Performing universal tasks on the Web: interaction with digital content by people with intellectual disabilities

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ABSTRACT

With this study we intent to better understand how a group with intellectual disabilities interacts with digital content, namely web content, when performing equivalent tasks from their daily school activities, such as: painting, making puzzles, playing games. To accomplish this we observed how a group with intellectual disabilities, without experience using computers, performed universal tasks (selection, manipulation and navigation) when presented with different activities on the Web such as painting, playing games or searching. We aimed at evaluating usability and accessibility and for this we registered the following variables: successful conclusion of activities, type of difficulties found, errors, satisfaction, motivation and autonomy indicators.

Participants showed motivation and learning skills when performing all the three universal tasks (selection, manipulation and navigation) which is confirmed by the number of participants that was able to conclude the activities. Concerning errors, it was observed that despite the large number of errors made by the participants, their motivation lead them to complete the tasks. When handling the input devices the participants had a good performance using the computer mouse. On the other hand, they could not use the keyboard alone because of their reading/ writing difficulties.

Categories and Subject Descriptors

H.5.2 [**Information Interfaces and Presentation**]: User Interface – *Input devices and strategies, Interaction styles, Training, help and documentation.*

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General Terms

Human Factors, Performance.

Keywords

Digital literacy, intellectual disability, learning disabilities, universal tasks, Web interaction.

1. INTRODUCTION

We live in an advanced technological world and the Web resources provided numerous advantages, professional and social, "just a click away". As Tim Berner-Lee, stated "The power of the Web is in its universality. Access by everyone regardless of disability is an essential aspect" [1]. Although, some users see their Web access hampered, in the particular case of people with intellectual disabilities, these barriers are increased, enhancing digital exclusion of this group of people [2].

This reality was presented to the research team when they were challenged to start working with a group of people with intellectual disabilities. After the first meeting with their teachers, we realized that they had many difficulties in motivating their students to perform school activities as well as choosing which learning material resources to use with a group of people that discourage very quickly and present many unfinished tasks. Such aspects lead us therefore to study not only if resources from the Web can be a viable option to enhance learning for this group of people as well as an option for special education teachers (and possibly a tool leading to the digital inclusion of a group previously excluded).

Thus, this paper presents a study on how a group with intellectual disabilities performs universal tasks on the Web (selection, manipulation and navigation). The activities presented to them were based on their daily school activities, such as: painting, making puzzles, playing games and word search. These activities were chosen to: motivate the group to perform daily school activities on the Web; enhance their abilities when performing selection, manipulation and navigation tasks; and train the use of the computer mouse and keyboard handling.

We observed and took notes of major barriers found in their interaction and their potential technological skills (manage to complete successfully digital activities using the usual input devices), errors and difficulties found, when using the Web. For this assessment we allied ethnography and usability evaluation (user tests).

2. Background

According to World Health Organization (WHO), an individual with special needs ("disability") has impairment (a problem in the body's function and structure), conditioned activity (difficulty in performing a task or action) and a restrained participation (it is a problem experienced by an individual, on a daily basis situation) [3].

Particularly, 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. Despite this disability, they can and should learn new competencies and abilities. However, their development will always be slower when compared to a child with medium intelligence and adaptive competencies [4]. It is therefore crucial to be aware of different pathologies (and degrees of severity) among the group of people with intellectual disabilities in order to choose appealing school activities and appropriate didactic methodologies and thus motivate these students to learn [2].

Several national and international studies indicate that the use of the computer and other technologies have major advantages in the learning process, pointing to increased motivation, performance and promotion of the use Information and Communication Technologies (ICT) [5] [6] [7] [8]. Explicitly, ICT provide several possibilities of communication, new ways to transmit knowledge, motivational tools to enhance learning, access, efficiency and quality of the learning process [9]. Moreover, the International Institute for Communication and Development (IICD) (2007) study reveals that 80% of the users "felt more capable by their exposure to ICT" and 60% said were "direct and positively influenced by ICT" [6].

Likewise, there are several studies that recognize the advantages of ICT use with students with special needs and disabilities [10] [5] [11] [8] [12]. In these studies it is strengthened benefits provided to these students by the ICT in education. ICT are more efficient and effective due to the user' motivation in the interaction with the computer, used as assistive technology or pedagogical tool [13] [14]. Although the great number of ICT studies in literature, it is highlighted the importance of further research on users-interface interaction, accessibility of contents, pedagogical approaches using ICT to support inclusion in special needs education [10] and usability of the different applications developed. It is also evident a lack of ICT solutions for people with disabilities, such as visually impaired people, but when compared with people with learning difficulties this number decreases [11].

We believe that the Web can be an unlimited source of activity resources to enhance education for people with learning difficulties and for people with intellectual disabilities. However, there are several accessibility barriers in this environment, particularly raised by their own disability, due to their slower learning, low reading comprehension, limited fine motor control, reduce spatial perception, low visual acuity, less hand/eye coordination, finger dexterity and lowered information overload thresholds [20], leading to digital exclusion of these users [15]. In several studies it is even questioned the possibility of finding a guiding principle when planning Web sites for people with learning and intellectual disabilities [16], also related to difficulties resulting from the wide range of disabilities among such group of people. Other studies highlighted problems found in Web interaction such as: text entry is problematic and multi-options are referred as difficult to use [16] [17]; hyperlinks recognition are difficult [18] [17] and also typing, scrolling, reading of instructions and understanding that users are in a Web environment [19]. One even stated that W3C-WAI guidelines for accessibility are insufficient to ensure access to people with intellectual disability [19]. Other study refers that despite these guidelines had important issues about learning disabilities, almost all elements regarding this disability are identified as lower priorities [20].

3. Web interaction study per people with intellectual disability

In this study we had the responsibility to train a group of people with intellectual disabilities (without Web experience) using the Web, by performing tasks related to their daily school activities. We aim at assessing their Web learning evolution process, by using the mouse and keyboard input devices, observing user-interface interaction and performing selection, manipulation and navigation activities.

3.1 Participants

Twenty participants were invited to partook in the pilot study, whose ages ranged from 19 to 46 years old. These participants were selected by a special education teacher and a psychologist, according to the average rate of literacy and primary education (coincident with the first grade). All were volunteers and had permission of their parents or tutors to perform the activities.

Concerning their intellectual disabilities, individuals were not associated to one pathology, but a set of pathologies (for example, fetal alcohol syndrome with dysgraphia). These pathologies can be classified according to severity levels, between mild to moderate, only one of the participants presented a high level of disability [4].

Furthermore, fourteen participants have normal vision and six have corrected to normal vision. Participants had no experience with digital environments or the Internet.

3.2 Methods

In this study, we allied ethnography (to overcome difficulties found in communication within the group) with user tests. The methods of data collection used were directly related to the research methods adopted: interviews, direct observation and videotaping. The activities defined were similar to the ones they performed daily in school, however we they used the Web to perform the activities. These activities were chosen to motivate the group to perform daily school activities, providing technological abilities on Web selection, manipulation and navigation tasks and also exercise mouse and keyboard handling.

3.3 Activities

The activities were defined to train users' selection, manipulation and interaction skills in the Web. We intended to increase activities' difficulty to assess their apprentice level related to mouse and keyboard handling and success of goal reached. This was measured through the increase number of clicks and adding specific objectives to successfully finish the task. All activities and difficulty levels are specified next:

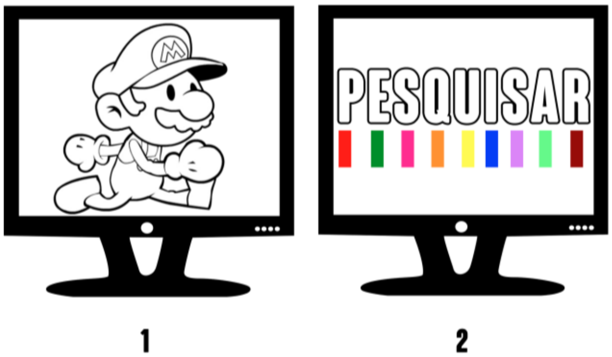

Figure 1: First activity (Painting).

In the first activity, participants had to paint two drawings. In the first drawing, participants had to paint it with colors random (7 to 12 clicks) (Figure 1). In the second, had to paint a word (9 clicks) matching each letter with a specific color (Figure1).

This activity aims to assess the **selection task (**fine motor skills aspects with the mouse use) and comprehension (painting with a specific order and color).

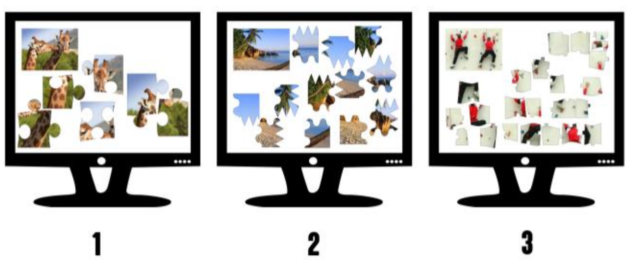

Figure 2: Second activity (Puzzles)

In the second activity, participants must build three puzzles. Specifically, in the first, participants must build a six pieces puzzle; in the second, a puzzle with twelve pieces and in the third, a puzzle with twenty-four pieces (Figure 2). In this task it is intended to evaluate **manipulation,** click, drag and drop movements and fine motor skills, with the mouse use.

Figure 3: Third activity (Games).

In the third activity, it was requested to play two games to introduce keyboard interaction. The first, participants play a game called Puzzle Bobble. This game consists in throwing colorful globes and group them by color, using only three keyboard keys (left and right arrows and space). Whenever they are grouped in, at least 3 equal balls, they disappear. The player wins when there are no globes left. If the player does not eliminate all globes before them 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 3).

The second game, the participants played a cars game called Extreme Racing 2. In this game, the player must move away of several obstacles that appear on the road. The full game duration is 1 minute and 30 seconds. They had to use the same three keyboard keys (left and right arrow and the space key) to accelerate. The level difficulty increased with the number of obstacles that appear in the road and with the limited time to finish the level (Figure 3).

With this activity we aimed to initiate keyboard handling and assess users' interface **interaction and navigation** and fine motor skills (speed control and precision).

Figure 4: Forth activity (Web search)

Participants performed a forth activity. With this activity we aimed to train them with both devices, mouse and keyboard, and user's interaction with a Web search engine, Yahoo! (Figure 4).

In this activity, users had to perform three searches, with the following keywords: animals, music and sewing tools. First, they had to recognize the search field and click in it with the mouse, then write the word in the search field (previously written in a paper) and click the search button. This task was performed on the Yahoo! Images so that participants can comprehend all search results because of their reading and writing disabilities. Note that this group presents a low level of literacy and it is not intended that they be constrained with text results, once they could not read. This task aimed to initiate user's interaction with the Web, assessing the interaction with Yahoo! layout (by the keywords insertion on the search field of the web browser engine) and fine motor skills, using both devices: mouse and keyboard.

3.4 Apparatus

The following material resources were used: a HP keyboard, optical computer mouse, Chrome Web browser.

3.5 Procedure

Before starting the planned activities, for two weeks approximately thirty-five hours in total and two and a half hours per subject) the group was faced with basic and essential issues needed to use the computer and the Internet. The participants were told how to connect a computer and how to handle the mouse/keyboard and its use. Also, we presented the basic features of the Web browser. It was given a brief explanation on how to open/close the browser, use buttons on the browser and their functionalities: the previous and next arrows, maximize, minimize and close windows, search the Web pages activity in the favorites options (previously recorded) and click in the Web page to start the activity. Furthermore, they were shown how they might recognize a link, or when the content is clickable or not clickable, based on the transformation experienced by the mouse pointer icon (e.g. when the mouse pointer is over a link the original icon, the arrow, becomes a hand).

After this preliminary stage, the group performed the four Web activities, in 16 weeks (approximately forty eight hours in total and two and a half hours per subject). The activities were performed individually, in a controlled environment. Each task was explained before the participant initiated it. Participants were seated correctly in front of the screen. All tasks were displayed in the computer and performed in the Web. The evaluator/observer did not help the participant on the input device interaction or resolution of the activity unless him/her asked for it.

3.6 Results and discussion

3.6.1 First activity - selection

In the **first activity**, participants painted two drawings. The **first drawing** was painted by nineteen participants (one user was absent from the class). The average time of conclusion of the task was 292 seconds. The fastest participant took 59 seconds to conclude the task and the slowest, 601 seconds. During this assignment, it was observed that ten participants use the mouse correctly; seven had difficulties with its use and control and two participants had difficulty in the beginning but overcome those difficulties before finish. No one quit.

The **second drawing** was painted by nineteen participants (one participant was absent from the class). In this activity we register: time to finish successfully the task (to match the predefined color to the letters), errors on color correspondence (an average of approximately 1.7 errors) and mouse clicks to finish the task, difficulties and dropout rate. The average time to complete the task was 326 seconds. The fastest participant finished in 90 seconds, with 18 clicks and 0 errors on color correspondence and the slowest 600 minutes, 53 clicks and 8 errors on color match. Errors observed were on color match (a total of 32) and on painting the surrounding area (six participants). Concerning the difficulties observed, five participants show difficulties in the mouse handling, such as: in the correct hand's positioning, correct use of the buttons and in cursor precision. Participants revealed interest and motivation to successfully finish this second drawing. No participant quit.

In this activity we observed a learning evolution on the mouse handling as, in the first drawing, seven had handling difficulties and in the second, five. Two participants improved their performance between the two drawings tasks. Specifically, in the first drawing, it was observed difficulties in the mouse input device handling when they had to painting small areas. In the second drawing, participants had difficulties on the colour matching. Despite these difficulties, no participant asked to quit. Another observation made, in the second puzzle, users painted the surrounding area of the drawing when trying to paint the character, they did not had the mouse handling precision needed to make the selection. When asked why, they answered the area (character) was too small. Regarding the results, we conclude this selection activity is ease to perform by the group and they will have technological abilities to repeat in another context.

*3.6.2 Second **activity – manipulation***

In the **second activity**, users made three puzzles. The **first puzzle** was made by nineteen participants (one was absent), with an average time of 112 seconds to complete the puzzle. The fastest participant did the puzzle in only 18 seconds, on the other side, the slowest took 231 seconds due his/her difficulties handling the computer mouse. Three participants have difficulties in handling the mouse and two in the correct position of the puzzle pieces, however no one quit.

In the **second puzzle**, from twenty participants only seventeen accomplished the task (three were absent). The average time for the level conclusion was 277 seconds. The fastest participant finished the puzzle in 64 seconds. The slowest user concluded the puzzle in 618 seconds due to him/her difficulties in the mouse handling. Three participants still had difficulties in mouse handling and five in the correct position of the puzzle pieces. Due to mouse handling difficulties, two participants refused to finish the task.

In the **third puzzle**, nineteen participate in the task (one was absent). This puzzle had a time average of 557 seconds. The fastest user concluded it in 289 seconds; on the other hand, the slower user finished the task in 1171 seconds, presenting many difficulties in mouse handling. Regarding difficulties found, three participants had problems with the mouse handling (specifically, one presents difficulties in the mouse' hand positioning) and five with the correct position of the puzzle pieces. Three users quit the task due to puzzle construction difficulty.

In figure 5, it is compared the average time for conclusion of the three puzzles made on the second Web activity.

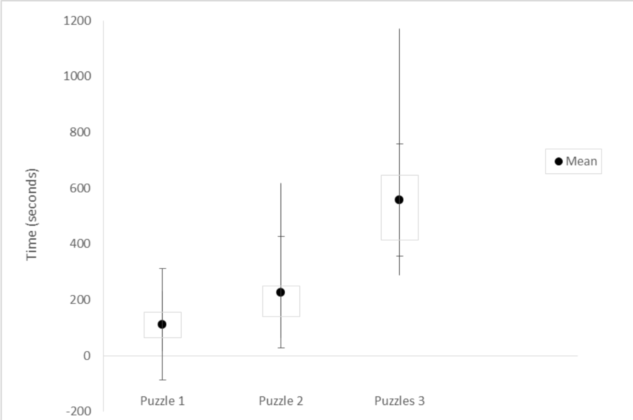

Figure 5: Average time for conclusion of the three Puzzles.

As expected, users take more time to finish puzzles with higher number of pieces because it increased the complexity of the activity, despite users having more experience with manipulation tasks and mouse handling.

In the **second activity** (puzzles) it is noted that previous learning with the mouse input device handling was not forgotten, once the participants improved their performance. After the first puzzle, three participants showed difficulties in the mouse input handling. In the second puzzle, the same three participants had difficulties and two quit this puzzle. However in the third puzzle, no one refuses to perform the task, three had difficulties but no one quit. Regarding puzzle construction (put the puzzles pieces in the correct places), in the first, two asked for help but no one quiet; in the second, five users needed help; and in the third puzzles, six participants asked for help and because of the large number of pieces, users showed some frustration in finishing and three wanted to quit. Despite the increased number of dropouts (when compare with the selection activity), we notice although users quit the task in hands they did not refuse to participate in the next Web activities. This was considered an important result by the group' teachers because they confirm that when participants refused and quit a school daily task (without using the Web) they never wanted to repeat a similar task (in such a short time) and teachers had to insist very hard to make them performed it. Regarding manipulation, we notice participants gained abilities to perform these activities with proper training.

3.6.3 Third activity – navigation

In the **third activity**, participants had to play two games. The **first game** was played by eighteen participants (two were absent). Only eight concluded successfully this level, i.e., eliminated all colour balls before "Game Over". The average time of playing was 171 seconds. The fastest user took 57 seconds to eliminate all balls and the slowest, 310 seconds. We also noticed that from the eight participants that successfully concluded the task, five did have difficulties in handling the keyboard. From the remaining ten, nine had difficulties but two participants overcame their difficulties during the task. Thus, thirteen participants showed difficulties in this first interaction with the keyboard. The difficulties observed with the keyboard handling, were: users press two keys simultaneously and switch the correct order of the arrows. Seventeen participants asked to repeat the game. No participant quit.

The **second game** was performed by eighteen participants (two were absent). Nine users did not present any difficulty in the keyboard handling, one improved during this level (however he/she did not successfully complete the task- before "Game Over"). Regarding, successfully conclude the task, four participants did not finished the game (not because of keyboard handling difficulties but due to the fact that they did not reach the requested velocities in order to finish before "Game Over"). It is noticed an improvement in the users' keyboard handling between levels. Eighteen participants asked to repeat the game. No user quit.

Regarding these results, it was notice that in the first game (Puzzle Bubble) the success conclusion rate was low (when compared with previously activities), ten participants did not finished the game successfully, i.e., before "Game Over". In the second game (Extreme Racing 2) only four participants did not finish successfully the game (before: GAME OVER). With these activities, they started to handle the keyboard (started to use the arrows, enter and space keys), and the major difficulty was found was that they click in two keys at the same time but they overcome it during the task. No one quit and just one participant did not ask to repeat the first puzzle. They seemed to be very comfortable in the interaction and showed great satisfaction and motivation to perform these activities. Concerning interaction, with proper training and time for learning, users showed technological abilities to perform these activities.

3.6.4 Forth activity – characters insertion

Regarding the **forth activity**, three Web searches, nineteen participants performed the task (one was absent from the classroom). In the **first Web search,** the average time for task conclusion was 373 seconds. The fastest participant finished the task in 249 seconds and the slowest in 803 seconds. The major difficulty observed was in the keyword reproduction, i.e. identifying the character to write the right word, seventeen participants had this difficulty. Regarding input devices handling difficulties, no participants had difficulties with mouse input device and four had difficulties with the Keyboard (they click in two keys at the same time). Also it was observed satisfaction on the search performance once they laugh and clap their hands showing great happiness went the result appear in the screen. Another observation was that users often clicked on the images found within the search results. No one quit the task.

In the **second Web search,** the average time for task conclusion was 386 seconds. The fastest participant concludes the task in 243 seconds and the slowest in 976 seconds. Twelve had difficulties in the keyword reproduction and three with the keyboard handling. No participants had difficulties with the mouse input device. They showed satisfaction and motivation to perform this search, asking to repeat the Web search. No one quit the task.

In **last Web search,** the average time for task conclusion was 390 seconds. The fastest participant concludes the task in 244 seconds and the slowest in890 seconds. Eight had difficulties in the keyword reproduction and three with the keyboard handling. No participants had difficulties with the mouse input device. They asked to repeat the Web search, showing satisfaction and motivation. No one quit the task. Here it was observed that they use the ENTER keyboard instead using the mouse and click in the search button.

In figure 6, we compare the average time for conclusion of the three Web search users made on the forth activity.

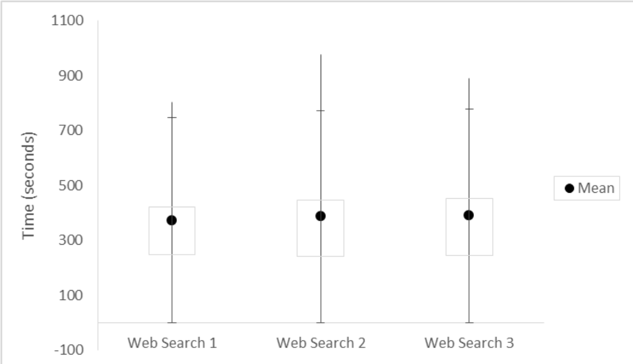

Figure 6: Average time for conclusion of the three Web searches.

Comparing average time between the three Web searches, it is noticed that the results were very similar.

In the **fourth activity (Web search)**, they performed three Web searches and it is noted an evolution in the users performance during the activity. Notice here they had to handle both, input devices, mouse and keyboard, and it was not observed any difficulties in the mouse handling, with the keyboard, users several times click in two keys at the same time or click continuously in one key but they overcome during the task. To write the keyword with keyboard to start the Web search was the major difficulty observed, participants struggled with character recognition (on the paper and keyboard keys) and with word formation. In relation to navigation, after the keyword insertion, users naturally navigate on the page, by clicking on the images presented and using the mouse input device.

4. Conclusion and future work

As this group often do not have the opportunity to perform activities with the computer and the Internet, because many professional (teachers, developers) feel that they have no abilities or the will to do so, this study pretend to shows that they can carry out (with training) basic tasks of selection, manipulation and navigation. The results showed that this group had great motivation and satisfaction to perform Web activities. Despite the difficulties found with the keyboard input device, they had an excellent performance in handling a normal mouse input device.

From the beginning of the activities they showed great progresses on the mouse and keyboard handling. After performing all activities they all could correctly handle the mouse. Regarding the keyboard, they did not have difficulties using the function keys (such as: arrows, enter and space) but had many difficulties with the character keys. This appended because of their reading and writing difficulties. Thus, we believe it will be very difficult to these users to use the keyboard input device with autonomy.

Also, we observed when asked users to perform complexes activities, which are difficult to conclude due to the participants own disability restrictions, can discourage the users with intellectual disability and lead them to quit.

Global results showed performing activities in a Web environment provided a high group’s success and a low dropout’s rate. We believe with regular training they can gain technological abilities.

As future work, we want to study alternatives solutions for keyboard input devices such as: voice application or search with images, to overcome reading and writing difficulties presented by the group with intellectual disability. Also, we intend to increase the number of participants to allow a more detailed analysis of the results with respect to the level/type of impairment. And thus continue to draw attention to this group of people that is digital excluded.

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