

## Consider the details

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# Consider the details: A Study of the Reading Distance and Revision Time of Electronic over Dry-Erase Whiteboards

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## ABSTRACT

Electronic whiteboards are replacing dry-erase whiteboards in many contexts. In this study we compare electronic and dry-erase whiteboards in emergency departments (EDs) with respect to reading distance and revision time. We find inferior reading accuracy for the electronic whiteboard at all three levels of distance in our study. For revision time, the electronic whiteboard is slower on one subtask but there is no difference on another subtask. Participants prefer the electronic whiteboard. Given the font size of the electronic whiteboard, the inferior reading accuracy is unsurprising but the reduced possibilities for acquiring information at a glance when clinicians pass the whiteboard may adversely affect their overview. Conversely, the similar revision times for one subtask show that logon may be done quickly. We discuss how details such as font size and logon may impact the high-level benefits of electronic ED whiteboards.

## Author Keywords

Electronic whiteboard, usability, efficiency, font size, logon

## ACM Classification Keywords

H.5.2 [User Interfaces]: Interaction styles; Screen design.

## General Terms

Design; Experimentation; Human Factors

## INTRODUCTION

The benefits that motivate the introduction of many new technologies in workplaces are high-level, yet when the benefits remain unattained the reasons are often apparently mundane details. For example, systems for increasing the capacity of air-traffic control have failed because the affordances of paper flight strips were under-recognized [3], systems for asthma self-management have failed because asthmatics did not want to continually think of themselves as ill [5], and systems for facilitating collaborative planning among mutually present people have failed because the screen size was sufficient for individual use only [8].

The background for the study presented in this paper is the high-level benefits that motivate the introduction of electronic whiteboards in emergency departments (EDs) combined with our observations of some potentially influential details that appear to have entered almost unnoticed into the design of the electronic ED whiteboards in Region Zealand, one of the five healthcare regions in Denmark. Historically, dry-erase whiteboards have been used for coordinating patient care and facilitating communication among ED clinicians and have proven to be quintessential for the smooth and safe operation of EDs [7]. The motivations for replacing these whiteboards with electronic whiteboards typically include: more efficient information management, access to whiteboard information from distributed locations, integration with other electronic records, ED capacity monitoring, extraction of statistical performance data, and real-time patient tracking [4]. However, during our involvement in the implementation and evaluation of electronic ED whiteboards in Region Zealand, we observed some design details that might threaten the attainment of these high-level benefits by degrading the usability of the electronic whiteboards.

One such design detail is the font size of the textual information on the electronic whiteboards. The font size is noticeably smaller than the font size of the handwritten information on the previously used dry-erase whiteboards. Informal observation suggests that this makes the displayed information harder to read at a distance and forces the clinicians to move closer to the electronic whiteboard when retrieving information, thus slowing their work pace. Another design detail is the mechanisms for interacting with the electronic whiteboard. Compared to the ease of writing and erasing information with a marker on a dry-erase whiteboard, the process of logging on to the electronic whiteboard and then altering information using either touch screen or mouse and keyboard appears time consuming and complicated. Informal observation suggests that this process may sometimes slow down or disrupt the clinicians and possibly cause frustration. Despite these apparent drawbacks the electronic whiteboards afford the clinicians with a number of possibilities and advantages not afforded by the dry-erase whiteboard. These include standardization of the otherwise often difficult to read hand written information as well as traceability due to login requirements. We decided to compare experimentally the

previously used dry-erase whiteboards with the electronic whiteboards actually used now to uncover the effect of these two design details.

### WHITEBOARD DESCRIPTION

The graphical layouts of the two whiteboards are similar. Both consist of a matrix-like structure with rows and columns displaying patient related information, see Figures 1 and 2. Each row represents a patient and contains patient information such as name, age, medical problem, triage level, attending nurse, and attending physician.

The dry-erase whiteboard measured 118×146 cm. The height of each row of patient information was 8 cm. Information on this whiteboard was handwritten using dry-erase markers and augmented with colour-coded cardboard squares used for indicating triage levels. The division of the whiteboard into rows and columns was permanently marked on the whiteboard.

The electronic whiteboard is a wall-mounted 52'' touch-sensitive monitor displaying a web application. The monitor measures 65×115 cm and has a row height of 3 cm. Information on this whiteboard is entered via the touch-screen interface or via mouse and keyboard. Clinicians log on to the electronic whiteboard by briefly holding a personal token onto a sensor. Log off is done by tapping an on-screen button.

### METHOD

We conducted a within-subjects study in which participants used the electronic and dry-erase whiteboards to solve a reading task and a revision task. The healthcare region and the management of the ED approved the study prior to it being conducted.

### Participants

The 18 participants (17 females, 1 male) were clinicians on duty the day the study was conducted at the ED. The participants comprised physicians, nurses, and auxiliary nurses with an average age of 49.9 years ( $SD = 7.7$ ). They had an average ED seniority of 8.2 years ( $SD = 9.7$ ) and rated the frequency of their use of the electronic whiteboard at an average of 20 ( $SD = 26.78$ ) on a NASA TLX-like scale from 0 (often) to 100 (never). Thus, participants were experienced users of the electronic whiteboard, which had been in use at the ED for 21 months. All participants had normal or corrected-to-normal eyesight.

### Whiteboards

In the study we compared the actual electronic whiteboard in use with the previously used dry-erase whiteboard. During the study the electronic whiteboard and the dry-erase whiteboard were placed in the same room away from the command room of the ED. Interaction with the electronic whiteboard was restricted to the touch-screen interface.

### Tasks

The study involved two tasks: a reading task and a revision task. For the *reading task*, participants were asked to read



Figure 1: The dry-erase whiteboard.

Figure 2: The electronic whiteboard.

out loud the contents of three of the whiteboard rows. The three rows were read at decreasing distances to the whiteboard, first 5, then 3.5, and finally 2 meters. The rows contained 30 to 62 characters of realistic data.

The *revision task* consisted of two subtasks: changing the triage code for a specified patient and entering transfer-to-ward information for another patient. On the electronic whiteboard, the first subtask involved logging on with the participant's personal token, changing the patient's triage code using a drop-down menu, and logging off. On the dry-erase whiteboard the same subtask consisted of changing the patient's triage code by replacing a coloured cardboard square with a square in another colour. Solving the second subtask on the electronic whiteboard involved logging on with the personal token, selecting the transfer-to-ward information from a drop-down menu, and logging off. On the dry-erase whiteboard the same subtask consisted of clearing the cell of any previous contents and writing the transfer-to-ward information with a dry-erase marker. The transfer-to-ward information was 3-4 characters in length.

We included the logon process in the use of the electronic whiteboard because actual whiteboard use at the ED consists mainly of logons to make one or two changes.

### Procedure

The study was conducted at the ED in a quiet room. Participants were first welcomed, explained the procedure, and asked a few questions about their background. Then, participants solved the reading task and next the revision task. Both tasks were first solved using the electronic

whiteboard, then the dry-erase whiteboard. Finally, participants rated the ease of use of each whiteboard on a scale with the anchors ‘easy’ (0) and ‘difficult’ (100) and ranked the whiteboards in order of preference. Participants were asked orally about the reasons for their preference. Each session lasted approximately 5 minutes.

### Data Collection and Coding

The sessions were audio recorded to capture the data from the reading task and the reasons for participants’ preference. Both authors individually coded the accuracy of the reading-task data by comparing these data to the actual whiteboard content. Accuracy was rated on a four-point scale from 1 (unable to read but may be able to discern colour codings) to 4 (fluent, error-free reading). The data from two participants were used for training, after which the authors discussed their coding. The Kappa value of the agreement between the authors’ coding of the remaining participants’ reading-task data was 0.80 indicating substantial agreement [2]. All disagreements between the authors were discussed and a consensus was reached.

For the revision task, the completion time for each subtask was recorded with a digital stopwatch.

### RESULTS

Below we analyse the obtained data using analyses of variance (ANOVA). For the analysis of the reading task, the independent variables were the type of whiteboard and the distance whilst the accuracy rating was the dependent variable. Due to a clerical error one reading task was not audio recorded, leaving 17 participants for this analysis. For the analysis of the revision task, the independent variable was the type of whiteboard while completion time was the dependent variable. All 18 participants were included in this analysis and in the ease-of-use and preference analyses.

Distance	Electronic		Dry-erase	
	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>
5 meters	1.71	0.92	3.65	0.49
3.5 meters	3.06	0.83	4.00	0.00
2 meters	3.76	0.44	4.00	0.00

**Table 1. Accuracy (1-4) for reading task,  $N = 17$**

Table 1 shows the results for the reading task. There was a significant difference in accuracy between the two whiteboards,  $F(1, 16) = 73.92$ ,  $p < 0.001$ , with better reading accuracy for the dry-erase whiteboard. There was also a significant difference in accuracy between the three distances,  $F(2, 15) = 43.89$ ,  $p < 0.001$ . Bonferroni-adjusted pair-wise comparisons indicated that reading accuracy decreased significantly for each increase in distance. A significant interaction between whiteboard and distance on accuracy,  $F(2, 15) = 30.70$ ,  $p < 0.001$ , indicated that the decreased reading accuracy at longer distances was mainly due to the electronic whiteboard.

Individual comparisons between the two whiteboards at each distance showed a significant difference in accuracy at 5, 3.5, as well as 2 meters,  $F_s(1, 16) = 58.86, 22.02, 4.92$ , respectively (all  $ps < 0.05$ ). At all three distances accuracy was better with the dry-erase whiteboard. Notably, accuracy with the electronic whiteboard was not better than with the dry-erase whiteboard for any participant at any distance.

Table 2 shows the results for the revision task. For the first subtask we found a significant difference in completion time between the two whiteboards,  $F(1, 17) = 12.28$ ,  $p < 0.01$ , indicating that the dry-erase whiteboard was faster than the electronic whiteboard. For the second subtask there was no difference in completion time between the two whiteboards,  $F(1, 17) = 0.20$ , n.s.

Subtask	Electronic		Dry-erase	
	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>
Subtask 1	26.52	9.58	19.66	4.09
Subtask 2	25.94	11.29	24.57	4.37

**Table 2. Completion time (seconds) for revision task,  $N = 18$**

Participants rated the ease of use of the electronic whiteboard at an average of 13.89 ( $SD = 17.54$ ) and the dry-erase whiteboard at an average of 6.94 ( $SD = 5.18$ ). For both whiteboards the rating is closer to the “easy” (0) than the “difficult” (100) end of the scale. There was no difference in ease-of-use rating between the two whiteboards,  $F(1, 17) = 2.36$ , n.s.

In terms of preference, 13 participants preferred the electronic whiteboard, 2 preferred the dry-erase whiteboard, and 3 had no preference. A Friedman test of the preference data showed a significant preference in favour of the electronic whiteboard as a whole,  $\chi^2(1, N=18) = 8.07$ ,  $p < 0.01$ .

The participants gave several reasons for preferring the electronic whiteboard. Generally, the participants preferred the electronic whiteboard as a whole because it was easy to use, because it was a smarter system than the dry-erase whiteboard, because it provided more information than the dry-erase whiteboard, and because the text displayed is independent of personal handwriting styles and thus always legible. The most frequent reason stated in favour of the dry-erase whiteboard was that it was very reliable because it had no down time.

### DISCUSSION

Given the design of the electronic whiteboard it is unsurprising that the dry-erase whiteboard can be read accurately at greater distance and revised at least as quickly. What is surprising is that the importance of being able to read and revise the whiteboard information accurately and rapidly seems to have been down prioritized compared to other design considerations e.g. showing more information.

The ED clinicians often glance at the electronic whiteboard in passing, as opposed to stand in front of it scrutinizing its contents. Similarly, the ability to gain an overview by simply glancing at the display is an important feature of other systems [6]. The possibility of retrieving information “at a glance” seems particularly important and useful in situations of fast pace and high workload. While such situations are common in EDs, this study shows that the electronic whiteboard has reduced the clinicians’ ability to read the whiteboard information accurately, especially at longer distances. This may impair the clinicians’ ability to quickly gain an overview of the ED status, in turn slowing down their work pace. An advantage of the electronic whiteboards is, however, that this system provides more and better information, which to some extent seems to negate the disadvantages of not being able to retrieve information “at a glance”.

The time required to revise the electronic whiteboard is longer for one subtask and the same for the other subtask, compared to the dry-erase whiteboard. While the slower performance on the triage subtask is important because triage codes are set and changed 100+ times a day, the similar performance on the transfer-to-ward subtask is the more surprising because the use of the electronic whiteboard involves logon. A candidate explanation for the similar performance on the transfer-to-ward subtask is that the physical token carried by the clinicians provides for an efficient logon procedure. The logon procedure is particularly important in hospital environments because work in these environments is nomadic, frequently interrupted, and characterized by brief periods of use [1]. Thus, clinicians perform the logon procedure many times a day. Bardram [1] identifies logon as one of the reasons why electronic systems often cause more frustration amongst clinicians than their manual counterparts. The participants’ preference for the electronic whiteboard and the absence of a difference in their ease-of-use ratings suggest that the logon procedure is considered quick and simple. The difference in revision time for the triage subtask, which also involved logon, shows however that the interaction mechanisms, including logon, of electronic whiteboards still need to be improved to compare with making simple changes on dry-erase whiteboards. A further challenge in devising these interaction mechanisms is that during real ED work clinicians often manipulate the whiteboard while having a phone in one hand and some papers in the other.

In order to avoid that important details go unnoticed in design processes and thus end up hampering system use, we recommend that systems be evaluated in the field before their design is finalized. Such pilot implementation under realistic conditions appear more likely to lead to the identification of mundane details, such as the importance of accurate reading at a glance, than more fieldwork prior to the design phase or more reflection during the design phase.

## CONCLUSION

This study shows that design details that may seem mundane and trivial can impact the usability of electronic whiteboards. The smaller font size of the electronic whiteboard reduces participants’ ability to read whiteboard content accurately; this may reduce ED clinicians’ ability to retrieve information at a glance and slow them down. The participants perform some whiteboard revisions slower with the electronic whiteboard and others equally fast with the two whiteboards. The similar performance on some revision tasks shows that logon does not necessarily consume extra time. The logon procedure seems to be efficient and fit well to ED work. In sum, apparently mundane details may have a substantial impact on the usability of a system. To tease out such details before a system is taken into operational use we recommend evaluation in the field.

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