Ergonomic and Usability Analysis of Interactive Whiteboards in the Academic Environment

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Abstract. This paper presents the usability analysis about the using of interactive whiteboards, specifically the EPSON Brightlink 475wi + model, evaluating its functionality for didactic purposes in classrooms. The research was done in CAC, the Centre of Arts and Communication of the Federal University of Pernambuco, where observations, interviews and questionnaires with potential users have been done. The aim of this research is to propose possible improvements that could be done in its hardware, software and interface, in addition to evaluate the educator's preparing in relation to all the tools that the interactive whiteboard disposes, and how its knowledge is shared to the students when using this equipment. The purpose of this investigation is to do an ergonomic analysis of this important educational tool, which is generally underused by the educators, and to bring the users possible solutions so they can explore its maximum resources in their classrooms.

Keywords: Technology in education · Ergonomics · Usability

1 Introducion

Usability is a term used to define the ease which people employ a tool or a certain object to perform a task. It's also the property of a system in making a user succeed when executing its tasks (1). Ergonomics is studied in order to improve, per example, the workspace of people, creating compatibility between the needs, abilities and the worker's comprehension capacities. When dealing with products and virtual interfaces, ergonomics studies the best way for an object, or information, successfully reach the user, thus achieve its own goal.

The digital interactive whiteboard mixes elements from a wide number of Technologies as well as typical educational utilities, as the computer, the traditional whiteboard, the touch function – formely present in tablets and smartphones – and the slide projector. Its board (or device) is connected to the computer and its image is projected by a multimedia projector. Until then, the datashow performed under the same procedure, however, the interactive board may have its projected screen directly manipulated by the user's finger or a special pen. In this aspect, everything that is

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available in the form of computer resources, multimedia, image simulation and web surfing is possible through the user's interaction directly with the content.

The digital boards are available in a wide array of models in the Brazilian Market. Regardless of the utilization approach by the user, the interactive boards can be used in: companies, shows, events, schools, universities, etc. This research studies the digital board in the educational setting, focusing on its use in the undergraduate/graduate levels. It can be observed that, in the XXI century, technology is operating everywhere, reaching the classrooms. There are four models of digital board in Brazil, as follows:

1. **The electromagnetic board** is an equipment that allows interacting through the touch of specific pens on a surface, that being an electromagnetic field. Despite the high-quality writing recognition ability, it only works with specially designed pens, which are costly if lost. Furthermore, it does not tolerate two or more simultaneous users.
2. **The resistive digital board** allows interaction through finger touch on its surface, usually made of polyester, what makes it very soft. What makes this board different from the others is that the touch command will only be identified if the surface possesses a resistive membrane that refuses the use by more than one person at a time, since it recognizes pressure points on the membrane. By requiring a resistive membrane, the board may also need more constant and expensive technical repairs.
3. **The infrared digital board** has been evolving along the years, becoming capable of being produced without the necessity of special pens, however, most equipment still demands pens that, if lost, will prove to be expensive for the consumer. The infrared digital board has infrared light rays being directed on the board in a down and across pattern. When an object touches the board, it stops the light rays and through coordinates, the computer identifies the location where the stroke is being made.
4. **The optical digital board** possesses sensors that capture the movements of the user and also allow interaction through finger touch or simple pens. Depending on the model, up to four users can be recognized by the board.

According to Jeffrey Rubin, usability can also be defined as the group of four factors united in a single device:

1. Capability of being successfully used;
2. Ease of being used;
3. Capability of the user learning how to use the device in a simple, fast manner;
4. Provoking visual satisfaction to the user.

Following these four factors, this article has the objective of evaluating the Epson Brightlink 475 wi + digital board, currently installed in the Design Department of Universidade Federal de Pernambuco. Basing ourselves on the parameters established by Jeffrey Rubin, an experiment was developed and put to practice with the Design students and other potential users of the device, such as teachers of other departments of the university. The equipment is being used in both public and private schools of Recife, and is available in different models.

The research was prepared for the Ergonomia e Usabilidade class of the Bacharelado em Design course of Universidade Federal de Pernambuco, conducted by

professor Marcelo Soares. The objective of this research is to evaluate the usability of the digital board, taking note of criticism, difficulties, observations and suggestions the users may want to make. The research, administered during the length of the discipline, is focused in the analysis of the digital board and its physical and interactive properties and, based on this, organize an experiment using surveys, observation sheets, functionality registration videos and thus, gather data for how to make best use of the equipment.

1.1 Selected Model: Epson Brighlink 475wi+

The digital board model was available for the research group in the Design Department office of UFPE, and was evaluated during the semester of the Ergonomia e Usabilidade discipline. To better understand the tools of the device, many assignments were done during the classes, summing up information about the digital board and its technical functions.

The box includes: one interactive projector (Fig. 1), two interactive pens (Fig. 3) and a remote controller (Fig. 2). This **infrared interactive projector** is usually permanently installed in a classroom, usually on the ceiling, what improves its short-distance function, avoiding the casting of shadows and visual disturbance caused by its light. The **interactive pens** can be used simultaneously by two users when the board is connected to an USB port, being a manually-operated device that can have its points and batteries (AA type) changed. The **remote control** takes care of two functions: projection and interactive configurations, besides controlling how the digital board must be activated (USB or VGA), and to control screens in real time.

Fig. 1.

Fig. 2.

Fig. 3.

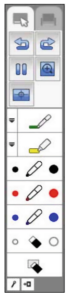

Fig. 4.

There are many differences between using this model either with or without the help of a computer the main one is regarding the simultaneous use of pens. In the VGA mode (without the help of a computer) only a single pen works when touching the surface. On the USB mode (with the help of computers), two users can use pens simultaneously. Another major difference is in the "screen saving" function, available on the USB mode but not on VGA, due to the absence of internal memory. Moreover, the interactive toolbar for the VGA mode (Fig. 4) has less functions than that of the USB mode, which makes use of the **Easy Interactive Tools** (Fig. 5), software that can

Fig. 5.

be installed on the computers for more complex annotations. One of the functions of the Easy Interactive Tools is to adapt itself to different software, as Power Point, becoming even simpler for presentations. Furthermore, the Easy Interactive tools can be configured by the remote control, making the interaction between user, desktop and computer devices, such as a mouse, possible.

2 Methodological Procedures: Field Analysis in Conjunction with the Academic Community

After the data-gathering period about the Epson Brightlink 475 wi + digital board, a practical analysis was needed for the team to know, regarding ergonomics and usability points, gather data about improvements, experiments and critics about the product. The field analysis became necessary due to the lack of use by the professors and the whole of the academic community. Few students knew the equipment was interactive, so it was being used just for projections. The professors of the department who knew the equipment was interactive did not use the pens due to fear or lack of technical preparation.

We decided to use methods learned during the Ergonomia e Usabilidade course for the practical analysis. The Epson Brighlink 475 wi + digital board studied by us belongs to the auditorium of the Design course of UFPE. The users selected for test are part of the academic community of Centro de Artes e Comunicação, where the Design e Expressão Gráfica course keeps the device. We've evaluated Design students and professors from different areas, including Expressão Gráfica, Design and Engineering.

An analysis in which the final product is appraised for the gathering of critical information and possible improvements of the product was made. For the purpose of studying all the participants in a uniform manner, we proposed a task they could perform on a daily basis: a powerpoint slide presentation. With the objective of evaluating how the user behaves while using the tool, regardless of having used it before or not, we asked them to only use the interactive pen on the digital board, without using the mouse or keyboard for any task.

The interface of the digital board has two lateral interaction bars: one that can be used on any screen, and another that becomes simpler when a full screen powerpoint presentation is being shown. We asked the users to use only the simplified interface.

The research group developed exercises of different difficulty levels, selecting that one which all of the users would be capable of completing. We prepared a presentation with seven slides, aiming for the observation of the behavior of users when *passing a page*. On the seventh slide, we asked from the users to perform three tasks of the interactive board (Figs. 6, 7).

A - Highlighting a part of text with the *highlights* tool.
B - Writing two notes, with two distinct colors each.
C - Erasing what had been written.

All the tasks were documented in video so that the research group could register the opinions and progress of each user, as well as the time taken by each one of them to accomplish each task.

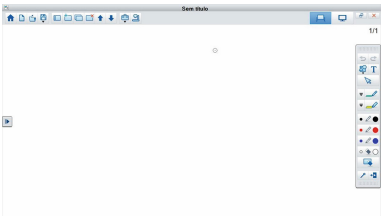

Fig. 6. Complete bar

Fig. 7. Simplified bar

The collecting of users' data was done through a semi-structured type interview survey developed by the group and given to the users at the end of the task, procedure that was also documented in video. We developed a survey on which the user would feel comfortable to take any notes about the product, and making use of questions that, if by any chance a user had forgotten to comment about at a given moment, they would be able to comment about moments later.

Semi-Structured Interview about the Use of the Digital Board:

Age: *Occupation:*

General	***About the interface***	***About the physical pen***
1. *Have you ever used a digital board before?*	9. *What did you think about its digital interface?*	15. *Did you like the physical pen tool?*
2. *Do you use this device? If the answer is "yes", how frequently?*	10. *Was it easy to locate the writing tools?*	16. *Did you think it was easy to use?*
3. *What did you think about the experience with this digital board?*	11. *Was it easy to select the desired tool?*	17. *Is the physical pen comfortable? Why?*
4. *What did you like about it?*	12. *Was it easy to select the color of the pen?*	18. *What did you like about it?*
5. *What didn't you like about it?*	13. *Was it easy to highlight the text?*	19. *What didn't you like about the physical pen?*
6. *Would you use this device again? Why?*	14. *Could you erase what you wanted?*	20. *What did you think about the pen's sensitivity?*
7. *Which were your biggest difficulties with it?*		
8. *What would you suggest to be changed?*		

An structured observation sheet with headings and pre-made, multiple-choice answers was developed, and in addition, open points for general observations and for the description of the environment, so that the observers could, as a unity, evaluate how each user behaved while using the digital board. The sheet used for this observation was based on a sheet used in a previous research, in which the professors (final users) of the public and private schools of Recife were appraised while using the digital

boards that belonged to the schools (BITTENCOURT, 2014). Differently from this previous research, the observers could, this time, study how the Design department board works for the purpose of elaborating a sheet and tasks which are more accurate to the product.

Observation Sheet for the Classroom – Digital Board

Institution: Occupation: Age:

1. Description of the environment of the classroom being studied:

2. Physical complement of the digital board:

( ) pen ( ) 3D glasses ( ) projector ( ) Others: _____

3. How does the user relates to the digital board?

( ) Without difficulties ( ) With little difficulty ( ) With a lot of difficulty, presenting interruptions ( ) With difficulty, requiring assistance of other people

4. How well could the user present the class making use of the slides?

( ) Without difficulties ( ) With little difficulty ( ) With difficulties, being helped by other people

5. How did the user passed from slide to slide?

( ) In one of the correct ways, by clicking on the screen ( ) In one of the correct ways, by clicking on the arrow located in the simplified tool bar ( ) Initially incorrectly, but later noticing his/her mistake and performing the correct operation ( ) In an incorrect way ( ) Could not pass the slides by him(her)self

6. Could the user highlight the text?( ) With no difficulties ( ) With little difficulties ( ) With difficulties, needing assistance of other people ( ) Could not perform the task

7. How did the user highlight the text? ( ) With the correct tool ( ) Initially with the incorrect tool, but changing to the correct one after noticing the mistake ( ) In the incorrect way

8. Could the user write? ( ) With no difficulties ( ) With little difficulty ( ) With difficulties, needing assistance of other people

9. How did the user write? ( ) With the correct tool ( ) Initially with the incorrect tool, but changing to the correct one moments later ( ) In the incorrect way

10. Did the user present difficulties while dealing with the pen? ( ) Yes ( ) No

11. Usually, which devices does the user – when a professor – uses during classes? ( ) Datashow ( ) White board ( ) Online researches ( ) Games and dynamics

12. General Observations:

The experiment was conducted during the course of two days, each day with students and professors of different age groups – precisely, six Design students and two Design professors, and the other two professors coming from Expressão Gráfica and Engineering.

As a result of the user experience, only three of them affirmed to have utilized some kind of digital board before, the first experience as user being with the interactive board

of the Design department. All the interviewed users maintain contact with touch screen devices, making the task easier for some.

The task was analyzed since the first moment in which the user touches the pen on the slide for the first time, making it possible to observe if they would click on the screen – what happened to half of participants. The other half employed another correct way of passing a slide, although a more laborious one, which is to reach for the interactive toolbar and to press the arrow to get to the next screen. Four of five users who simply touched the screen in order to pass to the next slide had the intuition of *sliding* the tip of the pen to pass to the next page, linking the experience to the use of an average touch-device (tablet and smartphones).

Regarding the graphic interface of the interactive toolbar, a unanimous opinion surfaced: the pen and highlights icons should be easier to differentiate – some users selected the wrong tool for a determined task – what made the experience of identifying an icon a matter of luck or trial and error.

While performing the task (writing two notes, each one with different colors), some users found it hard to accomplish due to some technical issues of the product: in some moments, the user pulled the pen away but the magnetic recognition remained as if the pen were touching the surface, leading to the appearance of non-intentional strokes. Another problem that was observed is that, even when touching the surface, some pen strokes were not recognized, what made the users try to repeat the command once more or apply extra pressure on the tip of the pen.

Out of the ten selected users, two raised the issue of the inadequacy of the surface used for the projection: a shiny, translucent glass board. It was mentioned that during classes without the digital board, marker pen strokes become hard to be seen due to the glass board. Design students have claimed to feel difficulty while reading from the glass surface. Even though a removable sheet of white canvas had been provided, the surface makes the task of writing on the board even harder, due to its lack of stability.

As a conclusion to the analysis, the participants raised criticism and suggestions about the physical pen. Complaints as poor battery access positioning and lack of texture – the body of the pen is completely slick, what makes it easier to slide off or hurt a user's hand – were also made. The users felt that the task would have been more dynamic if shortcut buttons were added to the pen, such as forward/backward buttons or buttons that could change the function of the pen from regular pen to highlighter to an eraser or a color function. Out of the ten users, three suggested that one of the extremes of the pen could work as a *magnetic eraser,* eliminating the need of reaching for the eraser icon.

None of the users expressed dissatisfaction about stature, given that the object of the activity did not allow for them reaching for extreme points of the surface, thus, making it possible to keep the activity within eye level. Nevertheless, while interacting with other software, some users could find it uneasy to use icons or menus set too distant from their regular reach area.

3 Conclusion

It was possible to verify that many of the difficulties found during the tasks happened because of the lack of familiarity or non-adaptation of the users to the equipment, making it being used only as a *datashow*. This issue could have been solved with a brief training with professionals from the companies that sell the product, as a way to increase the use of the boards by the users.

During the tasks performed by the participants, we observed that text highlighting was done in the incorrect way: by making a circle around the text instead of choosing the appropriate marker. These mistakes lead us to a reflection about the term "highlight the text" used on our activity sheets, since the word used could have caused some confusing (being mistaken with "emphasize") or by the fact of some people having habit of making their texts more visible by using circles around the words. Yet, another determining factor for the problems found was choosing the incorrect tool, since the pen and marker icons look similar; what left users in doubt or even lead them to make mistakes. Some participants opted for the trial-and-error method in order to verify if the selected tool was the correct one. This also happened because of the equipment being feedback-deficient.

Consequently, we propose a redesign of the highlight marker icon, as well as offering feedback to the user when selecting this tool, along with a color-choice feedback function, thus, decreasing the chances of mistakes and increasing rates of successful use of the tool.

Regarding the interaction between user and physical pen, used during every moment of the experiment, we could verify a deficiency in sensitivity from the device, especially during the free-handwriting moments, what put obstacles in the way of the task and made the users disconcerted. The classroom were the users took the tests has a glass board, what may influence on the sensitivity of the pen, given its surface being translucent and reflective. The ideal surface for the digital board should have a smooth, dull white finish. Some participants informed that the pen was a somewhat thick and caused discomfort when being manipulated.

To make the experience more productive and pleasant, the pen could be redesigned, in order to improve its sensitivity and speed to answer to commands, besides including, on its laterals, shortcut buttons so that more dynamic actions could be performed, making an easier use of the most used commands, such as forward, backwards possible and changing from pen to highlight marker or eraser.

In face if the results, improvements on the interface of the digital board are necessary, as well as improvements on the physical attributes of the device, with the aim of decreasing chances of uneasiness by the users, turning it into an easier, more enjoyable task. For this reason, it's essential that the companies and professionals producing this type of device give more attention to the needs of the users, making sure the equipment is adequate for them. Moreover, it's indispensable that the user should be interested and familiar with the equipment, what will help him/her to make better use of it – even though the device may present some technical issues, it's still capable of helping to produce dynamic, playful classes for both professors and students. Ergonomics and usability provide a base to these studies, placing humans as the main focus, improving relations between people, machines and interfaces.

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