Development and Beta Testing of Applications for Direct Trainee Observation in Medical Education Using an iPad Platform

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ABSTRACT

Direct observation of clinical skills, either in clinical settings or during medical exams, plays a key role in education and assessment of residents in General Internal Medicine. The Mini-Clinical Evaluation Exercise (CEX) is an educational tool, for clinical skills assessment, that facilitates learning and allows residents to gain insight into the strengths and weaknesses of their clinical performance.

Traditionally, direct observation has relied on paper-based documentation and the overall process of data collection, archiving, entry and analysis of Mini-CEX results has proven to be very costly and time-consuming. The rapid development of information systems and the advancement of technologies, provide the vast potential for improvement in teaching practices including medical education. Thus, the development of an electronic application of the Mini-CEX will facilitate the process of data collection and improve the quality of medical training.

Several interviews were conducted to properly extract user needs and system requirements, after which the application was developed. The tool was implemented on an iPad platform and tested on a sample of five representative subjects. Interview and usability results revealed positive attitudes towards the application and its potential improvement in patient care.

General Terms
Design, Human Factors.

Keywords
Health Informatics, Educational Information Technology, Medical Applications, iPad in Healthcare, Tablet Mini-CEX, Computerized Mini-CEX, Medical Technology.

1. INTRODUCTION

Direct observation of clinical skills, either in clinical settings or during medical exams, plays a key role in education and assessment of residents in General Internal Medicine. The Mini-Clinical Evaluation Exercise (Mini-CEX) is a method of clinical skills assessment and an educational tool that facilitates learning and allows medical residents to gain insight into the strengths and weaknesses of their clinical performance [6,11].

The movement towards competency-based assessment will likely significantly increase the role of direct observation in resident evaluation [3,8]. However, direct observation presents significant logistic challenges and has proven to be a costly and time-consuming process [13].

Traditionally, collection of Mini-CEX data was all paper-based or relied on the use of bulky hardware which proved to be inconvenient in everyday use. Moreover, subsequent data collection, archiving and analysis posed several logistic challenges and therefore many implementations of the Mini-CEX have failed [5,7,12].

Currently, the rapid development of information systems and the advancement of technologies, provide the vast potential for improvement in teaching practices including medical education. By easily summarizing data and facilitating performance tracking over time, electronic formats have the unique potential to streamline detailed feedback with significant learning gains for students.

For this reason, computerizing Mini-CEX data collection and linking it to automated archiving helps achieve higher levels of efficiency, and significant reductions in the overall costs of photocopying and data entry. Savings also include eliminating the need of specialized personnel (resources) and the ability to analyze results instantly. Thus, the development of an electronic application of the Mini-CEX will facilitate the process of data collection and improve the quality of medical training.

2. OBJECTIVE

The overall objective of this project was to develop a user friendly, tablet-computer application that will optimize electronic data collection, archiving, and analysis for the direct observation of clinical skills.
3. METHODOLOGIES

To identify user goals, preliminary interviews with potential users of the system were conducted. This was the first and most important step in the study, as it enabled me to define user needs, goals and system requirements. This involved a focus group, face-to-face and phone interviews. After obtaining the necessary feedback, I generated a set of use cases, which guided me through the generation of functional and non-functional requirements as well as activity diagrams.

The development of the tool took place shortly after the requirements gathering period. This was achieved using Filemaker Pro™ 11 software, which is a cross-platform, relational database, integrated with a Graphical User-Interface (GUI).

The overall design of the application consisted of several different, relational databases, along with a number of scripts and triggers. Each database carried the complete list of residents and examiners involved in the examination, along with their respective identifying information, as well as the relative performance graphs of each student. The design of the application also consisted of the design of the user interface, network infrastructure, and a pilot reporting system for data collection.

As for the user-interface of the application, it was configured for the technical specifications of the iPad display and designed in accordance with the Apple Human Interface Guidelines [4]. Some of the key principals that corresponded to this design were consistency, WYSIWYG (What You See Is What You Get), forgiveness and aesthetic integrity [1].

Likewise, I applied Cornell’s University Ergonomic Guidelines for User-Interface Design as well as the use of wire-frames, in order to ensure the flow of information from screen to screen is logical, follows user expectations and follows task requirements [2].

Next, the tool was tested with a sample of five representative subjects, as recommended by Tom Landauer and Jakob Nielsen, all between the ages of 20 and 55 years [9]. The sample consisted of four practicing physicians and one supervising staff. 80% of the subjects currently owned an iPhone or an iPad and considered themselves intermediately tech-savvy, while the other 20% have had hands-on knowledge with the technology and interacted with the device a couple of times. As a result, subjects were generally comfortable and familiar with the basic functionality of the iPad. Moreover, all participants have worked with medical technology in the past and were willing to adopt a technological approach if it solves practical problems.

4. RESULTS AND ANALYSIS

Overall, interview results revealed positive attitudes towards the computer-tablet and the potential improvement in patient care. All physicians seemed to believe that an electronic version of the Mini-CEX is a good tool for documentation, and will solve practical issues in terms of collecting, distributing and collating the data. However, this is very dependent on how well thought out and interactive the user interface is. Given the user interface is fairly quick, visually pleasing and data can be archived as needed in simple ways, physicians are more encouraged to use it.

Furthermore, interviewees agreed that an electronic format of the tool would enable formalization of the process of bedside assessment and allow examiners to structure the procedure of bedside learning, which is currently done informally.

Similarly, overall usability testing results revealed minimal problems with the usability of the tool. The general predicament that resulted from all of the issues was a lack of user guidance, that is – navigating some parts of the application seemed to be riddled with uncertainty, as the next step was not entirely obvious or explicit. The two issues that seemed to contribute to this problem were unclear icon meaning and ambiguous text.

Subjects had severe issues with screen metaphors, such as the ‘Clock’ icon. Subjects were unaware that pressing the ‘Clock’ icon automatically populates the observing/giving feedback time; see Figure 1 below. As a result, they manually populated the time-fields themselves.

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![Figure 1. Timer Icon](image)

Moderate issues were experienced with wording such as ‘Back’. When participants reached the results summary page, they were expected to either, choose to email the results or select the ‘Back’ button, which redirects them to the Home Screen, and in turn finalizes the examination; see Figure 2 below. However, after reaching the summary page, participants were unclear on what to do next – “So am I done?”.
Throughout the experiment, a ‘Talk-Aloud Protocol’ was employed in order to gather a better understanding of the process of task completion and gain insight into the user’s thought process. That is participants were encouraged to ‘think-aloud’, as they perform the examination [10]. They were asked to state what they were looking at, doing and thinking as they went through the task. As this was carried out, I took notes on everything users said, without attempting to interrupt the process. The total number of positive, negative comments and requests for help for each participant were also recorded.

Measurement results were graphed in order to demonstrate the varied reactions between participants, see Figure 3 below. By examining this graph, we see that most of the subjects conveyed positive emotion towards the application. Moreover, we notice that the number of negative comments and help referrals was very minimal for all subjects, except for Subject 4, which have never interacted with the iPad. As a result, their dissatisfaction was mainly related to the functionality of the iPad, such as zooming out after they had zoomed in and finding the keyboard.
Although the average time to perform the experiment was also recorded, it was not considered a major indicator of the tool’s usability as it may be directly correlated with iPad familiarity as well as the nature of the usability experiment and ‘Think-Aloud Protocol’.

Finally, following the usability experiment each participant was asked a number of questions regarding the ease of navigation and likes/dislikes of the application. Exit survey results revealed general satisfaction with the tool. Participants found the application to be intuitive in terms of data entry and very easy to navigate. Major dislikes were related to the functionality of the device itself; subjects were concerned with the ease of typing on the keyboard and the size of the iPad.

5. DISCUSSION

As mentioned by the participants, an easy-to-use, intelligent user interface is essential for such a tablet-based application. Therefore, the use of scripts and triggers eliminated all the administrative responsibilities, allowing more time for direct observation.

The use of drop-boxes was utilized to simplify data entry. Similarly, the size of fields and buttons was 43 pixels in height to accommodate for the average size of fingertips and facilitate the entry of information [4].

Moreover, to ensure the readability and legibility of information, the form’s content was displayed using a 22-point font. The paper-based form was also divided into three screens to avoid the need for zooming-in and further improve the legibility of information.

The electronic format of the tool was designed in consistency with the paper format, in order to facilitate learnability of the tool and reduce the time taken to learn it. Likewise, the design of buttons and headers was consistent throughout the application. Buttons were designed with the same size and color and headers remained the same from one screen to the other.

Finally, by summarizing the results at the end of the examination, users are able to correct any mistakes they might have made. This builds “forgiveness” throughout the tool and ensures a high tolerance for error. Similarly, although a button was scripted to auto-calculate the desired time fields, the design of the system allows users to manually enter the time. In case the user is doing something else while the timer is running, they can overwrite the calculated times, which emphasizes the forgiveness principle.

Following the usability analysis, a number of design changes and system improvements were executed.

With regards to the issue of ambiguous text, the meaning of the ‘Back’ button seemed to be too vague and unclear to the users. Therefore, this was replaced by a ‘Finish’ button, which provides users with the understanding that by clicking this button they are choosing to finalize the examination. Moreover, a button was scripted to generate graphic reports of average performance for each student and disease.

Additionally, the ‘e-mail’ button was replaced by ‘e-mail Results’. Although no usability issues were experienced with this button, the switch seemed to offer a better understanding of what one should
expect once they click the button. Figure 4 below illustrates these changes.

Unclear icon meaning was found to be a severe issue, as none of the participants realized that pressing the ‘Clock’ icon automatically populates the time fields. This problem was addressed by adding descriptive text next to the clock icons – “Please press the clock icon for observing time (Mins)”. The same descriptive text was added for the providing feedback timer, as can be seen in Figure 5.

Finally, usability measurements and exit survey results verified the overall user-friendliness of the tool and its ease of navigation. Participants indicated their satisfaction with the application and their willingness to adopt this technological approach instead of the paper-based.

6. CONCLUSION

In conclusion, the tool seemed to be widely accepted by physicians, as it simplifies the process of direct observation and facilitates performance tracking over time. The rapid development in information technology provides the potential to easily summarize data and streamline detailed feedback, with significant learning gains for students. Therefore, the implementation of a system, such as an electronic Mini-CEX, could improve the process of medical education, which would ultimately improve patient care.

However, this application can be taken to the next step with a more portable platform, such as handheld devices and smart-phones. Moreover, an interactive learning module is advised, as it would provide the user with a perspective of the tool’s functionality and how it works. This can either be implemented online or as a quick demo within the application that gives an overview of the tool.

Finally, a cost-analysis should be conducted in order to measure the cost-effectiveness of the product and quantify its advantages versus its drawbacks.
7. REFERENCES


