Performing universal tasks using a mini iPad: usability assessment per people with intellectual disabilities.

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ABSTRACT
With this study we aim at assessing if a mini iPad device is a usable option for digital interaction to perform selection, manipulation, and insertion tasks by people with intellectual disabilities. This study builds on previous studies where usability was evaluated for universal tasks using the keyboard and a mouse input device [1]. This allowed us to assess the usability of a small mini iPad and compare it with other two input devices, namely keyboards and the mouse.

For usability assessment we registered the following variables: successful conclusion of activities, type of difficulties found, errors and satisfaction indicators. The results showed that this group was much motivated to learn how to handle with the iPad, several asked to repeat the task and no one quit any task requested. Despite the number of errors as registered in their interaction, they always knew how to overcome the error and never showed frustration or demotivation. Furthermore, they had a good performance (relation between variables: time to conclude the task, number of errors and difficulties felt) with the mini iPad device, however when compared with the keyboard and mouse, their performance increased.

CCS Concepts
• Human-centered computing → User studies • Human-centered computing → Usability testing. • Human-centered computing → Interaction devices.

Keywords
Usability evaluation; mini iPad; universal tasks; user tests.

1. INTRODUCTION
Previous studies showed that people with intellectual disabilities, without major motor impairments, could interact with keyboards (not autonomously because they need help on the character recognition) and mouse (with some autonomy), but none of them provided actual ease of use regarding this group of users [2] [3].

On the other hand, the most basic tasks a user can perform are data selection, insertion and manipulation [4]. In this context, we intent to study more usable and accessible input devices to facilitate the interaction with digital environments. Likewise, it is important to train elementary tasks that the user can use to perform different activities in digital environments, which are as follows: data selection, insertion and manipulation [4].

Among different interaction techniques the touch proves to be the fastest and the most consistent mode of interaction, with little variations when it comes to usability evaluation, even considering different age-groups of users [5]. Therefore, mainly due to their ease of use, efficiency and intuitive nature, as well as the possibility to increase productivity rates as far as information use, the touch interfaces have shown great potential in user' interaction [6].

Therefore, it was perceived as an evident option to assess the usability of a mini iPad input device when performing different tasks and to compare it with the traditional keyboard and mouse devices. For that, we observed and assessed how a group of people with intellectual disabilities interact with a mini iPad when performing selection, manipulation and navigation tasks. This paper is structured as follows: the background, where the main concepts are exposed (intellectual disabilities, interaction, usability assessment, and other studies are analyzed); and the case study and its description (participants, methods, experimental design, procedures, apparatus, results and discussion). Finally, we present our conclusions and future work.

2. BACKGROUND
Digital environments must be accessible regardless of any special condition and/or human (in)capacities, ultimately to improve e-Inclusion. Still, there are several features constraining this access to some specific groups of people, one of them being the group of people with intellectual disabilities.

According to the American Psychiatric Association (APA), in the Diagnostic and Statistical Manual of Mental Disorders (DSM-V), a person with intellectual disability is characterized by having an intellectual quotient (IQ) significantly below average and limitations in the performance of functioning capacities in daily life areas such as communication, self-care, and social coexistence and in school activities [7]. Despite this disability, they can learn new

Interacción '16, September 13-16, 2016, Salamanca, Spain.
ACM 978-1-4503-4119-6/16/09.
DOI: http://dx.doi.org/10.1145/2998626.2998668

competencies and abilities, even in digital environments as it could by observed in several other studies [2][3][8].

The use of the computer and other technologies have major advantages in the learning process, leading to an increasing motivation, performance and promotion of the use Information and Communication Technologies (ICT) [9][10] [11][12].

It is important to study the usability of these user interfaces that can overcome difficulties as observed, in former studies, with the traditional input devices (mouse and keyboard) by this group of people. Specifically, in one research a case study was presented on how a group with intellectual disabilities interacts with Web content, when performing daily school activities, using the universal tasks (selection, manipulation and navigation). In this case, it was used a keyboard and a mouse input device. The results showed that they had a good performance using the mouse. However, they could not use the keyboard autonomously because of their reading/ writing difficulties [1].

Another remarkably important case study is one where it was assessed if the touch screen input device was a more usable option for digital interaction by people with intellectual disabilities, when compared to a traditional mouse input. The results of this research showed that the group with intellectual disabilities presented a better performance and made less errors when using the touch screen [2].

These results were satisfying as a preliminary study. However we think it is important to study not only the selection task but also manipulation and insertion tasks. They are considered key tasks to a fully digital interaction experience. In this context, as past studies had already mentioned there are many problems in user interaction observed, as: the text entry (the most problem register) [13], selection of hyperlinks [14] [15], selection of multi-options [13] and typing instructions or keywords [14].

So, it is perceived that many users with intellectual disabilities still struggle to interact with digital content. There seems to be indicators that this struggle arises when they use the traditional input tools - keyboards or mouse, since these tools do not allow an autonomous interaction. And, still, several studies point to an increase in motivation in the interaction of digital environments, by this group, so these barriers cannot hamper the interaction in order to achieve a straightforwardly autonomous and valuable user experience [2][3][15][16].

3. CASE STUDY

For four weeks (two hours per participants, forty hours in total), we performed a preliminary training phase, where the participants used for the first time the mini iPad. In this phase, users were invited to perform different tasks: selection, insertion and manipulation. This training phase enabled them to learn how to use the different actions to interact with the different objects, namely: touch the screen; drag; touch and drag; and resize objects. From the observations made we noticed that the action they had difficulties in learning was how to resize action, which led us to think that this movement is not a "natural movement" for them when compared with the touch and drag movement, where they did not show to have any problems with those movements.

3.1 Methods

In this study, the case study and ethnography are allied with the usability evaluation (user tests). The methods of data collection used are directly related to the research methods adopted and include: logbooks; document analysis, interviews, direct observation (methods used in the case study and ethnography). In the user tests, we register: efficiency, effectiveness, and satisfaction variables.

3.2 Participants

The participants were selected to participate in this study as long as they fulfilled two conditions: firstly, the average rate of literacy and primary education had to be coincident with preschool and the first grade (these conditions were attested by a special education teacher); secondly, they had to have experience with digital environments or the Internet (all of them participated in different projects with digital environments).

Therefore, twenty participants partook in this preliminary study, whose ages ranged from 19 to 44 years old. Regarding their disabilities, they all have intellectual disabilities that can be classified according to severity levels, between mild to moderate [4]. Additionally, sixteen participants have normal vision and four have corrected to normal vision. All were volunteers and had permission of their parents or tutors to perform the study.

3.3 Experimental design

The tasks selected for this evaluation were based on a previous study "Performing universal tasks on the Web: interaction with digital content by people with intellectual disabilities". By using the very same materials it enabled us to compare the usability results obtained in the interaction with the devices - mini iPad, mouse and keyboard.

Thus the five tasks defined to assess usability were the following:

Figure 1: Task 1- Selection task (touch action).

- Task 1 - Selection (T1): participants had to paint a drawing using the touch action (two touches). For that, first, they had to select the color and second, to tint the drawing area (Figure 1).

Figure 2: Task 2 - Selection and manipulation (touch and drag action).

- Task 2 – Selection and Manipulation (T2): participants had to paint a drawing by using the touch and drag action. In this task they had to drag the colour to tint the drawing area (Figure 2).

Figure 3: Task 3 (first puzzle) - Manipulation (touch and drag action).

Figure 4: Task 3 (second puzzle) - Manipulation (touch and drag action).

- Task 3 – Manipulation (T3): participants had to make two puzzle using manipulation skills (were using two movements, touch and drag). First, they had to select the piece of the puzzle (one touch) and then they had to drag the piece to link the right place on the composition (Figure 3 and 4).

Figure 5: Task 4 - Selection and manipulation (touch action).

- Task 4 – Selection and Manipulation (T4): participants had to play a game (puzzle bubble) using touch action. This game consists in grouping colorful globes, touching three different buttons (left and right and fire). The player wins when there are no globes left. If the player does not eliminate all globes before they pass the bottom central bar the game is over. The game duration time depends on each player and the time it takes to complete the level or lose it (Figure 4).

Figure 6: tsk 5 - Selection and insertion.

- Task 5 – Selection and Insertion (T5): participants had to perform three searches in Youtube website, using the following keywords: music, animals and sewing techniques. For that, they first had to recognize the search field and touch it to start writing the keyword (previously shown to them and written in a paper) and they click the search button or press enter. This platform was chosen because participants had previously, shown a great interest on it (Figure 6).

3.4 Procedures

For nine weeks (four hours per participant and eighty in total), we assessed the interaction with the mini iPad by performing universal tasks: selection (one touch), manipulation (touch and drag), and navigation (touch).

The tasks were performed individually, in a controlled environment. Participants were seated correctly in front of the iPad. After explaining the task, they started the activity. The evaluator/observer did not provide the participant any further help, unless him/her asked for it. The tasks were performed randomly.

3.5 Apparatus

The following material resources were used: an iPAD 4. Note that users were seated and the device was on the table. All observations were registered on video.

3.6 Results

In this section the results regarding effectiveness, efficiency and satisfaction are presented and analyzed accordingly and divided by tasks.

Regarding **effectiveness** (performing the tasks without giving up): in the first task (T1), second task (T2), third task (T3) and fifth task (T5) all participants successfully completed the tasks. In the fourth task (T4), only eight participants concluded the task with success. No one quitted.

Concerning **efficiency** (resources spent: time to conclude the task, errors made and difficulties observed), starting with the average **time to conclude successfully the task**: in T1, they spent approximately 114 seconds to conclude the task. The fastest participants finished the task in 50 seconds and the slowest, in 254 seconds. In T2, participants took approximately 105 seconds to conclude the task. The fastest took 47 seconds and the slowest took 354 seconds. In T3, in the first puzzle, they took approximately 43 seconds and 50 seconds to conclude puzzle 2. In the first puzzle, the fastest participant took 21 seconds and the slowest 78 seconds. In the second puzzle, the fastest participant took 19 seconds and the slowest 93 seconds. In T4, the eight players that successfully concluded the task took 67 seconds, in mean. The fastest took 45 seconds and the slowest 102 seconds. In T5, in the first search, they took, on average, 85 seconds; in the second, 68 seconds; and, to the third, 71 seconds.

Specifically for task 5, it is presented the performance comparison between the three search made (Figure 7).

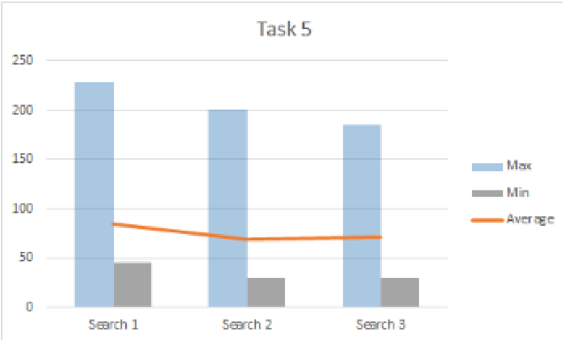

Figure 7: Performance comparison of the task 5 (in seconds).

Still on the **efficiency** assessment, we registered the **difficulties** observed in the interaction with the mini iPad, on the five tasks.

In the first task (T1), nine participants showed difficulties in selecting the drawing areas with one touch regarding the pressure needed to perform this movement and one participant showed many difficulties on tint small drawing areas. Eleven users did not show any difficulties and even revealed abilities to tint these small areas. Nine have some difficulties to understand the task

In the second task (T2), thirteen participants did not present any difficulty with the drag movement, seven have some difficulties to understand the drawing limits but during the task they overcame this difficulty.

In the third task (T3), first puzzle, sixteen users did not present any difficulty. Four had difficulty to drag the pieces from long distances, they many times lost the piece. In the second puzzle, they did not show any problem with the manipulation of the pieces.

In the fourth task (T4), thirteen participants had difficulties to finish the game before the globes reached the top horizontal target. Other difficulties observed as: seemed fumble to recognize/identify the globe' colour, and let joining many globes. They also had difficulties I positioning the hand on the mini iPad. The seven participants that successfully finished the game showed some difficulties to throw the globes to the corners.

In the fifth task (T5), the major difficulty observed was in writing the keyword. No participant recognized/identified the icon search option. Five users clicked directly in videos, after se first search, only one used the search field again.

Regarding **errors** made, in T1, an average of 13 (selecting the background); in T2, no error was observed; in T3, 27 (placing incorrectly the puzzle elements); in T4, 66 (manipulating incorrectly the orientation of the colour globes); in T5, nineteen on the writing of the keyword to initiate search. Despite these number of errors as registered in their interaction they always knew how to overcome the error and never showed frustration or demotivation.

About **satisfaction** (comfort and acceptance of the work within the system), we observed that users liked to interact with the iPad, they frequently asked to repeat the task regardless of the task he/her performed. They never asked to dropout.

3.7 Discussion

Regarding T1, selection (to paint a drawing using the touch action), users did not present much problems in performing this universal task. They seemed to be very interested in the activity in hands. The errors observed were made because they tint an area that was area tinted without want to change the colours and two participants tried to tint by using the drag action.

In T2, selection and manipulation (to paint a drawing by using the touch and drag action), participants showed a natural instinct to tint by using the drag action, as it was observed in the previous task. They fully understood what the task was and the actions that had to be used to complete the task successfully.

Next, it is presented the performance values when we compare the two puzzles made (Figure 8).

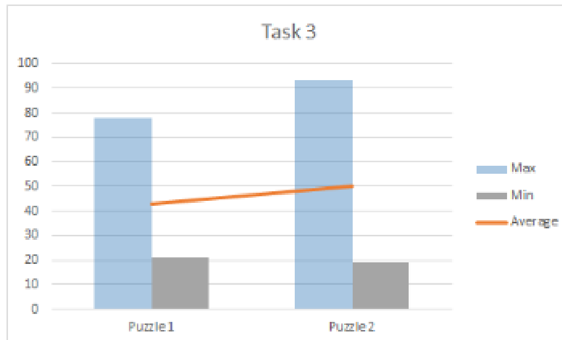

Figure 8: Performance comparison of task 3 (in seconds).

Concerning T3, manipulation (to make two puzzle using touch and drag actions), participants had to perform two combined actions – touch and drag – but with a different objective, to build a puzzle. Overall, they did not show much difficulties in the interaction, however we notice that the drag action was where they had difficulties to perform because when they drag the piece to an incorrect side of the puzzle, they lose the piece, and had to start again. Nevertheless, they did not want to quiet and did not show frustration on finishing the task.

To discuss T4 and T5, one resorts to a former study where it was assessed the interaction with keyboard (T4) and Keyboard and mouse (T5) input devices for the same activities.

3.7.1 Comparison with other studies

In T4, selection and manipulation (to play a game), with the keyboard, eighteen participants partook in this activity (two were absent) and eight participants successfully finished the task. We also noticed it from the eight participants that successfully concluded the task.

Next, we present a table that compares efficiency results between the keyboard and mini iPad (table 1):

Table 1. TASK 4 - efficiency values for Keyboard and mini iPad

	Keyboard	iPad
Number of participants	18	20
Number of participants that successfully finished the task	8	8
Average time to conclude the task	171	67
Best Performance (time/errors)	57/10	45/0
Worst Performance (time/errors	310/35	102/6

By analyzing the table results, we noticed that: when users performed this task with the keyboard, they took an average time of 171 seconds, much longer than achieved with the mini iPad (67 seconds). Also important to mention is that with the keyboard the best performance took 57 seconds to conclude the task, and the worst 310 seconds. When compare with the mini iPad, the fastest users took less than 12 seconds, not a big difference. However, when we compare the worst user's performance, the uses with the mini iPad took less than 208 seconds to finish the same task. This seemed to happen because with the physical keyboard they have to divide their attention when interacting with the keyboard input device and output device (monitor), they cannot make a direct manipulation of the information that is possible with the mini iPad device. When users present more difficulties in concentration or show problems in fine motor skills, the direct manipulation of the information helps to concentrate attention. Another important issue to register is that the number of participants that successfully finished the task is very low, considering the total number of participants in the task, because users had to have a great fine motor skills, to rapidly burst all globes. These did not have to do with the device interaction.

Concerning **difficulties** as felt, with the keyboard, users showed difficulties when they had to press two keys simultaneously and switch the correct order of the arrows [3]; with the mini iPad these difficulties disappeared because they could control all the game by using one finger.

These results indicate that the iPad provides a better performance, as our audience become more effective, more efficient and satisfied.

We compared the task 5 (T5) navigation, users had to perform three search in the Web. As they had used the Yahoo! Images browser and had much time to learn their interaction, we did not use this platform again. Because the learning time they had could influence the results.

With the keyboard, nineteen participants partook in this activity (two were absent) and all participants successfully finished the task.

Next, we present a table to compare efficiency with the two devices (table 2):

Table 2. TASK 5 - efficiency values for Keyboard/Mouse and mini iPad.

	Keyboard/ Mouse	iPad
Number of participants	20	20
Number of participants that successfully finish the task	20	20
Average time to conclude all tasks	383	71.25
Best performance (time/errors)	243	49
Worst performance (time/errors)	976	348

As for difficulties felt, users struggled with the keyboard and mouse: they usually confused the keys from the keyboard and mouse buttons, and continuously clicked in one key, which lead them to frustration. Likewise, they had many difficulties in writing the keywords with the keyboard. Despite the fact that they had to have the word written in a paper, they seemed to do it easily with the iPad. Another observation made was that users had low precision to click in reduced areas in the mouse and with the mini iPad they got around this difficulty during the tasks. They did not had any problems with scrolling option on both devices, neither with the task comprehension.

4. CONCLUSION AND FUTURE WORK

After performing this study, we believe that in terms of effectiveness, efficiency and user satisfaction, the results obtained suggest that the mini iPad is a usable device for this group of people with intellectual disabilities when comparing with the keyboard and mouse.

Specifically, when we analyze all variables these results seemed to be more prominent. Regarding the time to finish the task it is evident that the mini iPad helped to spend less time in their performance; also the number of errors made is a good indicator of the efficiency of this device.

The difficulties felt with the keyboard and mouse where overcame with the mini iPad interaction. In detail, they continuously clicked on a key and frequently confused the right and left mouse buttons. These difficulties were not observed with the mini iPad because the control in this device is made directly through the screen, and this fact seemed to be a more effective way to interact also because they presented some problems in the fine motor skill coordination. Also, the mini iPad does not trigger the writing of a character without the letter key is released, i.e., for each touch only trigger one letter.

Regarding satisfaction, participants showed interested in performing the tasks and never asked to quit, despite the difficulties they encounter. Likewise, participants seemed to be highly motivated as they frequently ask to try new features of the interface and to experiment other activities.

As future work, we want to perform more activities using the iPad device, also we intend to increase the number of participants to allow a more detailed analysis of the results with respect concerning to the level/type of impairment and work with other groups with intellectual disabilities and with different levels of disability, from severe to profound, in order to replicate these results. Ultimately we wish to continue to draw attention to this group of people who are digitally excluded.

5. ACKNOWLEDGMENTS

We thank all people who directly or indirectly helped in this study. This work is partially supported by the project "TEC4Growth - Pervasive Intelligence, Enhancers and Proofs of Concept with Industrial Impact/NORTE-01-0145-FEDER-000020"is financed by the North Portugal Regional Operational Programme (NORTE 2020), under the PORTUGAL 2020 Partnership Agreement, and through the European Regional Development Fund (ERDF).

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