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The long and twisting path: An efficiency evaluation of an electronic whiteboard system

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Abstract. Electronic whiteboard systems are becoming increasingly popular as replacements for the dry-erase whiteboards previously used for communication and workflow coordination at Emergency Departments. With this it also becomes increasingly important that these systems do not disrupt or delay the working practices of the departments where they are taken into use. Usability evaluations should therefore be employed as part of developing and implementing these systems. We report on a subset of the results from a larger usability study of a electronic whiteboard and find that there are inefficiencies, which could be mitigated by a relatively simple redesign and thus improve the usability of the system.

Keywords. Electronic whiteboards, usability evaluation, efficiency, GOMS-KLM

Introduction

Electronic whiteboard systems (EW) are becoming increasingly popular as replacements for the ubiquitous dry-erase whiteboards used for communication and workflow coordination in emergency departments (ED) [1]. However, with this increase in popularity it becomes ever more important that these EWs do not disrupt or delay the working practices of the EDs where they are taken into use. Usability evaluations should therefore be conducted as part of developing and implementing these systems to uncover any potential usability issues. In this paper we report on a subset of the results from a larger usability study performed as part of an evaluation of a specific EW system at two Danish EDs. The focus of this paper will be on efficiency, which refers to the number of resources needed to complete tasks with a system and which constitutes a key aspect of usability [2]. For example, high efficiency occurs when minimal steps are required to complete a task using a system such as an EW. In this paper we explore the analysis of data collected from real users working with an EW system over time in order to determine if inefficiencies can be identified leading to proposed redesigns developed based on the analysis.

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ANKOMST	TRIA/BOY RUM	FORNAVN	ALDER	VENTER PÅ	PROBLEM	SYGEPL	LÆGE	PLAN	RESSOUR NOTAT	AFGANG	NÆSTE STOP	LINKS
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+2:17	BC	21-2	Eigen Collesen	81	faster	galdeblæ	● Starter J.		org meldt ti	anaes ...		

Figure 1: Screen shot cutout of the EW system's user interface

1. Methods

The usability study was performed as a longitudinal and naturalistic study of the ED clinicians' interactions with the EW system. The study involved continuous and long-term screen recordings of the clinicians' interactions with the EW system throughout multiple five-hour periods during dayshifts at two EDs. The healthcare region and ED management approved the study prior to it being conducted. Also, because the study involved collection of live patient data the study had to be registered and approved by the Danish Data Protection Agency. Clinicians on duty during the study were briefed during morning meetings and throughout the study if questions or concerns arose.

1.1. The Electronic Whiteboard

The EW system is a web-based application installed on a central server and is accessible from all web-enabled devices connected to the same network as the server, e.g. laptops, workstations and wide screen displays. The system displays patient related information relevant for coordinating workflow and patient care e.g. name, age, medical problem, triage levels, attending nurse and physician, lab results, etc. Figure 1 presents the general information structure using a matrix with rows for patients and columns for patient data.

1.2. Procedure and Materials

User interactions with the EW were captured using the HyperCam 2 screen capture software installed on 4 Gb flash drives. The resulting video files were stored on either an external 2 Tb hard drive or a 16 Gb flash drive. User interactions were captured over a period of five days between 10 AM and 4 PM each day at two EDs. This period was specifically chosen because experience proved this was often the busiest time of the day and should therefore produce the highest number of interactions with the EW.

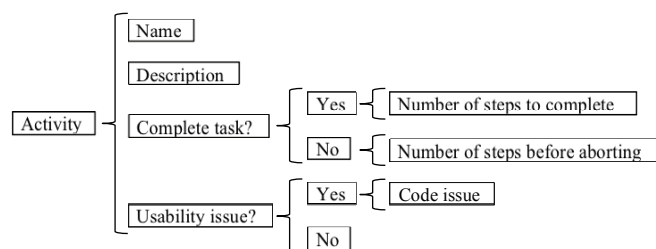


Figure 2: The coding scheme used for logging on-screen activities

The recordings rotated between different workstations throughout the departments and the wide-screen displays located in the ED command rooms. Finally, the first-author was present at the departments during the study to carry out concurrent observations and in-situ interviews with users of the EW system and to administer the recordings.

1.3. Data Analysis

Each video file was viewed and logged by the first-author using a predefined coding scheme developed by both authors – see Figure 2. The initial viewing and logging was carried out solely by the first-author due to restrictions imposed by the Danish Data Protection Agency's directives. Using the coding scheme, on-screen activity was recorded and entered as entries in separate log files. Each entry contains a timestamp, an activity indicator, a name for the activity and a description of the activity. In instances of task oriented activity the entries indicate whether or not the task was completed and the number of steps taken before completing or aborting the task. When usability issues were discovered we marked them with an indicator and coded the issues using one of the following categories: System bugs, efficiency problems, error messages and work patterns. We also provided a description of the issue including whether or not the user solved the issue.

Following the logging process both authors perused each log file and coded activities of interest for further analysis. All codings were discussed to mitigate biases in the analysis. The initial coding of the data was used to locate particular interactions of interest that were further analyzed to identify efficiency issues. In this paper we focus on the analysis of potential inefficiencies. This involved using the GOMS-KLM method [3] to calculate how much time a theoretical expert user would spend on completing a task with the EW system following a specific pathway determined by the original system design.

Based on these analyses, our approach then involves proposing a redesign aimed at improving the efficiency for that task, calculating how much time an expert user would spend using this design before finally comparing this with the GOM-KLM calculations for the original design.

2. Results and Discussion

We logged a total of 2863 entries and recorded 13 unique usability issues: 4 system bugs (55 instances), 4 efficiency issues (141 instances), 3 error messages (38 instances) and 2 inefficient working patterns (229 instances). The most common efficiency issues found in the results concerned complicated and long pathways, which the EW system forces the users to follow when using the system for specific tasks. This issue occurred a total of 63 times (44.68 % of all instances of efficiency issues) in the results. The complicated and long pathways become very apparent when new patients are added to the EW or when certain information fields are updated. In logging the video files we found that adding a new patient on average took 12.3 steps to complete. When users completed this task error free e.g. without mistakes or interruptions and provide the maximum amount of information the task required 19 steps to complete. These steps are the following: **1)** Open "Add row" dialog box **2)** Open "SSN" dialog box **3)** Input SSN **4)** Close "SSN" dialog box **5)** Open "Note" dialog box **6)** Type note **7)** Close

“Note” dialog box **8)** Open “Problem” dialog box **9)** Open problem selection dialog box **10)** Search/select problem **11)** Close selection dialog box **12)** Close “Problem” dialog box **13)** Open “Waiting for” dialog box **14)** Select waiting for option **15)** Close “Waiting for” dialog box **16)** Open “Location” dialog box **17)** Select location option **18)** Close “Location” dialog box **19)** Close “Add row” dialog box. As this indicates the current design of the EW is based on individual dialog boxes for input into each information field. In the following, we will use the add-patient task as an example to demonstrate how the efficiency of the EW design could be improved via a simple redesign. Using the GOMS-KLM method [3] we are able to calculate how much time a theoretical expert user of the EW system would spend on completing the add-patient task (see Eq. (1) where H = moving hands between mouse and keyboard, P = pointing to a position on the display, K = tapping a key or button, M = mentally preparing for next step – see [3] for definitions of the GOMS-KLM operators). Assuming that the user starts the task with hands off the keyboard, that there is no system response time and that the user inputs a 10-digit SSN and a 30-character note the calculations will be as follows:

$$\begin{aligned}
 & H + M + P + K + M + P + K + H + M + (K * 10) + H + M + P + K + P + K + H + M + (K * 30) + \quad (1) \\
 & H + M + P + K + M + P + K + M + P + K + M + P + K + M + P + K + M + P + K + M + P + K + \\
 & M + P + K + M + P + K + M + P + K + M + P + K + M + P + K + M + P + K = \\
 & \text{time spent in seconds}
 \end{aligned}$$

When replacing the operators in Eq. (1) with the times they represent (H= 0.4 seconds, P = 1.1 seconds, K = 0.2 seconds and M = 1.35 seconds) we find that a theoretical expert user would spend 56.4 seconds on completing the add-patient task when following the pathway that the system currently enforces. The amount of input information needed to complete the task is independent of the pathway followed and therefore cannot be reduced by redesigning the interface. However, by reducing the number of steps needed to complete the task it is possible to make the interface more efficient than the current. We will demonstrate this by proposing a theoretical interface design where the input information is entered directly in text fields or by selection via drop-down menus instead of opening new dialog boxes for each individual input. Once again we assume that the user starts the task with their hands off the keyboard and mouse, that there is no system response time and that the user inputs a 10-digit SSN and a 30-character note. In this case we have the following steps for the task: **1)** Open "Add row" dialog box **2)** Select "SSN" input field **3)** Input SSN **4)** Select "Note" input field **5)** Input note **6)** Select "Problem" option from drop-down menu **7)** Select "Waiting for" option from drop-down menu **8)** Select "Location" option from drop-down menu **9)** Close “Add row” dialog box. When applying the GOMS-KLM calculations to the proposed redesign we arrive at Eq. (2):

$$\begin{aligned}
 & H + M + P + K + M + P + K + H + M + (K * 10) + H + M + P + K + H + M + (K * 30) + H + \quad (2) \\
 & M + P + K + M + P + K + M + P + K + M + P + K = 31.25 \text{ seconds}
 \end{aligned}$$

Thus, it would take an expert user of the EW system 31.25 seconds to complete the task of adding a new patient when using the proposed redesign of the systems interface. This simple redesign of the EW interface thereby presents a reduction of the theoretical task completion time by 25.15 seconds (44.6 %). Taking into consideration that each ED receives approximately 40.000 – 45.000 patients each year a redesign of this pathway could prove to be a significant time saving improvement over the current

design. In a conservative estimate the clinicians provide the maximum amount of information for a new patient for every second patient admitted to the EDs and added to the EW. This leads to a time saving of 157.2 hours each year for this task alone. In cases where the clinicians do not provide the maximum amount of information this time saving will be smaller but still noticeable. Furthermore, since adding patients to the EW is not the only task where the system enforces longer than necessary pathways, a redesign of the input method used throughout the EW system's interface could even further increase the amount of time saved when using the system.

Whether or not the proposed redesign would in fact translate to actual time saving if taken into everyday use is of course a matter of further researcher and experimentation. However, previous evaluations using variations of GOMS methods have proven that these calculations are often precise [4] and therefore we feel assured that our proposed redesign would in fact provide the calculated time saving benefits.

3. Conclusions

Through our usability evaluation of the EW system we found a wide range of usability issues in the EW system. In this paper we chose to focus on long and complicated pathways within the EW system. Using the GOMS-KLM we illustrated with an example how the system could be redesigned to increase its efficiency. We found that our proposed redesign could reduce the time needed to enter a new patient to the EW by roughly 45 % and with the reservation that the clinicians do not always provide the maximum amount of information we found that this could provide a time saving of 157.2 hours pr. year. Also, since the EW system can be accessed via multiple devices the potential increase in efficiency could be far ranged and have a positive impact upon the work practices at the ED. Furthermore, we argued that this redesign could have an even greater impact than our results show since it could potentially affect a larger part of the EW than we studied here. In conclusion we call for more and earlier usability evaluations of healthcare information systems such as the EW studied here to ensure a higher quality of the systems used by healthcare professionals.

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