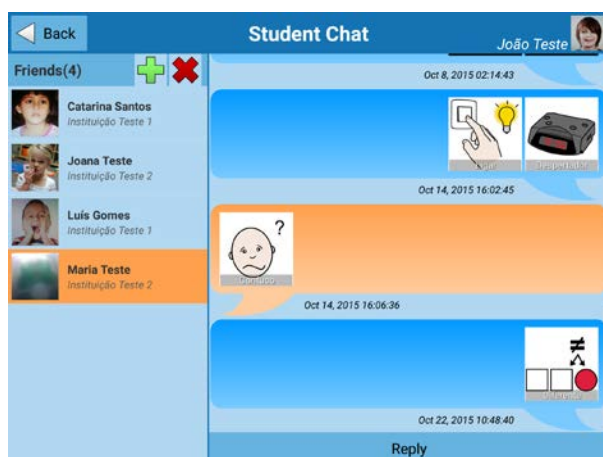


Fig. 11 – Section “Chat”

#### 4 TESTS WITH THERAPISTS

Creating a robust application that meets the needs of those who will use it will have to go through a testing phase with therapists and its students/patients. In order to guarantee the usability of the system, it was built using a User Centre Design methodology. Therefore the needs, wants, and limitations of end users of Symbolium were given extensive attention at each stage of the design process. However, our main users have special features and limitations making it impossible

for us to completely know what is best for them, and to directly involve them in all the process. Consequently, there were the therapists which participated in this multi-stage process the ones asked to analyse and foresee how users are likely to use Symbolium. In order to test the validity of our assumptions, with regard to user behaviour in the real world, before testing with real patients we questioned their therapists at each stage of the process creating a circle of proof confirming or modifying the original requirements. In our methodology the support of therapist was crucial in order to optimize the product around how users can, want, or need to use the product, rather than forcing the users to change their behaviour to accommodate the product.

So, several types of tests are intended: tests with patients (with and without new interaction devices) and tests with the therapists. However, in this document only the tests with the therapists will be reported. We decided to start with the latter because the therapists make the configuration of the entire tool, so it is important for us to have their approval.

For this purpose, we gathered 4 therapists from the institution “Associação Portuguesa de Pais e Amigos do Cidadão Deficiente Mental, Portuguese Association of Parents and Friends of Mentally Disabled Citizens, in english” (APPACDM), each one having, at their disposal, a tablet with Symbolium installed.

After the initial guidelines, with an explanation of the features of Symbolium, the participants/therapists were allowed to use the application freely for 5 minutes. Then, it was asked the participants to carry out a list of specific tasks. As the therapists have a lot to do in the system it is important to verify whether or not they like all the interaction. Therefore, they are given all the tasks possible in the system to see if they find it easy to understand. The list of tasks was the following:

1. To launch the application;
2. To log in as a test therapist;
3. To access the data of one the account and change the name and the password;
4. To create a new student/patient with a photo;
5. To change the name of the generated new student/patient;
6. To view the messages of a student/patient;
7. To create a new category with a photo;
8. To add a new language, English, to the generated category;

9. To eliminate the generated category, but only in the English language;

10. To create a new symbol with an audio in a category;

11. To create a new other symbol, exclusive for a student/patient;

12. To add five more symbols to a student/patient board;

13. To add three symbols to all the student/patient boards simultaneously.

Concerning task 1, the therapists did not show any difficulties, so they easily performed the task.

For the therapists, the accomplishment of task 2 was also considered easy. They liked the two possible ways of existing authentication. However, they pointed out that, for a student/patient, there may be problems in entering the password and suggested the use of a standard of colours or images, rather than a typical alphanumeric password.

In general, task 3 was also successful. There was a little confusion on the part of one of the therapists. One of the buttons on the main menu suggested her that the data of her account could be altered, through it, although it was not possible. The name of the button was, then, changed, in order to avoid other confusions.

Task 4 was successful for all the therapists. There were positive findings in relation to some aspects of the interface. However, there was a small detail that caused some displeasure. It was also noted a lack of necessary information.

Task 5 was successful, with nothing to point out.

Task 6 was successful, with no difficulties, but one of the therapists wondered about what she was doing. The information presented was related to the messages created by the selected student/patient, but there were some doubts as to the origin of the displayed messages.

Task 7 was successful. There was, however, a grammatical error pointed out that generated some confusion. It was also difficult to take a photo and obtain it automatically in the application, but this problem is external to the application because it stems from bad implementation in the original application of the camera found in the brand Samsung devices. Using a third-party application, these difficulties do not exist.

In the successful task 8 was just pointed out the fact that a country flag should not represented the communication language used there, but, instead, it should be used some other representation.

Task 9 was performed without any problems and without comments.

In task 10 there were no difficulties and there was a positive assessment because a symbol also had an audible component. One of the therapists thought that possibility was very interesting, for example, allowing a student/patient to go to a public place, for example a coffee shop and show the message, simplifying the communication process and his/her autonomy a lot. That therapist further considered that this mechanism could help the communication between patients with different difficulties. Some suggestions were also made, such as adding different audios to a symbol, in order to simulate the voice of an adult (men or woman) and a child (boy or girl). The most negative aspect revealed with this task was related to the recording time (5 seconds) of those same audios because, as it was, it proves to be a little short. This change was immediately altered.

Task 11 generated some doubts concerning assigning a single symbol to a student/patient and the possibility of, eventually, this symbol being passed on to another student/patient or being available to all of them. Some of the suggestions made by the therapists were a little against the idea of using a single symbol: a symbol that just has meaning to a certain student/patient, as for example a symbol with the photo of his parents. In this context, to pass on this symbol to another student/patient would not make sense and even less if this symbol was available to all the students/patients. A suggestion to solve this problem could come by creating a category with symbols that only one or a few students/patients could use.

In task 12, the icons of the button and expressions used generated some confusion concerning each one's features. Several suggestions were made to improve, such as a new design for the icons and additional information visible when editing the board of a student/patient. There were also found some critical errors that were corrected, after the tests.

Task 13 also generated some confusion for the same reasons of the previous task.

When the tasks were completed, the participants filled out an evaluation questionnaire concerning the system whose purpose was to gather additional information about their experience of using it. A five point Likert scale was used, where 1 is "Very difficult", 2 "Difficult", 3 "Moderate", 4 "Easy" and 5 "Interesting". Aspects were filled on "Easiness of use", having this aspect obtained the classification of 4.5 (Easy), Organization of the information, having



obtained the classification of 4.25 (Good), Layout of the screens, having obtained the classification of 5 (Obvious), Nomenclature used in the screens, having obtained the classification of 4.25 (Obvious), Messages of the system, having obtained the classification of 4.75 (Obvious), Assimilation of the information, having obtained the classification of 4.75 (Easy) and overall assessment, having obtained the classification of 5 (Interesting).

In the end, the participants also had the opportunity of openly comment on the tests. So, they had the chance of entering a student/patient's account in order to also give some opinions and suggestions concerning the difficulties they thought the patients would experience. Overall, they liked it and they found useful and suitable the implemented features. There also were some suggestions concerning the implementation of new features. Among them, there is the possibility of sending a message created by e-mail. Another one concerns the existing of a new button, in the screen where the message is created, enabling erasing a message at once. This button would still have a new role of restoring the message, if the student/patient would have touched it by mistake.

In performing some tasks that required more information from the server, such as listing all the categories and symbols, there were some technical problems due to the slow access to the Internet. One of the most serious problems was the fact that the application was constantly waiting for the rest of the data, but these data were slow to be sent by the server. If a connection remains too long without any flow, it is cancelled. However, it was not the case during the tests with the therapists. Once the application is "blocked" when communicating with the server, it will be necessary a way to cancel the operation, if a similar situation happen again.

Another problem found, in only one of the test devices, was the lack of memory to support all the symbols available at the time. Although the device had more than enough memory to support the information that was being requested, for one reason or another, the application was discontinued by the Android system because there was no more available memory for the application. As this problem could quickly become alarming, when the number of symbols would increase, it was fixed as soon as possible.

## 5 Conclusion

As active citizens working with technologies, we cannot ignore the possibilities that they can offer to promote the inclusion of people with disabilities. In this paper we presented the Symbolum, an alternative communication system using pictographic symbols to promote the possibility of individuals not able to communicate verbally and/or writing (such as those with cerebral palsy). Since the beginning of the planning process, we followed an iterative development methodology focused on users. Hence, throughout the development we focused on understanding the user, their goals and tasks as well as the environment (physical, organizational, social) around them, with permanent meetings with therapists and carrying out some observation sessions with Cerebral Palsy users and with users who just have speech difficulties. Now, because the Symbolum application is almost finished, we submit it to tests with therapists. The description and results of these tests were presented in this paper. The next phase will be the scenario-based usability tests with patients. This is a fundamental aspect, which was not forgotten, because if they negate the system then all other evaluations will not make sense. Nevertheless, we considered that the small-scale evaluation done was useful for improving usability of the Symbolum and UX of prospective users.

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