Scaling Mobile Applications Using Interactive-Device User Training

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ABSTRACT

As smartphones become cheaper and more ubiquitous, they are increasingly used in global development projects for data collection, processing, and computation-intensive tasks. To sustainably implement such solutions, the costs of deployment, overall training, and long-term usage must be considered. In this paper, we examine the training process and sustainability of mobile application for Integrated Management of Childhood Illnesses (IMCI). We first report a comparison of application Mobile-IMCI with the incumbent paper-based module on accuracy, time, and performance in both qualitative and quantitative analyses. We then report an initial exploration of techniques to minimize training time and costs by enabling users to learn applications via a method called "Interactive-Device Training" or IDT. We show that IDT can yield significant improvement in training and learning outcomes with reduced error rates. We conclude that such device-enabled training can reduce the need for explicit training and thus create a more sustainable development approach.

CCS CONCEPTS

• **Human-centered computing** → **User interface design**; *User studies*; *Graphical user interfaces*; *Smartphones*; • **Social and professional topics** → *Medical technologies*;

KEYWORDS

Mobile Applications, User Training, Refresher Training, Interactive-Device Training, ICT4D, HCI4D, Paper-based, Medical Applications, IMCI, Low-resource settings, Sustainable Development

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1 INTRODUCTION

There has been a gradual shift in the different Information and Communication Technologies (ICTs) utilized by the technology community to implement global development interventions. With the evolution of technological resources, we have seen a shift from kiosks to PDAs to desktop applications, to the more recent use of IVRs and smartphones. Factors like cost of implementation, deployment, technology penetration, and user experience have played a role in the selection of these technologies.

Mobile phone based applications, in particular, are a powerful medium for development-focused, initiatives. Continuously lowering mobile phone costs, increasing penetration of mobile Internet connectivity, and a steady increase in smartphone usage are all precursors that build the case for mobile phone-based systems. With the availability of USD 20 phones, low-cost deployments seem possible. Moreover, initiatives like Open Data Kit enabling users to author, field and collect mobile data [15] giving efficient data collection on cell phones [3]; the CAM Framework using mobile phones camera to process paper-based documents [23] and web-based tools like App Inventor [17] and Data Plug [21] enabling users to make mobile applications in hours without the knowledge of complex coding etc. open avenues for easy development and low-cost deployments using mobile phones.

While governments are investing in large-scale e-governance initiatives giving smartphones and mobile devices to field staff, they must focus on sustained deployment strategies particularly in terms of user training at such scales. Limited acceptance of new technology, low computer literacy, unfamiliarity with touchscreen phones, and lack of regular staff education and training have been listed as some major factors behind the failure of e-government initiatives in the public sector [8]. The Government of Punjab is proactive in using mobile phones for development and e-governance projects for instance; using smartphones to control dengue outbreak [20]; tracking immunization coverage [6]; documenting water levels in irrigation systems and proactively seeking citizens feedback on service delivery [5]; all of which mandate the use of smartphones by government officials. Though all of these systems show the proactive governance of service delivery, they also require an intensive

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investment of time, money, and effort to provide the user training followed by refresher training.

The digital transition of paper-based systems and resources is not an easy task. It is important that the continuous evolution of technologies is followed along with the continuous development of human capital since this component may focus entirely on the training of involved staff members. However, with the continuous progression of technologies, the frequency of these training must increase in parallel to the technology. Another reason for frequent training is that users typically only remember frequently used features and the features not used regularly are soon forgotten. Thus, to get better implementation and sustainability of an ICT project, the training and learning process of staff members needs to be efficient [1].

Most of the work that discusses the transition to mobile-based systems focuses on user interfaces, device availability, and device sharing models. We, in this research, explore a step further - that is to gauge the user learning needs and reactions, along with a discussion of the improvement in efficiency, accuracy, time, and cost with a mobile application. We further explore the time and money spent on training of users in using these systems and propose a method of reducing external help or intermediated usage in these mobile phone based applications.

Our contribution is the recommendation, and discussion for the need of a device delivered user training for the user without any external help or training. We suggest and compare different mechanisms through which such support can be provided and compare the results of each of them, finally suggesting a prioritization in the case of low-resource settings. *The core focus of our contribution is around the proposal and design of self-learnable system and creation of a generic API that can be integrated into any Android based application. This API can be further used to incorporate the Interactive Device Training.* Effective user training is critical to the large-scale adoption of an effective technology and can mean the difference between the failure or success of a solution. Our paper discusses these issues in the context of the developing world and health technology solutions. In this paper, we address the following questions:

i. What are user's reactions and learning needs when presented with a digital implementation of a previously paper-based system?

ii. What kind of interactive device training methods can be used to achieve device based training?

iii. Exploration of ways that can be used to first reduce and eventually remove the need for user training and enable the devices to help the users use and navigate the systems on their own.

Our work explores the effectiveness of an interactive mobile application, which was developed to reduce the training time and cost spent in enabling the users to use the application features. The interactive applications also help to recall usability in case of forgetting any infrequently used features.

In the sections ahead, we explain our work. Section 3 discusses the related work, Section 4 describes development & evaluation of m-IMCI, Section 5 describes the Interactive-Device Training (IDT) module and shares the results, and Section 6 is a discussion followed by the conclusion.

2 OUR WORK

Using previous knowledge and collaborations in m-health, a medical protocol called the Integrated Management of Childhood Illness or IMCI was chosen to be digitized to see the effects of digitization and training methods on the users.

2.1 Integrated Management of Childhood Illness

IMCI is a paper-based booklet designed to address major causes of child mortality developed by the World Health Organization (WHO) and UNICEF. IMCIs chart booklet was introduced by WHO to help the treatment of infant children by following simple clinical signs and diagnosing the actual disease [10]. Each country has to adopt the standard IMCI clinical guidelines to the country's needs, available drugs, policies, and to the local foods and language used by the population. So far, more than 100 countries have adapted and used components of IMCI. WHO identified five major diseases responsible for a high number of deaths among children across the globe, mainly in developing countries and devised the IMCI manual to assess, diagnose and treat sick children suffering from one or more of these diseases. Many studies have shown better health indicators with the introduction of paper-based IMCI protocol [25] [2] including increased reported and assessed children [12]. The booklet contains three core steps: Assess, Classify and Identify treatment [22]. Assessment consists of a series of question. Depending on the answer to each question, one is led to a different classification and treatment plan on different pages of the booklet for each case. This back and forth sifting through the booklet pages is not only time consuming, but can also lead to errors.

In Pakistan, national IMCI was formally endorsed by the Ministry of Health, Pakistan in September 1998 [13]. For Pakistan, the 5 major diseases are fever, cough, diarrhea, ear & throat issues, and malnutrition. In Pakistan, IMCI is taught as a part of the curriculum in the 5th year of medical school to students of medicine and surgery. The research reported in this paper is based upon the IMCI protocol for Pakistan and thus could not build upon existing solutions in Tanzania [25] and Ghana [16].

2.2 Selection of Android platform

Since PDAs are now obsolete, the introduction of low-cost Android phones has made smartphone applications a feasible medium for this protocol. Mobile phones without Internet facility may be used and synchronized with the central server once internet connection is available. Based on the factors of affordability, ease of use, the prevalence of the platform and customizability, Android was selected as our target platform. We refer to our Android application as mobile IMCI or m-IMCI in the remaining parts of the paper.

2.3 Participants Selection

All participants for the research described in this paper were medical doctors of both public and private teaching hospitals and medical schools - all facilities which used the paper-based forms. The exact number of participants is explained in the respective sections. Existing familiarity with IMCI protocol and duty in the pediatrics department were the two prerequisites for eligibility to participate. Although IMCI is recommended nationwide, our research revealed that only a few facilities implemented the paper-based protocol. We used our own devices for the research. Despite interest from users, we did not allow m-IMCI installation on personal phones to protect private health data.

3 RELATED WORK

There are two categories of related work with respect to our work. The first category includes the IMCI related work in the space of m-health technologies whereas the second is related to training methods for users.

The first implementation of IMCI was done in 2008 where DeRenzi et. al created a PDA based application called e-IMCI which included some modules present in the chart booklet [10]. The purpose of this initiative was to increase the adherence to protocol and enhance the treatment capability of field workers. It also reduced the chances of error while treating infant and young children and during the collection of important health data. Although e-IMCI reduced skipped steps, branching-logic errors and miscalculations, end users still required some form of training and the speed of performing tasks on both systems was found to be almost the same. The authors also trained one clinician who agreed to train other individuals [9].

A known form of training is human mediation where one person teaches the target user how to use a device. However, learning from another individual can be intimidating, can cause a fear of being perceived as technologically illiterate, is time-consuming and not scalable. Mediated usage can also cause dependence on the intermediary [24], hindering self-empowerment. Furthermore, digital tasks can be very personal in nature, making users unwilling to seek out an intermediary for help. Such examples include searching a contact, reading a message, making a private group etc. - all of which require disclosing personal information in the process of receiving help. All of these reasons drive our motivation to train users without reliance on any mediated help.

A more recent implementation was by Ginsburgh et. al [14] which utilized IMCI protocol in their mPneumonia application. In this system, ODK [15] was used to create the mPneumonia application which was integrated to work with the software-based breath counter and pulse oximeter. The focus of the work was the management of childhood pneumonia in Ghana. The work observed the similar shortage of doctors and potential of IMCI as our work. Although the qualitative pilot study used tablet to seek feedback, the time taken to complete mPneumonia was repeatedly reported as an issue by the health providers. The work also provided one-day mPneumonia training with demonstrations and practice sessions and recommended refresher training of the IMCI protocol and other forms of training.

Our work builds upon the works listed here and is motivated by these and other similar initiatives which include user training. However, since IMCI protocol is adapted for each country and because the device training had to be incorporated in the Android native toolkit, we had to implement a new application based on IMCI Pakistan booklet with Android, instead of using PDA or Open Data Kit.

Many ideas are being tested to improve user learning by providing training and self-learning features. One such example is Integrated Maintenance Information System (IMIS) which was designed to provide the maintenance technician with a single source training simulator for all information necessary to do his or her job [7] so that technicians can learn all use cases without actually working on airplanes. Another such example is the full strategy game "Clash of Clan", with more than one hundred million downloads; the game uses interactive device training to train the user on the fly [27]. Ibtasam et. al argues that the need for human intermediation could be reduced by providing side-by-side audio help in mobile application [18].

Computer Based Training (CBT) is one of the training methodologies which allow end-users to complete interactive lessons that walk them through the processes of performing common tasks, after which the software tests them on their performance and understanding [26]. Adaptive User Interfaces (AUIs) have shown promising results in usability, usefulness, and user satisfaction of smartphone applications [28]. In adaptive user interfaces, an application adapts itself according to the user's need instead of showing extra detail (Predictive Aiding (PA)) [4].

Another technique called "Gamification" has shown great results - the technique teaches users certain behaviors through game-like activities. It involves the use of gaming concepts and game mechanics in non-gaming contexts to enhance user involvement. Research has shown that the video game environmental approach is very effective in application development [19] [11].

4 PHASE ONE: DEVELOPMENT & EVALUATION OF M-IMCI

We initially designed mockups for cough and fever, out of the five diseases covered by the IMCI protocol. We visited city's second largest public hospital and sought feedback from the doctors. The visit helped us identify the perceptions and expectations of our potential users.

Our discussions revealed that doctors did not like text-heavy screens and interactions which required frequent textual inputs. In order to replicate the paper-based model without losing content, we used multiple screens of content. The transition from one screen to the next was automated, which previously had to be done manually in the booklet. However, the doctors mentioned the need for a fewer number of screens to reduce the complexity of navigation during patient diagnosis. The need for reduction of screens was also reported by previous work [10], thus we designed a three-page application with one scrollable screen for each step out of three steps of the IMCI manual.

We used this opportunity to seek feedback on paper-based IMCI. Doctors found it difficult to remember and understand the lengthy 58-page manual, especially because of the time consumed in flipping through the pages amidst the large patient turnout, the difficulty in calculating medicine dosage and potential errors in the calculation of the aforementioned when relying on memory.

4.1 Designing the Modules

After incorporating the feedback from the doctors, the three modules (assessment, classification, and treatment) and 5 diseases (for Pakistan) were implemented. Registration module registered the doctors and helped track their performance whereas patient registration included information like name, age, height, and weight etc. which helped in implementing the follow-up modules. Assessment module was designed to work on the basis of the patient information as well as the symptoms which helped classify the disease in the next stage. Classification of a particular disease leads to the identification of the treatment plan for the patient. Algorithms were defined for all the diseases as per the protocol, they were inspected for errors and reviewed by IMCI expert doctors certified in providing the 11-day IMCI training. It was important to map the algorithms exactly like the manual to avoid any errors or dangers to the patients. Upon completion of development of a cough and fever diseases, and lab testing we took the application for evaluation by doctors in a real-time environment. The doctors used m-IMCI with actual patients.

4.2 Randomized Testing before Evaluations

m-IMCI was initially tested with 20 OPD doctors to remove any errors from the application. Human errors, hardware or software failure, wrong dosage calculations, application crashes and database connectivity failure were classified as critical errors whereas wrong entry of demographic information, wrong symptom identification, or issues due to mishandling of the device were classified as minor errors. The table below shows the frequency percentage of each of these errors.

Percentage of critical errors	Percentage of minor errors	Error-free rate (Percentage of participants making no error)	Overall successful task completion by the doctors
10 %	50 %	40 %	75 %

4.3 Research Methodology

Focus groups were conducted to evaluate the implementation. Due to the acute shortage of doctors in the public hospitals and a huge influx of patients, doctors were not easily available for our study in such a large number. Thus, a total of thirty-five participants were recruited and five focus groups, each with seven participants, were conducted. Participants were selected from diverse backgrounds including fourth and fifth-year medical students, IMCI trained on-duty doctors of the hospital, and IMCI trained health providers. Before the evaluation sessions, all participants were trained. The training sessions included a demo of the application, telling participants about its purpose, and how to use the application.

4.4 Scenario-Based Evaluation

During the m-IMCI evaluation session, structured scenarios were given to the participants. A sample scenario consisted of hypothetical patient information and history that comprised of one or more disease symptoms from the manual. Different complexity scenarios were designed to engage the user in most of the application features; the cases were unique each time to remove repetition in scenarios. These difficulty levels were based on the number of inputs i.e. more inputs meant a higher difficulty level scenario. The results of these scenarios, provided and verified manually by the IMCI expert doctor, were used to evaluate the performance on each scenario. Some sample scenarios are:

(Easy Scenario) *Sameer age 4 years, weight 16 kg with no danger signs, has cough for 5 days with wheeze and breath count 45 per minute*

(Medium Scenario) *Amir age 2 years, weight 5.6 kg, suffering from fever 101.22 with no danger signs, has cough for 2 days with wheezing and lower chest in-drawing*

(Complex Scenario) *Sadia has diarrhea for 2 days, is 7 months old and weighs 6kg. She does not have blood in the stool, is restless and irritable. Her eyes are sunken. She is not able to drink liquids and a skin pinch goes back very slowly.*

All 35 participants were required to perform some scenarios using both the manual and the m-IMCI, not necessarily in this order. Participants were divided into two groups for evaluation. One group was given the IMCI manual first and the other group was given the Android phones containing m-IMCI first with the same structured scenarios. Afterward, each participant filled a feedback form for both systems.

4.5 Comparative Analysis of Manual & m-IMCI

Correct Classification of the Disease: We compared correct classification (Figure 1) of the diseases by the doctors using manual and m-IMCI for all the cases (according to the solutions provided).

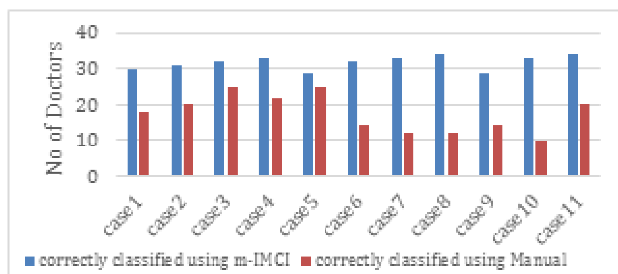

Figure 1: Comparison of correct classifications of cases using m-IMCI vs. paper manual

Time Taken: To measure the time efficiency of the systems, we analyzed the time taken to complete tasks in minutes (Figure 2).

Responses to the quantitative parameters showed positive responses for the application. However, these might have been due to the technology or novelty aspect of the system. Thus, we set out to find qualitative anecdotes of how doctors felt about each system.

Preference in future use: Participants were asked which one of the two systems (paper-based IMCI vs. m-IMCI) they were likely to use in the future. Most respondents believed that all three modules were easier through m-IMCI application when compared with the paper-based manual. Figure 3 shows the percentage responses.

Complexity: IMCI manual is based upon five diseases with somewhat overlapping symptoms. Doctors find the reliance on memory and dosage for all of these calculations complex. While talking about the paper-based IMCI one participant said: *"It does not help much although treatment, classification, and dosage plans are well described but as we have to rely on memory or consult manual,*

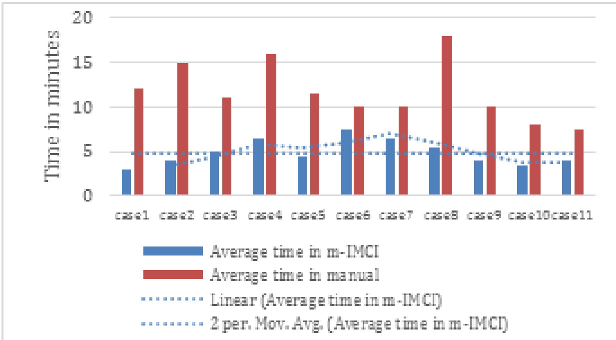

Figure 2: Time taken to solve cases using m-IMCI vs. paper manual

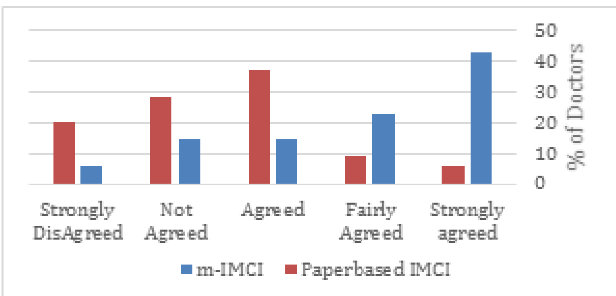

Figure 3: Preference of doctors to use m-IMCI vs. paper manual

it is not easy to use in the field". Thus, while using the paper-based manual, users, doctors in this case, always need to keep it nearby to consult it quite often while examining their patients. One participant said *"Classification and assessment can be memorized but you ALWAYS have to look to the manual to prescribe the correct treatment plan".* Whereas one participant said about the IMCI mobile application *"The best part of this is the fact that I don't have to memorize anything except for my login credentials".* Figure 4 shows the responses to the complexity of the two systems.

Need for Training and Assistance: Although a majority of the participants found m-IMCI easy to use, some of the participants

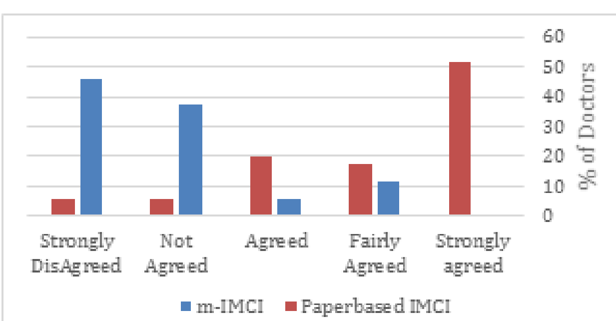

Figure 4: Participant's view regarding the complexity of m-IMCI vs. paper manual

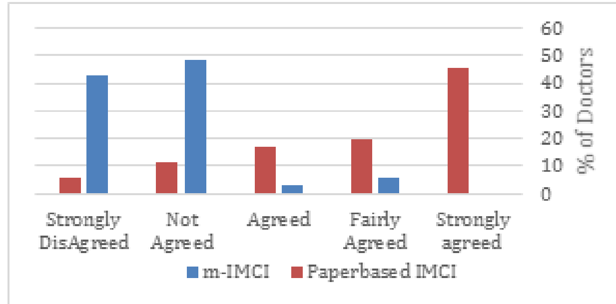

Figure 5: Participant's view regarding the complexity of m-IMCI vs. paper manual

required more training; corroborating previous results [9] [14]. We provided multiple application demos to familiarize the users, while some still needed help during the practice because they were not used to mobile applications. Figure 5 illustrates the training and support requirement in both cases.

Ease of Use: As discussed in the sections above, the current paper-based IMCI manual requires doctors to write the patient data, their symptoms, history and treatment plan on a prescription sheet while going through multiple pages of the manual. This is both inconvenient and time-consuming. One participant said that *"In my opinion time consumption is the worst part of IMCI manual".* Participants appreciated the ease of use and user-friendliness of m-IMCI mobile application because it reduced the effort required to input the patient data. However, some participants requested for printed prescriptions, because after using the application, they had to copy the treatment plan for patients on a sheet. We incorporated this feedback by attaching a printer to the central pediatric department computer which printed the dosage for the patient. Figure 6 shows the responses to the comparative ease of use.

Time and Cost Effectiveness: Our visit to the hospitals as well as discussions with participants revealed that during rush hours, doctors are unable to see all the waiting patients. In public hospitals, the timings are from 8 am to 2 pm or 5 pm, after which the remaining patients have to go back home without examination. Research [14] shows that 30 percent health care providers note that although feasible, the application would add to their workload.

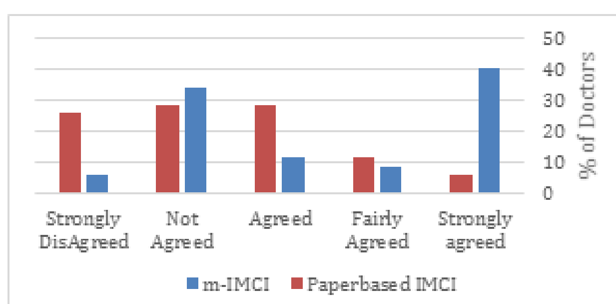

Figure 6: Participant's responses to relative ease of use of m-IMCI vs. paper manual

However, during our feedback sessions, the doctors shared that they believe this application could help save precious time, not only for the doctors but also of the patients.

When asked about its effectiveness in terms of time and cost, participants responded with comments like *"It should be provided to doctors, it is much more effective than paper-based".* Participants also mentioned that this application can provide effective ways to monitor and evaluate the performance of health providers.

5 PHASE TWO: INTEGRATION OF THE INTERACTIVE-DEVICE TRAINING

Our interaction with the participant doctors and their feedback revealed that giving them a mobile phone application based on an instrument already in use by them would still require technology acceptance, transition time, and extensive user training. Some participants also informed that they had forgotten the 11-day IMCI manual training since they do not use each and every part of the manual. During the 11 day training, they were shown videos to understand and differentiate between concepts. For example, the concept of wheezing chest could only be demonstrated using a video of a child with wheezing sound. Later, in the absence of refresher courses, the doctors relied on their memory, peers, or guesswork to recall what the terms meant or the what the next step could be. These learnings formed the basis for the introduction of IDT (Interactive-Device Training) enabling self-learning in this application. For this, we developed a generic API which can be easily integrated into any Android mobile application to provide training functionality.

5.1 Research Methodology:

We selected a group of 21 doctors each with 5 years of medical education and a minimum of 2 years pediatric experience to achieve consistency in results. Nine of them were females and twelve were males. We further sub-divided the 21 participants into three groups of 7 participants, each with 3 females and 4 males for our three experiments explained later. Although we set the ownership of smartphones as one of our eligibility criteria, during the random selection process, all doctors encountered (whether they agreed to participate or not) were smartphone owners. The scenarios designed for phase 1, described in the section above were used for these experiments as well. Each participant was allocated five scenarios sequenced in the particular order of two easy followed by one medium, then two difficult scenarios. Reasons for particular sequencing were to remove the learning effect caused by performing scenarios and to give an incremental learning experience. This technique was inspired by games, where each new level has slightly higher difficulty level so that users do not feel repetitions and stay engaged in the game. Each participant had to complete all five scenarios individually.

This phase consisted of following experiments. In the first experiment, we tested the users without the IDT module. In the second experiment, the Interactive-device-training module integrated into m-IMCI application was tested. In the third experiment, we compare the effectiveness of different IDT modules. The parameters used to make comparisons in all of these experiments are:

i. Total time spent on a single test (including the time taken to read the case)
ii. Total number of mistakes
iii. Total number of incorrect navigations
iv. Total number of assists required during test

5.2 Experiment 1: m-IMCI Application without IDT

Before adding additional components m-IMCI was tested against the same parameters. 7 doctors (4 males and 3 females) with earlier formal IMCI training were chosen from the pediatric departments of public and private hospitals. A basic survey about computer literacy and m-IMCI reviews was conducted. Each participant was given a 4-5-minute training and an overview of the application with the help of a scenario. At the end of the training, the users were able to operate the application on their own. After the introduction and demo, each participant was randomly given five (5) different scenarios to perform using m-IMCI on a given device. The users took an average of 45 minutes to complete the five scenarios. Along with application data, an observation sheet was filled out to record the participant behavior. Afterward, the participants were given feedback forms regarding application usability and level of usefulness. Participants highlighted the difficulty in understanding medical terms, problems in navigating among different screens of the existing m-IMC, issues in filling out the input fields while using the application etc. All the interviews were audio recorded and lasted for 30 minutes on average.

5.3 Interactive Device Training

Our training module, which incorporated input from Experiment 1, took six weeks to develop. We called it IDT (Interactive-Device Training). This is a technique similar to a video demo of an application, but the key difference is that it is an interactive application simulation. In this technique, the users are asked by the application to perform specific tasks, like entering some data in input fields or by selection of some options (checkbox or radio buttons). During each simulation, users are able to complete a tutorial on a specific part of the application (like user registration etc.) The IDT module was able to assist the users in utilizing the following helping modules. Each of the helping modules can be used independently or in combination.

i. Images with textual description
ii. Contextual Tool Tips
iii. Audio/Video assistance

The main advantage of this technique is that each part of the application can be simulated and users can be asked to repeat this process until he/she learns the application. However, in video demos, no such instructiveness is possible due to its pre-recorded nature. To overcome this issue of the need for extensive development, we created our own application automation API which made the IDT process smoother and faster. The content for designing IDT module was obtained from different online health-care sources.

Module 1 - Image with the Textual Description:

During our surveys, some participants mentioned the difficulty in understanding certain medical terms. The IDT feature provided them context-aware help. For example, if a user wanted to know

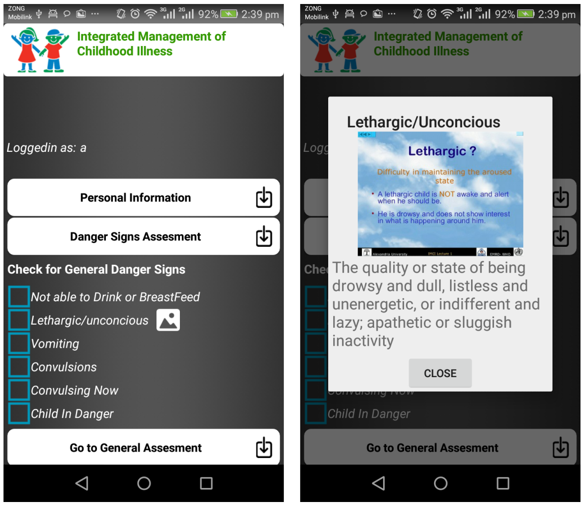

Figure 7: Image on right side shows contextual image help

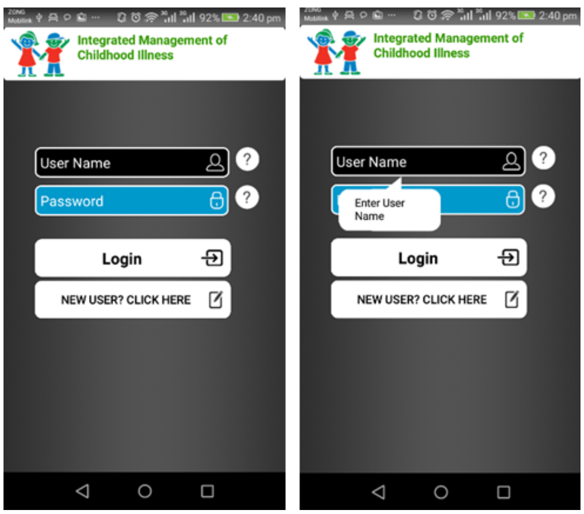

Figure 8: Right screen shows contextual tooltip

the meaning of a specific item, then s/he is just required to click a picture icon next to the word. An image with textual help will be shown with all the required information specific to that button (Figure 7).

Module 2 - Contextual Tool Tips: Some participants were unable to enter the correct data into input fields. So, we included a tooltip feature for individual items. For example, if a user wanted to know the functionality of a button, then s/he is just required to click question mark icon next to the button. By doing this, the user can read the information shown in a small window next to that item (Figure 8).

Module 3a - Video Assistance: We found that some medical conditions were difficult to express in words or pictures, so short videos were included to address this problem. To play a video the user was only required to press the video icon next to checkbox or input field about which the user wanted to know as shown in

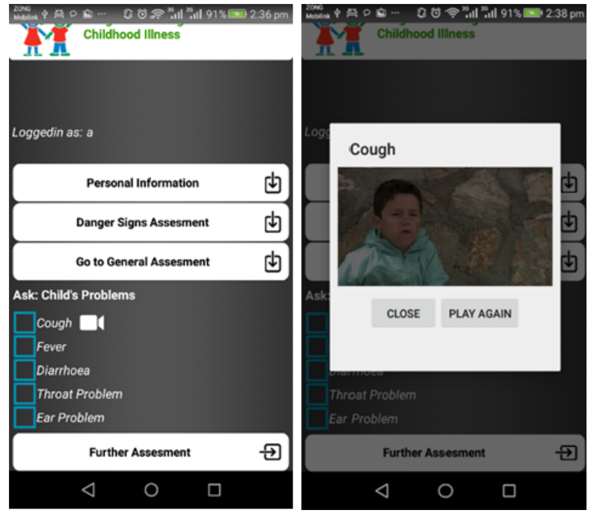

Figure 9: Right screen shows video assistance

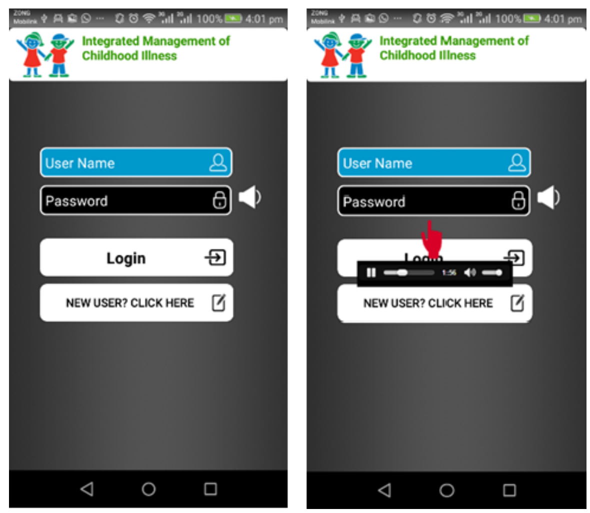

Figure 10: Right screen shows audio assistance

Figure 9. A video was played showing the actual concept of the specific medical condition that the user wanted to know about.

Module 3b - Audio Assistance: We have found that the users are reluctant in reading textual help so we added a background audio to remove the burden of reading and provided audio help regarding the functionality of a particular item. The user is just required to click a speaker icon next to the input field (checkbox, radio button, textbox) or a button as shown in Figure 10. By clicking the icon, an audio is played describing the functionality of the button. The user can pause or replay that audio again and again.

5.4 Experiment 2 - Application Testing Including Interactive-Device Training

After development and integration of IDT, we started our study with the second group of 7 doctors (4 males and 3 females). The parameters, observation forms, and feedback forms were kept the same. Users were not given any kind of training about m-IMCI and were just given the application and asked to use it. The IDT module took about 5 minutes to train each participant. At the end of the training, the users were able to operate the application on their own.

5.5 Experiment 3 - Comparison of Different IDT Modules

Once testing with the IDT module was completed, we decided to cross compare performance and effectiveness of the individual training features - audio, video, textual and tooltips. For that, we created three more sources of variation in our training module as follows:

i. IDT with only text
ii. IDT with only audio
iii. Only contextual help (No IDT)

IDT with only Text: In this variation, all training modules were removed from the application except the textual or image based help. This information was accessed by clicking the help button as shown in Figure 7.

IDT with only Audio: In this type of training, the demo application was played with only audio and an arrow sign was shown at the bottom of each control about which the audio was being played, as shown in Figure 10.

Only Contextual text-based Help: In this mode, no demo was played but users were given the application to self-learn by using the contextual text and image help or text as shown in Figures 7, 8, 9, 10.

Participants for the comparison group: The third group of 7 doctors (4 males and 3 females) was part of this testing. After testing, we collected data based on the same metrics discussed above.

5.6 Results

Task Completion Time: The first usability metric was to analyze the effectiveness of interactive-device-training. As we can see from the graph in Figure 11, there is a slight difference between the time of completing tasks with or without IDT. The graph shows the average time taken by each participant to complete a scenario which was calculated by dividing the total time taken by the participants with the number of participants for individual cases.

$$AverageTime = \frac{TotalTime}{TotalParticipants}$$

This difference indicates that IDT is an effective way to train a user without any external help. From the further study of the graph, we can see that there is almost an equal level of time difference within each case. As each case is totally different, user learning due to the previous case has a very little effect on the next case.

Error Rate: This was the most important parameter to compare user learning with IDT. Figure 12 shows that there is almost 40% improvement. The results were obtained against each scenario by dividing the total number of errors made by the total number of participants for individual cases.

$$AverageErrors = \frac{TotalErrors}{TotalParticipants}$$

This shows that IDT has a significant effect on improving user experience with respect to missing fields.

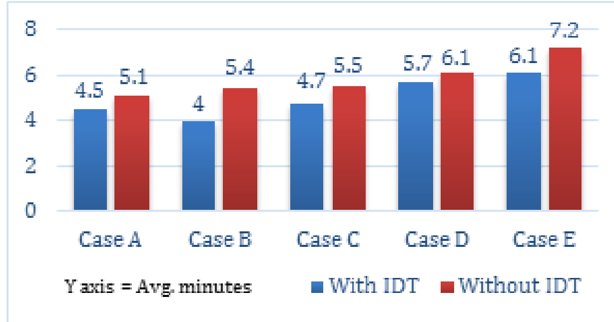

Figure 11: The blue bars show the average time taken by each participant having IDT module while the red bars show the participants with no IDT

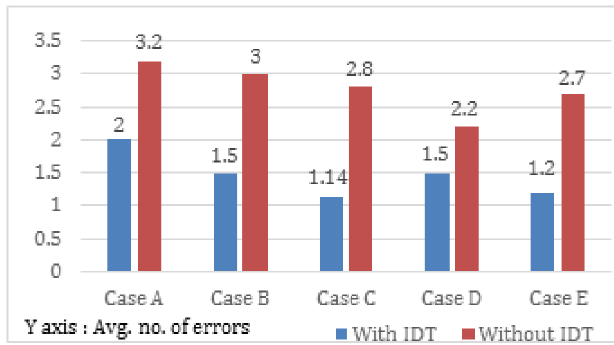

Figure 12: The blue graph shows the significant improvement in user learning by reducing the no. of errors.

Number of Assists: To evaluate this usability metric, we count the total number of assists given to users in order to complete the task. As we can see from the Figure 13, the graphs show about 50 to 60 percent improvement in user learning using the IDT module. This was also calculated against each scenario by dividing the total number of assists given in each case by the total number of participants in that case.

$$AverageAssists = \frac{TotalAssists}{TotalParticipants}$$

This was a very positive indicator that user experience can be improved by adding this kind of training in applications.

Wrong Navigations: In order to assess the user learning from IDT, we also count the number of wrong navigations. These wrong navigations (deviations from actual workflow) were counted from each screen of the App.

$$AverageWrongNavigations = \frac{TotalWrongNavigations}{TotalParticipants}$$

We can see from the Figure 14 that there is almost 40 to 50 percent improvement in user learning.

Overall comparison between conventional training and IDT: To better understand the outputs of all parameters, we plotted a graph showing the overall comparison of each parameter side by side. This graph represents three things: the total count of errors, assists, and wrong navigations. As we can see from the Figure 15 that there is almost 50% improvement in all types of decision parameters. So we can say that IDT has a positive effect on user

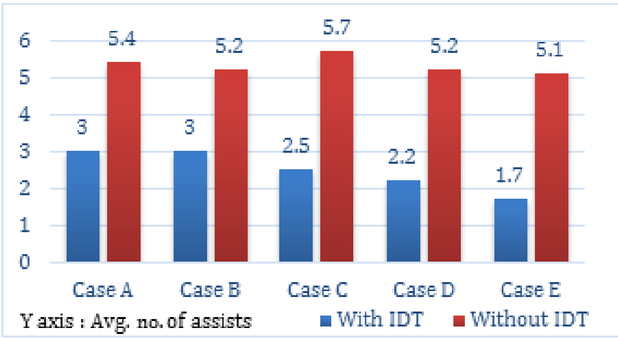

Figure 13: The blue graph shows the significant improvement in user learning by reducing the no. of assists.

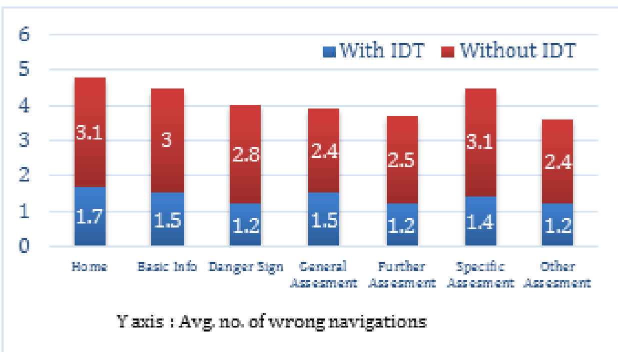

Figure 14: The blue graph shows the significant improvement in user learning by reducing the no. of wrong navigations at each screen.

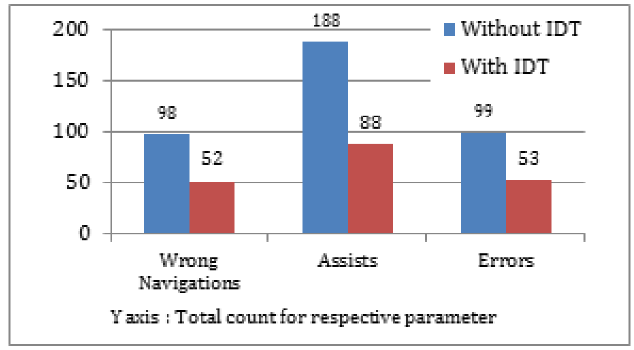

Figure 15: The blue bars in graph show the improvement in user learning using IDT against above mentioned parameters

Figure 16: The graph shows the comparisons against each IDT module against our decision parameters

learning. We use the percentage difference (PD) formula to calculate the percentage of improvement between methods. Following are the results for each of 4 different testing parameters.

$$PD = \left(\frac{v2-v1}{\frac{v1+v2}{2}}\right) * 100$$

Where

v1 = values with IDT

v2 = values with No IDT

PD (Error) = 60.5%

PD (Wrong Navigation) = 61.3%

PD (Assists) = 72.4%

As we can see, almost every type of test parameter has shown more than 60% improvement as compared to non IDT training method.

Result of Experiment 3: After completing our initial study on IDT, we wanted to compare the individual effectiveness of each training type. For this purpose, we divided it into three different types as previously mentioned.

i. Only text based demo

ii. Only Audio based demo

iii. Only contextual help (no demo)

The text based demo played a full scenario to train the user by only showing help text next to each input field as shown in figure 8. After completing the demo for each section, users were asked to fill the input fields as shown to them in demo.

In the Audio based demo, only audio help was provided. The hand icon placed next to the text pointing at input would trigger audio help. After completion of the demo, users were asked to fill input fields similar to the audio demo.

In the third application variant, only contextual help was provided. Help was triggered by clicking the help icon next to any button or input field as shown in Figure 7. In this, no demo was played and users were not asked to input data in the application. In the end, we normalized data points gathered from experiments of each training type. Figure 16 shows comparison of the 4 training types.

6 DISCUSSION

One of our concerns was patient's reaction to the doctor's use of phones while treating them. Our assumptions were that the patients might question the skill of the doctor or see them as reliant on an external device on treatment. Similarly, we feared patients would see doctors as distracted when looking at their phones. However, our observations in phase one revealed that the patients did not question the skill or intention of the doctors. They were further convinced of the IMCI system when they received the printed receipts. In some instances, when doctors were asked to look at the videos in the presence of patients, the patients trusted the doctor to be performing relevant tasks on the phone.

DeRenzi et. al. [10] and mPneumonia project [14] both mentioned the need for initial training of workers as well as refresher courses for IMCI training. We propose incorporating some in-device training - providing contextual help during treatment along with some passive training -video trainings accessible in their free time.

Our other assumption was that doctors depended on memory, rather than the manual, for diagnosing a patient. However, doctors said that it depends on frequent cases and they always refer to the manual for confirming treatment plans.

Doctors also requested a built-in timer to count breaths. Currently, they have to look at their watches to see time while counting respiration or pulse while using the app. We initially used the timer to calculate time taken to diagnose, but we observed that doctors were often multitasking to talk to other colleagues about the patient and going to other rooms for supplies or questions. We planned to overcome this issue by audio recording the interactions between doctors and patients. However, because of the absence of specific consent of patients voices, we did not pursue this. Thus, our experiments in the second phase were in a controlled environment instead of real settings.

7 CONCLUSION

In this paper, we have discussed the transition of paper-based systems to an Android-based mobile application. In the first phase, we explore the relative efficiency and accuracy achieved through this system. We also illustrate the possible benefits and prerequisites for such deployments. In the second phase, we have analyzed factors that affect the usability of the application after user training. In developing countries like Pakistan where computer literacy level in major fields of life is very low, implementation of technology projects especially e-government projects faces problems of end-user training.

Our first goal in this study was to digitize a paper-based system and obtain user feedback on the overall transition. We saw important factors like the need for visual training and matching user pace along with technology acceptability. Our second goal was to devise a method that can be used in any application to enhance the end user learning experience and reduce training effort and cost. In doing so, we cross compare the effectiveness of each training technique to find the most effective and efficient way of training. We employed error, wrong navigations, time to complete tasks, and the number of assistance as parameters for modeling such results. Finally, we demonstrated that interactive-device training is an effective way of end-user training with respect to conventional techniques.

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