Measuring Doctor's Quickness and Effort of Using Key-Stroke Level Model: A Case Study of Drug Order Entry

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ABSTRACT

Drug Order Entry (DOE) is one of the most important components in Electronic Medical Records System (EMR). Doctor's appropriate order of drugs via DOE is very important to reduce consultation hour per patient and medical errors. Keystroke-Level Model (KLM) was employed to estimate the doctor's quickness and effort while performing DOE at two public hospitals in Malaysia. Observation method was used in this study. The results showed that the proposed scenario represents the DOE behaviours well, and confines to the doctor's workflow, easy to be understood and navigated, hence increases the efficiency of the EMR, reduce medical errors, and increases the acceptance level of the system.

Keywords

Malaysia, Electronic Medical Record System (EMR), Key-Stroke Level Model, Acceptance

1.0 INTRODUCTION

Drug Order Entry is one of the most important components of Electronic Medical Record (EMR) (Mohd & Syed Mohd, 2005a).

Various opinions were given by doctors regarding the effect of computerized DOE for instance task alteration performed by physicians to issue medical orders slower than handwriting orders (Cusack, 2008), on the other hand, Foster and Connelli (2002) cited that the reduction in time of retrieving information. Another opinion is that the use of the system tends to limit and direct physician's choice of medication and procedure (Davidson, 1999). Thus, there are pros and cons situation regarding the implementation of computerized DOE. In addition, factors related to human characteristics (Mohd & Syed Mohd, 2005a) were also being raised because some of DOE processes are unable to deal with human factors, especially related to cognitive aspects of user's activity (Anceaux et al.,1999). Consequently, doctors feel uncomfortable to interact well with the DOE (Beuscart-Zephir et al., 2000). Nevertheless, Anderson and Aydin (2005) stated that computerized DOE is important to reduce consultation hour and medical errors. Therefore, there is a need to simplify the existing DOE processes to enhance doctor quickness and effort. Hence may increase the acceptance level of the system. Quickness is defined as rapid response and movement time in relation to a given stimulus (David, Klyde, Birnal, & Aponso, 1995). Whereas effort is defined as the amount of time spent on a particular activity (Tyler, 1979).

Thus, the objectives of this study are to measure the quickness and effort of performing DOE by the doctors, and to propose simplified scenario for DOE.

2.0 REVIEW OF PREVIOUS WORKS

KLM is used to estimate execution time for a task (Card, Moran & Newell, 1980). John & Kieras (1994) proposed seven operators (Table 1): K, T(n), P, B, BB, H, and M with time estimation for each operator and one operator, W(t) as self reported time. These operators and the time estimation can be used to estimate the execution time for DOE in the existing EMR and the proposed DOE scenario. Sittig, Kuperman, and Fiskio (1999) suggested that the arrangement of information on the screen should focus on: 1) the key data, 2) use of familiar terms by clinicians, facilitating the process of correcting mistakes, and 3) the routine tasks must be performed in a straightforward approach. In addition, Ash et al. (2004) stated that DOE must portray friendly user interface which easy to understand and navigate to simplify the healthcare process and reduce medical errors.

Therefore, the KLM could be an appropriate technique to estimate doctor's performance while performing DOE. On top of that, scenario description was used to get clear view of the steps and activities that are required to perform the DOE. Scenario description was used to describe user's activity while performing certain task (Lim & Sato, 2003).

3.0 METHODOLOGY

The case study was perfomed in two public hospitals in Malaysia. The DOE was the observed entity. Furthermore, The DOE functionalities in two hospitals were developed by different vendors therefore the user interfaces of the systems were different.

In total, about 20 doctors involved in the observation at outpatient clinic in the hospitals, with at least 3 months experience in using the DOE. They volunteered to be observed by the researcher.

The observation was specifically focusing on basic tasks performed by the doctors via DOE during consultation hours. During the observation, the doctors explained the process involved of the drug ordering process and provide some comments on the existing drug ordering function in the EMR system. The researcher wrote the comments on paper. Video recording was not recommended to protect patients and doctors' privacy as well as information confidentiality.

Then, the tasks were transformed into two scenario descriptions respecting to two hospitals to acquire clear view of the tasks that represent the doctors' actual activities of DOE. Both scenario descriptions were analyzed to identify the task similarities and simplify the complex tasks. Consequently, simplified scenario description was proposed.

4.0 RESULTS

Table 1 shows standard operator and estimation time of the KLM proposed by John & Kieras (1994). The operators and the estimation time were used to estimate the time taken to perform the DOE based on scenario 1 and scenario 2, taken from the DOE processes at two hospitals. Scenario 3 was the proposed scenario description after simplifying the two respective scenarios. Table 2 shows the result of the time estimation for each scenario.

Table 1. *Standard Operator and time estimation of Keystroke Level Model (John & Kieras, 1994):*

Operator	Description	Time Estimates (second)
K	Keystroke: pressing only a key button on the keyboard.	0.28
T(n)	Type-in a sequence of character such as search for a specific word.	n * K
P	Point with mouse to a target point on the screen.	1.1
B	Press or release mouse button.	0.1
BB	Click mouse button	0.2
H	Home hands to keyboard or mouse	0.4
M	Mental action of routine thinking or perception	1.2
W(t)	Waiting for the system to respond that depends on the system performance.	Self-reported

Table 2: *Time estimation keystroke for drug ordering.*

Scenario Statements	Operator	Time Estimation in seconds
Scenario1		
1) Choose and click on the drug ordering	M, P,BB	2.50
button.	BB	0.20
2) Press button to view alphabetical number from A-Z.	M, BB or	1.40
3) Browse the browser up to	M, P, BB	2.50
the relevant alphabet.	M, P, BB M, BB or	2.50 or 1.4
4) Choose the drug initial alphabet.	M, P, BB M, P, BB	2.50 2.50
5) Browse the drug name under the initial alphabet.	[H, M, P, BB, T(n)] * 4	[2.9 + 0.28(n)] * 4
6) Choose the related drug.		
7) Key-in the drug information (drug dose, frequency, route, and	Self-reported	

specific instruction).		
8) Modify the drug prescription if necessary.		
Total time estimation (excluded self-reported time):		24.60 + 1.12(n) to 25.70+1.12(n) sec.
Scenario2		
1) Choose and click on the drug ordering button	M, P,BB	2.50
2) Type-in drug initial alphabet in the search field.	H, M, P, BB, T(n)	2.9 + 0.28(n)
3) Browse the drug name under the initial alphabet.	H, M, BB or H, M, P, BB	1.8 or 2.90
4) Choose the related drug.	M, P, BB	2.40
5) Key-in the drug information (drug dose, frequency, route, and specific instruction – 4 fields).	[H, M, P, BB, T(n)] * 4	[2.9 + 0.28(n)] * 4
6) Modify the drug prescription if necessary.	Self-reported	Self-reported
Total time estimation (excluded self-reported time):		21.20+1.40(n) to 22.30+1.40(n) sec.
Scenario3		
1) Choose and click on the drug ordering button	M, P,BB	2.50
2) Type-in drug initial alphabet in the search field.	H, M, P, BB, T(n)	2.9 + 0.28(n)
3) Browse the drug name under the initial alphabet.	H, M, BB or H, M, P, BB	1.8 or 2.90
4) Choose the related drug.	M, P, BB	2.40
5) The drug information will display as default in the drug ordering table.	W(t)	Response time
6) Modify the drug prescription if necessary.	Self-reported	Self-reported
Total time estimation (excluded self-reported time):		9.60+0.28(n) + W(t) to 10.7+0.28(n) + W(t) sec.

The statement "Browse the browser up to the relevant alphabet" in Scenario1 is the case selection, where the keystroke operators were M, BB if the relevant alphabet is already on the screen display and the user just click to the relevant alphabet, otherwise the keystroke operators were M, P, BB**,** which means the user has to browse the alphabets list to access the relevant alphabetical character.

Statement "Key-in the drug information (drug dose, frequency, route, and specific instruction)" in Scenario1 and Scenario2 required [H, M, P, BB, T(n)] * 4 , H operator was required because the hand movement from mouse to keyboard character at average take about 0.4 second (John & Kieras, 1994). Operators M, P, BB were to justify the cursor movement to the relevant field and click the cursor to start keying-in the drug information in the related drug field which takes about 2.5 seconds where (M+P+BB = 1.2 + 1.1 + 0.2 = 2.5, T(n) represented keying-in a sequence of character such as search for a specific word. There are four fields in the drug's ordering table that have to be filled-in by the doctor and these are: drug dose, frequency, route, and specific instruction. Doctor has to key-in every field with relevant characters, T(n) is equal to K * (n). K is the time estimation for pressing a key button on the keyboard, which on averagely take 0.28 second (John & Kieras, 1994). Therefore, the [2.9 + 0.28(n)] * 4 was required in the calculation for the keystroke estimation to key-in the drug information in the drug ordering table.

The estimated time for: Scenario1 is 24.60 + 1.12(n) to 25.70+1.12(n) seconds, Scenario2 is 21.20+1.40(n) to 22.30+1.40(n) seconds, and Scenario3 is 9.60+0.28(n) + W(t) to 10.7+0.28(n) + W(t) seconds. The W(t) was included in the estimation time because of this statement, "The drug information will display as default in the drug ordering table", where the display time was depend on the response time of the system.

Where n is the number of typing characters and W (t) is the waiting time for the system to display the information on the screen which is totally depends on the system performance. The time taken by Scenario3 was 2.56 times faster than Scenario 1 and 2.32 times faster than Scenario2.

5.0 Discussion

The results show that the time estimation for the proposed scenario (Scenario 3) is better as compared to the existing user interface of the EMR system. Therefore, the proposed user interface as seen in Figure 1 is able to reduce the time taken by the doctors to make order as well as able to reduce the frequency of the keystrokes and the steps involved to perform the drug ordering process. Hence, this can be reduced complexity user interface and reduce the time to access and process the drug information.

Therefore, the results justify that the proposed Scenario is well represented the DOE behaviours, and confines to the doctor's workflow, easy to be understood and navigated, hence may increase the efficiency of the EMR, reduce medical errors, and increase the acceptance level of the system.

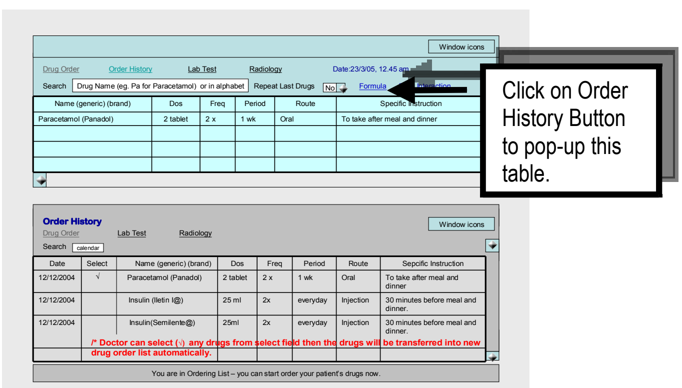

Figure 1: DOE Window.

In addition, the results also confirm that the KLM technique is able to calculate user performance that is free from external constraint for instance hardware and software performance, and environment factors such as: telephone call, manual administrative requirements, and doctor's conversation with the researcher that may affect the execution time performed by the doctors.

The standard operators and the time estimation for each operator in KLM as proposed by John & Kieras (1994) allows system operator to estimate the time performed for the DOE functionality based on the existing EMR drug ordering user interface and the proposed scenario. Therefore, the quantitative prediction of time estimation for both user interfaces can be calculated to justify the usability problem of the existing drug ordering user interface and the strength of the proposed DOE scenario description.

Researcher found that the usability problems of the existing drug ordering functionalities are: 1) too many keys to hit, 2) drug ordering in the existing EMR system does not use default value that may avoid prescription error and reduce the time to performed the drug ordering.

The use of scenario description in this study is important. Scenario description was able to describe in detail every step involved in performing certain task. Therefore, scenario was able to provide usable information to KLM especially regarding the use of keystrokes in the process of performing the DOE activity. Consequently, KLM was able to generate the time estimation for the DOE functionality.

Researcher also found that observing doctors in the real work setting will help designers to obtain and convey the ideas of the real doctor workflow into system design. This could consequently lead to improve system design in term of the usability to increase the acceptance level of the system (Mohd & Syed Mohd, 2005b).

The researcher would suggest that, the evaluation method can be used where: 1) the user manual and technical manual of the system is not exist; 2) the system is strictly protected by the system vendor where the system evaluator is not able to hang-on with the system; 3) the system is very confidential; especially in this study where the system was closely related to the patient information; 4) the external factors that may effect the performance of the system such as hardware and software performance, environment factors, and user's conversation that interrupt the task performed in the middle of the process.

This study can befurthered enhanced to estimate the execution time using Natural GOMS Language (NGOMSL) if the training period for the DOE functionality can be justified. Hence, the learning time of the DOE functionality can be estimated (John & Kieras, 1994, Paterno, 2001).

6.0 Conclusions

Doctor's quickness and effort of performing DOE can be predicted using KLM. Therefore, this technique will facilitate user interface designer to make a comparison, identify the usability problems of the existing DOE, and justify the strength of the proposed scenario description. The KLM provides quantitative evidence to the user interface designer in the direction of justifying the weaknesses of the existing DOE, and the strengths of the proposed scenario description. Thus, the method used in this study can be used as a guideline to help the user interface designer enhance the existing user interface layout of DOE.

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