A Comparison of the Usability of Locally-Produced and Commercially-Acquired Telemedicine Device for Filipino Health Workers

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ABSTRACT

With the advancement of technology today, various industries have benefitted from innovation of systems that have been and are being developed, with the healthcare sector being one of them. Usability evaluation of medical devices is essential to ensure its effectiveness and to increase acceptability of the technology. In the Philippines, there has been a project on development of a locally-produced medical device. Similar to any other health care applications, there is a need to ensure that this is usable for Filipino health workers. A usability evaluation was conducted on the prototype of this telemedicine device, focusing on maternal monitoring, with user testing and interviews. Another similar device (commercially-acquired) was evaluated and compared to the existing design. Results of the evaluation indicate that there were usability problems in terms of the hardware and interface for both the locally-produced and commercially-acquired device designs. The former has a lot to improve in terms of its interface. Both still needs further improvement to make it easier for users to use the device. Usability evaluation has been very useful in identifying the areas for improvement in the design of the medical device and is seen as an essential part of its development.

Keywords: Usability, User Testing, Think Aloud Protocol, Medical Device, Maternal Monitoring Device

INTRODUCTION

Medical devices play a vital role in health care systems. Innovations on this filed are intended to facilitate a more efficient and more effective delivery of patient health care. Today, a vast number of medical equipment, computer applications and medical systems have been and are being developed. To ensure that the maximum benefit is achieved from these, it is essential that these systems be usable for its intended users. Usability of systems indirectly affects user acceptance (Maguire, 2001) and thus, developers must be able to come up with innovative and good system design.

According to Jaspers (2009), poor design often becomes a hindrance to user adoption and utilization of interactive health care applications. It makes the system difficult to use and makes it hard for the users to learn them. In this research, other studies were discussed highlighting the effects of poor design to errors (Jaspers, 2009; Kushniruk, et. al., 2005; Han, et. al. 2005; Ash, et. al., 2004; Campell, et. al., 2006; Horsky, et. al., 2005; Peute, et. al., 2007;

Koppel, et. al., 2005).

In the Philippines, the government has started projects on development of local devices and computer applications intended to provide better service to its people, one of which is a telemedicine device. This is a medical device developed with capability of measuring patient vital signs and other data through sensors and at the same time, a capability for telemetry. The main function of this device is focused on maternal health care – check up and monitoring. These devices are intended to be deployed to many provinces and islands of the country to improve health services especially in the remote areas. Currently in its development phase, a usability evaluation is a necessity to know how it is going to be used by the Filipino health workers especially in the rural areas. As Hyman (1994) and Obradovich and Woods (1996) discussed, the risks of having human errors in medical equipment use increases if the machine interface is poorly designed, thus, the need to evaluate this locally-produced equipment. During the initial deployment of the project, another version of the device, commercially-acquired, was distributed in some areas. To be able to help in identifying the improvements needed in the development, the usability of this commercially-acquired device was conducted and compared to the one being developed to know how it will fit the Filipinos.

USABILITY EVALUATION

Medical device usability has become a growing interest (Mchome, et. al. 2010). This is rationalized not just for the criticality of these systems but also for better product development and financial benefits.

Various usability evaluation techniques exist today. In general, these can be classified into two: user-based or expert-based (Jordan, 1998). In terms of deciding which technique will be best for different product development phases, Tan, et. al. (2009) recommends that heuristic evaluation be utilized at the early stages and then conduct user testing at the latter stages of the development. They also discussed some of the research works covering usability evaluation methods, where each is applicable and the strong points of each technique. They compared heuristic evaluation, the most commonly used expert-based technique, to the most commonly used user-based technique, user testing. Heuristic evaluation permits the possibility of identifying what is possible rather than just to what already exists. Jeffries et. al. (1991) also compared user testing and heuristic evaluation and came up with the conclusion that the former was able to identify more problems but the more severe ones were identified through user testing. Liljegren (2006) compared hierarchical task analysis, cognitive walkthrough, heuristic evaluation and user testing with the following criteria: thoroughness, validity, reliability, cost effectiveness and clarity. Liljegren (2006) and Lindgaard (2006) both recommends user testing to be used as primary technique in usability evaluation since it addresses the “difficult to make errors” aspect. For Choi, et. al. (2010) and Stinson (2010), user testing is the preferred methodology.

For medical devices, a number of studies have also been done for usability evaluation. Jaspers (2009) has compared heuristic evaluation, cognitive walkthrough and think aloud method for a specific medical device and has concluded that each of the technique has its own advantages and disadvantages and further recommended that a combination of the techniques will be more powerful than any individual method.

Although the most commonly used and lowest-cost option is an expert-based heuristic evaluation, there are cases in which this is not viable because of the lack of experts in the field. This applies in the current setup of this telemedicine device development. Given the constraint on lack of experts and the primary need of the developers at this phase, which is to determine the need of the users and how the device is going to be used by medical personnel in different areas, the evaluation conducted is mostly user-based techniques: user testing, questionnaires and interviews.

Methodology

The usability evaluation in this study was conducted during the initial deployment of the devices to selected areas (combination of rural and urban) within the Philippines. Trainings, which include use of health information system and use of the telemedicine device, were conducted on the different health units. Each health unit is deployed only one version of the device, either the locally-produced or the commercially-acquired one. Both of these, however,

were designed and customized to work with the current health information system being developed and implemented as well. The main functionalities that the devices have are blood pressure, pulse oxymeter, tocometer, fetal heart rate monitor and ECG.

Before data was gathered, the medical workers were given orientation and were taught about the different functions of the device. After the training, the device is used in actual patients and this is when the data for usability was collected. Videos were taken while the users interact with the device for checkup and monitoring of patients. These were later analyzed for identification of the problems encountered while it is being used. These were also used to obtain an estimate of how long the health workers take in doing the tasks discussed in the next section. After the testing, specific users were interviewed to elaborate the problems they encountered or have difficulties doing in the device. Then analysis of the data was done and the devices were compared in terms of its usability for Filipino health workers.

Test Subjects

McClelland (1995) emphasizes that a representative user population must be chosen as sample users for the trial. With this, the test subjects in the study were selected from the participants in the training conducted for the Telemedicine program, part of which is on using the medical device being developed. The participants in the training consists of Municipal Health Officer(s), Public Health Nurses, Rural Health Midwives and Doctors, the primary users of the device. Their ages range from 22 to 60 years old, with an average of 42. It is noticeable that the variability between ages is high but since the study is limited by the training and the personnel in different health units, everyone who tested the device was included in the study.

Garner et.al. (2002) highlights the importance of including novices in usability tests since they are the ones who encounter the most serious and most number of errors. In this research, most of the users are classified as novices although there are a few who can be considered experienced already in using the device as some health centers or hospitals are using or have used a similar equipment.

For Virzi (1992) and Lewis (1994), 18 people are needed to identify 90% of the usability problems. Hwang & Salvendy (2010) on various heuristic evaluation studies done before found out that the 10±2 rule would apply. According to Ericsson and Simon (1993), 8 subjects suffice to gain a thorough understanding of task behavior or to identify usability problems with a computer system (Nielsen, 1994). Other usability specialists recommend 5 participants to achieve the maximum benefit-cost ratio (Nielsen & Landauer, 1993) and can identify about 80% of the usability problems. For user testing, Nielsen (1999) recommends observation of about 10 subjects for detection of major usability problems in an interface. According to him, having subjects beyond 5 to 6 will not economically justify the tradeoff between additional cost and additional problems that will be identified. Given that the usability evaluation during this time is limited by the training in sites where the devices were deployed, the number of subjects varied per site but ranges from 2 to 6 per health unit. A total of 4 health centers were included.

Tasks

The tasks observed during the evaluation of the medical device being studied are described below.

1. Patient record is created and/or accessed from the health information system.
2. Medical device is set-up. The sensors are attached to the device. The sensors are then attached to the patient to obtain the mother's vital signs (blood pressure, pulse, oxygen saturation, contractions excluding ECG) and the fetal heart rate. It is important to note here that the main use of the device observed during this time was for pre-natal check-up and maternal monitoring.
3. After vital signs have been measured, data obtained is exported and saved to the information system under the patient record.

ANALYSIS AND DISCUSSION OF RESULTS

The average task duration of each activity is given below.

Table 1: Duration of tasks (in minutes) in using the devices

Tasks	Locally-developed	Commercially-acquired
Create/Access patient record	4.51	4.77
Set-up device and get vital signs	2.95	2.89
Save data in information system	1.03	2.86
TOTAL	8.49	10.52

Comparing the times given in Table 1, it can be noticed that there is no much difference in the duration for the first two tasks. The general flow of activities in the patient record creation and/or accessing it (if already existing) is almost the same for the two devices mainly because it uses the same hospital information system linked to it. The commercially-acquired device may take a little bit longer because it requires another application to be opened to link the device to the information system and vice versa.

For device setup and getting vital signs, the difference is more negligible for the two devices. This can be attributed to the number of sensors and how the sensors are to be used in the patients. The same set of sensors are provided for both devices – blood pressure, pulse oxymeter, tocometer and fetal heart rate monitor. The ECG sensor was not observed to be used during the training. The time for the last task, saving the data reflected in the device into the hospital information system resulted in a significant difference between the two devices. This is because the commercially-acquired device needs an extra set of steps to be saved in the system – the user has to extract the data from the device through another application and then this application will be linked to the information system (device – application – patient record).

The qualitative part of the evaluation mainly came from observations on how the users interacted with the device and based on interviews conducted by the proponents. Tables 2 and 3 below compares the different aspects of the device design which were seen to affect the users while performing the tasks assigned to them from the videos taken.

Table 2: Hardware-related usability issues identified in using the devices

Aspect	Locally-developed	Commercially-acquired
Keyboard/Input	Older users have difficulty typing in touch-screen interface No shortcut buttons are provided in the device so the user has to access all the commands/buttons from the main interface (touch screen)	Users find it easier to input information since they have to access the information system through a laptop Shortcut buttons for getting measurements are provided in the device (for example, start for BP)

Components	Users have difficulty identifying which sensor should be connected to a specific socket due to confusing coding on the wires A certain orientation on how the plugs are to be connected to the sockets is required	Users have the same problem of identifying which sensor should be plugged into a certain socket in the device due to coding A certain orientation on how the plugs are to be connected to the sockets is required Requires more wires to be connected to the device Requires the use of a dongle (USB) to connect the device to the computer. This USB is small and is prone to be misplaced
Printer	To be able to print the results obtained from the device, user has to access the patient record in a separate computer with printer	The device has built-in printer that can print the needed data during patient monitoring. This can be accessed with just one push on the print button
Placement	The device works over wifi. During use on patients, only the device and the sensors need to be placed in a table or near the patient then it automatically connects to the information system, thus requiring smaller area	The device works over LAN so it needs to be connected to a laptop or computer for the data to be retrieved. During use on patients, space can be a constraint because aside from the device and sensors itself, a space for the laptop must also be provided.

It can be seen from Table 2 that each version of the device has its own advantages and disadvantages in terms of its design.

Starting with the keyboard or input device, the commercially-acquired device has provided shortcuts (buttons) in the device itself which makes it easier for the health workers to start an action (e.g. BP) in one step. It was noticed during the experiment that older participants had hard time adjusting to a touch-screen type keyboard as opposed to the normal computer/laptop keyboard.

For the components part, the locally-produced device is advantageous because it has less number of cables/sockets to attach. However, both medical devices require a certain orientation on how the cables/sockets must be placed which makes takes more time for the workers. Another factor that caused confusion on the users is the color-coding system used in the cords. The users tend to match the color codes to the wires itself and not on the ring around the socket which resulted to wrong cable connected to the port.

The commercially-acquired device has a built-in printer that prints the mother's contractions and baby's heart rate real-time as the readings are being taken by the machine. This is very quickly done. Usually, a printout of this type is needed when the patients have to be referred to a hospital for giving birth. This is opposed to the locally-manufactured device that, although it has the capability to generate the graphs/plot similar to what the commercially-available prints, to obtain a printout, the user has to access a separate computer connected to a printer and retrieve the patient's file from it before printing. This takes more tasks and time to finish.

Lastly, placement is one advantage of the locally-produced device since it requires less space in the clinic. Only the telemedicine device and its components need a space in the labor room as opposed to the commercially-acquired one which has to be connected to a laptop or computer for the data to be retrieved from the device. For health centers with space limitations, this is a disadvantage.

Table 3: Interface-related usability issues identified in using the devices

Aspect	Locally-developed	Commercially-acquired
Content	Some of the measurements/vital signs displayed does not have the corresponding unit of measure Some status messages (for the device) was mistaken as the patient status (CRITICAL signal)	Readings has corresponding units of measure Status messages not seen in the device
Consistency	Appearance of keypads and location of keys vary from one window to another	No variation in the interface since main input and access to the device is through the computer
System Status	No signal is given when the measurement is done No indicators when critical vital sign readings are obtained	No signal is given when the measurement is done Gives an alarm when a certain vital sign goes beyond the "normal" range

Monitoring Screen	individual measurements from the different sensors are displayed separately and has to be clicked one by one to be seen	All readings/patient vital signs are displayed in a single screen and is recommended by doctors (based on interviews)
Screen	The tablet has limited screen resulting in visibility and legibility issues especially for older users	The device has a larger screen available for displaying patient vital signs

With regard to the interface, it can be seen in Table 3 that the commercially-acquired device has an advantage compared to the locally-developed version. The aspects pointed out in the table are the areas identified where the design of the locally-produced device must be improved. Since the medical device is still being developed, the issues identified here serves as input to the developers to be incorporated in the next release of the telemedicine device.

In terms of the content, most of the errors or messages in the locally-produced device need to be re-stated to be clearer and at the same time easier to understand for the users. In particular, there was a status message indicating "CRITICAL" so the health workers thought that the patient is in critical condition but the system meant "POOR" for the signal that the device is getting. With this, it can create possible confusion on the users. It is suggested that messages and warnings be made clear so that misperception can be avoided during use.

Consistency of the interface was also pointed out as an area for improvement because in the different vital signs where the readings can be seen, different layout and arrangement of keys and buttons were seen. For example, there were windows where the "OKAY" button is on the upper right, in some cases it is on the bottom of the window. Given this inconsistency can also contribute to user confusion in using the system and furthermore, make the tasks longer because locating the needed keys/buttons may still take time of the health workers.

For the system status, however, both interfaces of the commercially-acquired and locally-manufactured device, can be improved by sending a prompt to the user when the device finishes getting measurements from the patient, for example, blood pressure, through a pop-up message in the screen or though a sound. This was recommended since it was noticed that when the health workers get vital signs, they wait for the device to finish but are unsure of how long they should wait and they are uncertain of when to say the measurements have already stabilized.

Lastly for the screen, since both devices have limited screens, many users requested for larger fonts and larger images so that they could easily read and see the vital signs. In the commercially-acquired device, all the vital signs are displayed at the same time so the health workers just need to glance at the different parts of the screen to obtain the readings desired. This is compared to the locally-manufactured device, which shows the vital signs one at a time. During monitoring, this is a disadvantage because the health workers will have to shift from one window to another to get a "complete picture" of the patient's condition.

One disadvantage of heuristic evaluation is that sometimes, the real needs of the users are not identified because of the lack of experts with enough knowledge on the discipline and technology being studied (Jaspers, 2008). In this research, other qualitative issues were identified from interviews with the health workers themselves. The insights of the nurses, midwives and doctors on the use of the device were obtained and examined. The following items summarizes these results:

1. Having the device in their health centers will help improve the efficiency especially in pre-natal checkup and patient monitoring. Respondents are happy with the device given to them but some are hesitant to use the system as part of their routine because they find the management of online patient records too tedious and time-consuming. Doing the tasks manually is significantly faster for them (approximately 5 minutes versus 8 to 10 minutes using the devices).

2. Midwives aged 40's to 50's admitted that they would find a hard time using the device (both versions) since it is already difficult for them to learn new technology.

3. There were components of the device in which some health workers are not familiar to, especially the ones in the rural areas. The subjects specifically requested that it should be part of the training for them, for example, interpreting the graphs generated for contractions and fetal heart rate.

4. Doctors gave their suggested layout on how the locally-produced interface can be improved based on their experiences with other devices similar to it. In almost all the sites where the locally-produced device was deployed, the doctors emphasized the need for displaying the vital signs all at the same time (one screen) for labor monitoring.

5. Use of the device depends on the number of patients that the health center caters to. In a clinic where there is a significantly large number of mothers giving birth, the health workers are not sure if they could actually use the device. They suggested that it will be more appropriate for pre-natal checkup than that of lying-in monitoring since they only have one set of the device and there are a lot of patients that would need attention. Identifying to whom the device must be used will be another issue for them.

After the quantitative and qualitative evaluations, it can be seen that a lot of issues related to the use of the device were identified. These, however, will serve as opportunities for improvement in the current design of the locally-manufactured device.

CONCLUSIONS

The user-testing and interviews conducted from the evaluation of the medical devices led to identification of usability issues. Comparing the locally-manufactured and commercially-acquired devices highlighted the advantages and disadvantages of each. In terms of the interface, the locally-produced device still has a lot to improve in terms of its design. The main benefit from this study is that the developers of the local medical device will be able to identify the specific aspects of system that needs to be enhanced.

Since the usability evaluation conducted here focused during the initial deployment of the device (prototype stage), it is recommended that after the initial suggestions on design improvement is implemented, another usability evaluation be conducted to check for other problems that users may encounter in using the device.

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