A Mobile Virtual Patient for Medical Learning

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***Abstract*—Many young doctors have their first experience of the anxiety of treating an acutely sick patient only during internship. Unfortunately, the risk of medical error is very high at this point. Learning through computer simulated virtual patient has been proven a solution to bridge this gap. Recent developments in electronic healthcare research have produced highly reliable patient simulators. This paper presents a mobile application which can be very readily accessible for medical education using virtual patients. At the current state of the research, a mobile application useful for medical education using virtual patients has been developed. It has been built in such a user-friendly manner after rigorous elicitation of knowledge from medical practitioners. It is particularly targeted at medical students who only need to input their user log-in to start using the application. A medical student can learn while also catching fun using this system.**

Keywords—Medical e-Learning; Mobile Applications; Modelling and Simulation; Virtual Patient

I. INTRODUCTION

In the world of medicine, doctors, nurses, physiotherapists, pharmacists and a host of other medical practitioners are made out of years of rigorous training. This typically involves long hours of study, experiments with various specimens coupled with real-life on-the-job trainings. They also have the tedious and burdensome task of attending to all forms of patients with diverse kinds of infirmities, diseases and sicknesses some of which may be very strange or uncommon in the environment of study. The curriculum of medical schools is typically divided into two halves. The first is the pre-clinical segment and the other is the clinical segment, the duo of which makes up the Bachelor of Medicine Bachelor of Science (MBBS) programme. For the medical students, the major practical exposure is only the clinical segment of the study and because of the uncommon nature of some certain diseases the students may be unavoidably unable to practically diagnose such diseases throughout their stay in the medical school.

The insufficiency of some basic educational facilities in many of our medical schools in most teaching hospitals contribute to reasons for students not getting the adequate level of training and practical exposure required to make world-class medical practitioners. All these coupled with the natural unavailability of patients having the differential diagnosis of certain diseases have been obstacles towards the achievement of full-fletched training in medical schools. It is therefore of significant importance to seek for an alternative means of rescuing the medical educational standard in Africa especially by exploiting the possibilities of the rapidly growing world of information technology. Virtual patient (VP) is one of such technology implement.

A medical learner such usually a medical student uses a VP by playing "the role of a health care professional treating a computer-based simulated patient." The use of VPs is common in teaching skills such as "clinical interviewing, bioethics, basic patient communication, history taking, and clinical decision-making"[1].

II. VIRTUAL PATIENTS THEORY

Diverse educational frameworks that characterize VP cases are distinguishable. There are static and dynamic cases [2]. A more extensive list of unique features of VPs are: "linear-passive cases, linear-interactive cases, branching cases, and student-authored cases" [3].

The most frequently use computer-based training tool is "Static patient interactions". A static patient case teaches "students how to ask relevant questions and to order relevant tests in the context of a patient's medical condition." Moreover, static patient is aimed at teaching "students to recognize abnormal findings and to infer a diagnosis followed by development of an appropriate treatment plan."

Conversely, in dynamic interactions, medical conditions are made to progress over time, thus allowing students to be pressured to make decisions. The goal of dynamic interaction is to allow students to practice an immense series of skills such as "medical history taking, physical examination, ordering and reviewing laboratory tests, requesting additional investigations, and planning treatments" [1 – 3].

Linear-passive cases "progress in one direction without options." They are well suited for learning in a small group [3].

Linear interactive cases also progress in one direction, but offer choices. "Some experts characterize linear-interactive cases as exploratory" [4]. For example, different tests can be ordered to help confirm or discard differential diagnoses.

Branching cases allow multiple choices with multiple outcomes. Consequently, various choices beget different clinical scenarios.

In student-authored cases, a "medical student creates a part of or a whole virtual patient as an exercise." A review conducted in [5] found that 26 of 108 (24%) responding American and Canadian medical schools had developed VP case scenarios. Among the 26 medical schools, "case scenarios were used mostly in undergraduate medical education rather than residency and tested primarily internal medicine and pediatrics topics."

As reported in [1], "evidence suggests that the use of virtual patients (VPs) as a component of escalating simulations from computer-based to standardized patient (SP) to actual clinical encounters may be the most appropriate and effective strategy."

III. RELATED WORK

Research shows that effective VP simulations should provide chances for trial-and-error, allow the student unhindered opportunity to query and examine the patient, allow the student to control certain time aspects of the VP simulation and allow the student to observe "virtual anatomic and physiologic changes" [2]. Additionally, principles guiding VP design emerged from a focus group consisting of medical students on their pediatric clerkship. These principles included relevance, appropriate level of difficulty, interactivity, optimal use of media, recapitulation of key learning points, authenticity, and questions and explanations tailored to the critical-thinking process [6]. Posel and colleagues at McGill University provide 12 tips to be consider before developing VP simulations. These include:

- developing relevant case content and a suitable case model,
- organizing and storyboarding ideas,
- matching case complexity to case objectives,
- including feedback from the start of the simulation,
- supporting individualized learning,
- designing the virtual patient in ways that encourage collaborative learning,
- encouraging interactivity and engagement,
- developing intuitive and logical case navigation,
- ensuring privacy,
- branching to include expert treatment plans,
- choosing of the right authoring program, and
- including instruction and feedback throughout the instructional cycle [4].

Hubal and other researchers in [7] describe a Virtual Standardized Patient (VSP) application that "offers training benefits that include enhanced adaptability, availability, and assessment." The contribution of their work is in demonstration of the VSP using well-established Standardized Patient scenarios commonly used in the clinical setting for evaluating patients who have specific illnesses. Huang and research fellows in [5] present an inventory of information regarding in-house virtual patient development at U.S. and Canadian medical schools to promote the sharing of existing cases and future collaboration. According to the study as at September 2005 "Twenty-six out of 108 responding schools reported that they were producing virtual patients." This reveals the infancy of virtual patient technology. More recent studies [8 – 17] have revealed that:

- "Virtual patients should be designed and used to promote clinical reasoning skills. More research is needed to inform how to effectively use VPs."[8]
- "Virtual patients are associated with large positive effects compared with no intervention. Effects in comparison with non-computer instruction are on average small. Further research clarifying how to effectively implement virtual patients is needed."[9]
- "Although on-screen virtual patients (VPs) have been around for decades, it is only now that they are entering the mainstream, and as such they are new to most of the medical education community." [10]
- Findings in [11] suggest that "using VPS both for learning and for assessment supports learning. VPS are better than traditional assessment methods when the virtual application is used for both learning and evaluation."
- Poulton in [13] viewed the year 2010 as "a vintage year for virtual patients (VPs) with an almost continuous sequence of publications and presentations at the major conferences." The author further reported that "VPs have finally become embedded in the curriculum: in problem-based learning; as core components of lectures, tutorials and seminars; as assessment tools. The medical education community can increasingly turn its attention to the ways in which VPs can be used with the greatest efficiency and pedagogic value."
- Furthermore, [17] concludes that "the continued development, implementation and evaluation of narrative virtual patient simulations across a variety of health and social care programmes would help ascertain their success as an educational tool." It thus becomes imperative for African research and training community to begin or continue to develop aboriginal virtual patients.

IV. JUSTIFICATION AND DELINEATION

The medical field is a very wide and vast domain. It encompasses a very broad scope of knowledge. It is in fact one of the broadest scope of studies in the world. It therefore is not surprising that in its various areas of specification, there are always insufficient medical practitioners who can stand with full confidence and boast of a technical expertise. In developing parts of the world (especially in Africa) there are always very few competent medical practitioners in various fields. It is no news to state that the system of education in Africa is below par with other parts of the world, and the medical field is not an exception. Data is scarce on the use of virtual patient to enhance medical learning. Medical learning is best done with Aboriginal cases instead of using cases alien to the community of the practitioner. Africa can thus not depend on the use of virtual patients developed in other parts of the world to train her medical students. It is to this effect that we have come out with something that could be worthwhile – an application that is used for medical education on mobile devices using virtual patients.

This work is limited to just a collection and display of symptoms of certain diseases, sickness and malfunctioning of the human body systems. It is not a replacement of any medical procedure or education process, neither is it another medical education on its own. It is meant to be an aid to medical students who with this application have the opportunity to learn while also 'catching fun' because of the way this application has been designed in form of a game. It is hoped that this application will benefit and help medical students in their endeavours. This application is open to further developments and it will serve as a template on which others can work on and broadly expand.

V. Research Methodology

The approach used in the course of accomplishing this work involves knowledge acquisition/elicitation, knowledge representation, tool design and implementation.

A. Knowledge Acquisition/Elicitation

This process involves gathering medical knowledge needed for the development of the virtual patient (expert system) from medical doctors (experts in the field). The means of eliciting knowledge from the doctors include questionnaire, personal interview and knowledge gathering from Internet sources.

1) Questionnaire: One of the methods that was employed during the course of the knowledge acquisition is the use of questionnaires. Questionnaires were designed and given to proven medical doctors with reputable qualification and length of service in the medical field. They were thoroughly intimated with the project aims and goals and were absolutely carried along in the course of the project.

2) Personal Interview: Interviews were carried out to thoroughly elicit knowledge from the ever conservative medical experts. This was done through online interraction – using e-mails and chats, interviews based on appointments and telephone interviews.

3) knowledge gathering from Internet sources: The vast sources of knowledge available on the Internet was also explored in the course of knowledge acquisition for this work.

B. Knowledge Representation

The goal of this work is to develop a virtual patient simulator for diseases that are uncommonly presented in everyday clinical cases. As a result of this we selected Cushing's Syndrome, phaeochromocytoma, Carcinoid syndrome and PCOS - Poltcystic Ovarian Syndrome.

As prescribed by the differential diagnosis settings in the inference engine of this virtual patient software, the following diagnosis were provided for the given set of symptoms as shown in Fig. 1. The output of the tool is to display no particular diagnosis if the differential conditions shown in Fig. 1 are not met as stated. A user-friendly message is therefore displayed to inform the user about the outcome of the differentials he/she selected.

Phaeochromocytoma (PCC): as a result of the combination of the following differentials
Headache and Anxiety
Skin sensations and rashes
Flank pain
Rapid weight loss in the body
Elevated heart rate
Excessive sweating (Diaphoresis) and
Elevated blood glucose level
provided that other differentials are not selected.

Polycystic Ovary Syndrome(PCOS): as a result of the combination of the following conditions
The patient being "FEMALE"
Age within the range of 12 and 45
Body Mass Index(BMI) >= 25.0
Menstrual disorders
Lack of ovulation leading to infertility
Acne
Darkened skin patches
Male pattern of hair growth
provided that other differentials are not selected.

Cushing's Syndrome: as a result of the combination of the following differentials
The patient being "FEMALE"
Body Mass Index(BMI) >= 25.0
Male pattern of hair growth
Excessive sweating (Diaphoresis)
Dilation of capillaries(telangiectasia)
Hemorrhage on the trunk, buttocks, arms or breasts and
Development of fat pads along the collar bone and a round face(moon face)
provided that other differentials are not selected.

Carcinoid syndrome: is a result of the combination of the following differentials
Nausea and vomiting
Flushing and Diarrhea
Heart failure or Bronchoconstriction
Cardiac fibrosis
and
Abdominal pain
provided that other differentials are not selected.

Fig. 1. Differential Diagnosis Settings in the Inference Engine

C. Tool design and implementation

The design of the tool is divided into two separate interfaces. One is the VP learning interface. The second is the VP quiz. The user interface for the VP Diagnosis learning interface designed as shown in Fig. 2.

User starts tool
If User is registered then
If user selects VP diagnosis then
control is transferred to VP learning
user is given list of question portraying symptoms
user respond to questions to describe symptoms
the inference engine diagnoses the disease based on the set of symptoms selected by user.
tool displays result of diagnosis
user is allowed to carry out another diagnosis until user returns to previous or main or selects to exit.
Else If user selects Diagnosis Digest Help then
the tool displays a list of diseases
user selects disease to learn about
tool displays a description of disease, its likely causes and symptoms
user is allowed to return to previous/main menu or to quit tool
Else If user selects About VP tool then
tool displays information about the application developers
user is allowed to return to previous/main menu or to quit tool
Else If user selects Quit then
tool exits
End If
Else

Fig. 2. VP Diagnosis Learning Interface

In order to test knowledge acquisition by students, a separate interface for assessment of students' knowledge about diagnosis of diseases is designed. The interface works as shown in Fig. 3.

VI. Mobile User Interface and Discussion

The User Interface (GUI) snap-shots taken from the tool are shown below with a discussion of how the tool has been used.

Figs. 4 to 8 demonstrate how the tool works for a student wanting to have the tool diagnosis a case presented with known symptoms. The student is asked a series of questions after which the tool diagnoses the case and presents the diagnosis, prescription and medical advice. Fig. 7 and Fig. 8 are examples of such diagnosis.

Start
If user is registered to take VP diagnosis examination then
user is permitted to login
user is presented with series of multiple choice question based on a described case.
user selects answer at each stage of the questioning
tool presents a final page showing a list of diseases from which student must make selection
tool determines correctness of user's selection
result is displayed with students grading
Else
user is taken through registration process before taking the examination
End If
User Quits

Fig. 3. Student Assessment Interface

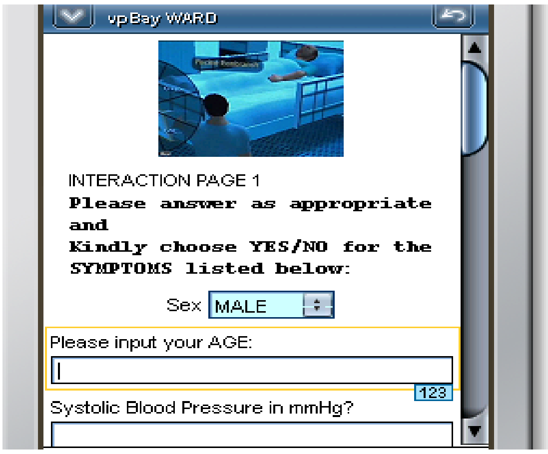

Fig. 4. Virtual Patients Ward 1

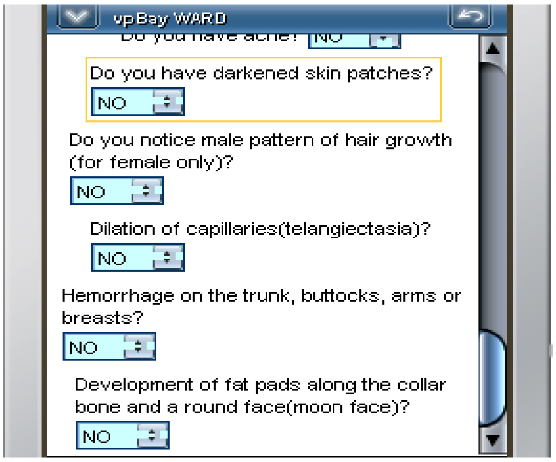

Fig. 5. Virtual Patients ward 2

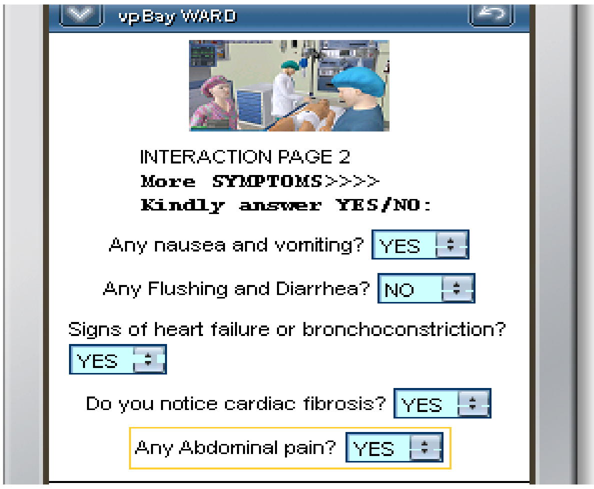

Fig. 6. VP Ward More Symptoms

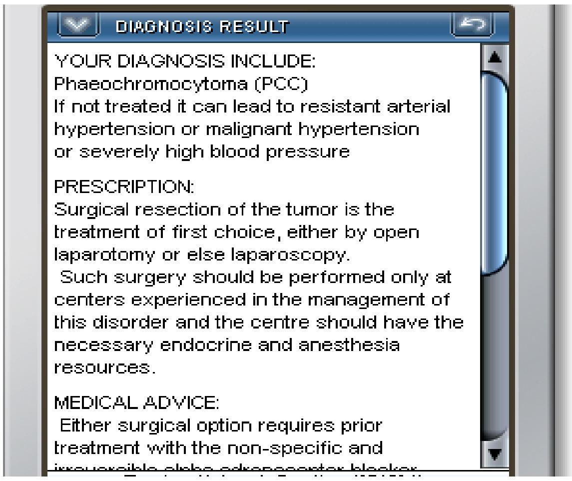

Fig. 7. Phaeochromocytoma(PCC) Result

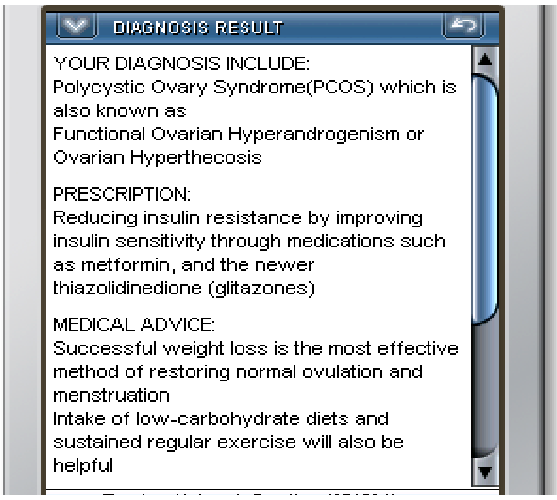

Fig. 8. Polycystic Ovary Syndrome(PCOS)

Fig. 9 and Fig. 10 are screen shots showing an example of learning about medical conditions from the VP tool. This aspect of the tool is designed to educate students about as many diseases as possible. Since it is an informative part of the tool, it is not limited to the four diseases coded in the inference engine.

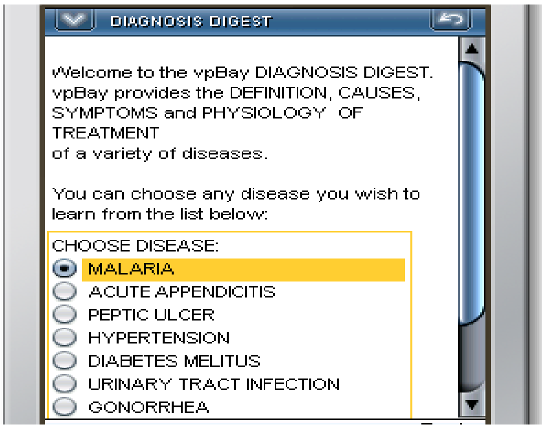

Fig. 9. Diagnosis Home

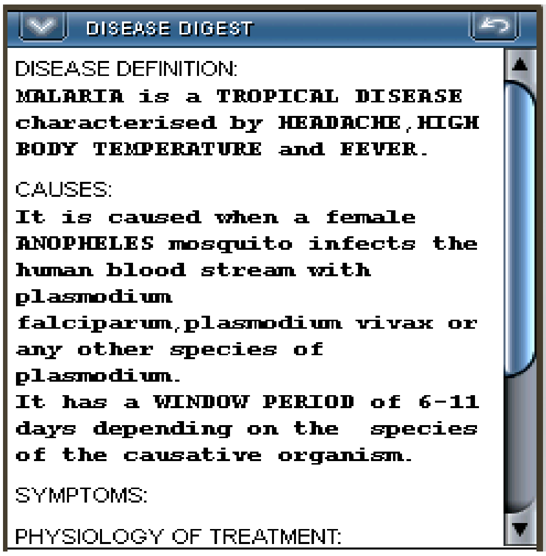

Fig. 10. Diagnosis Digest Result

In Fig. 11 to Fig. 13, we demonstrate how the tool is used to assess students on their knowledge of diseases diagnosis.

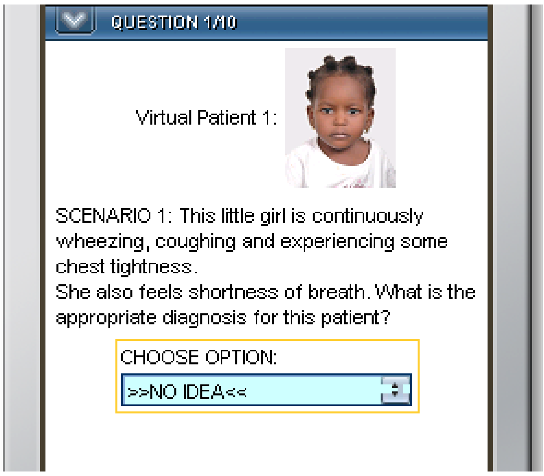

Fig. 11. Scenario/Question 1

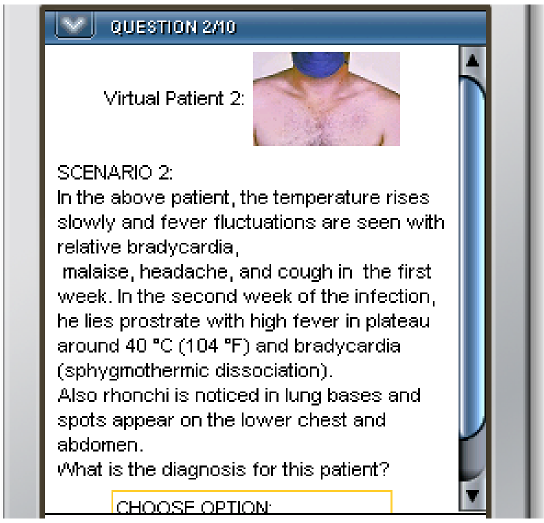

Fig. 12. Scenario/Question 2

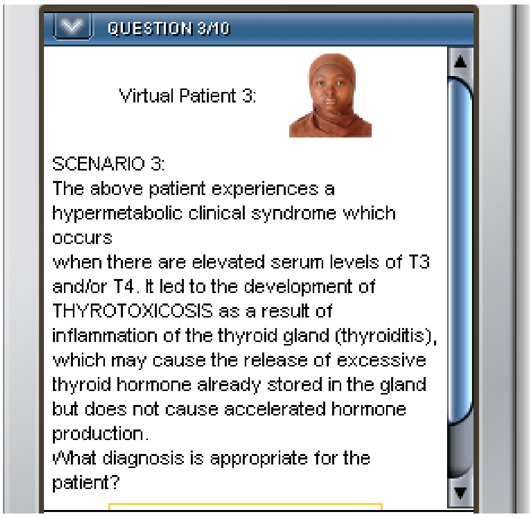

Fig. 13. Scenario/Question 3

VII. Conclusion and Further Work

Currently in our VP research we have concentrated on modelling and simulation of the tool that will enhance medical learning. Our goal is to enable real life ubiquitous usage of the tool for pre-clinical learning in medical schools, we will present tool to medical schools in selected medical schools in Africa for free test using. The target users are medical students who are very good at using mobile computing devices and would be fascinated by user friendly interface. Thus, the user interface will be improved by making use of based on the criticisms from our users. As we advance the development and testing of our VP tool, we will add more user-friendly interfaces by the use of standard illustrations. More non-technical informative content will be included to encourage non-expert to use the too to acquire medical knowledge for their wellbeing or to enable them take care of their loved ones as caregivers. In the future, the tool will be available as web-based open source VP tool.

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