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Virtual Patient Simulation: a Comparison of Two Approaches for Capacity Building in Sub-Saharan Africa

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Abstract. Background: given the diversity of virtual patient simulation systems, this study provides a comparison of two different tools, in the perspective of deploying them for supporting initial and continuing medical education in Sub-Saharan Africa. Method: the evaluation was based on existing documentation, analysis of the data models, usage of implemented of virtual patient cases, and interviews with the domain experts. Results: despite some shared similarities in their contents, there are many differences between the two applications especially in respect to their pedagogic models, technical architecture, types of interactions, feedback, and the learner's performance evaluations. Discussion and Conclusion: the implementation of learning activity based on virtual patient in a given context should consider these differences. According to their respective approaches, this study suggests that MVP is more suitable for novice learners whereas VIPS is more suitable for experienced learners.

Keywords. Computerized patient simulator, Virtual patient, E-learning, Medical education, Developing countries, Africa

Introduction

Virtual patient simulation is a learning method defined as “*an interactive computer simulation of real-life clinical scenarios for the purpose of medical training, education, or assessment*” [1]. This activity focuses on acquiring knowledge and skills with the main objective to develop clinical reasoning and decision-making [2]. It has progressed in developed countries during these last years, although its adoption remains limited [3]. In developing countries, there are only a few described experiences [4, 5]. The goal of this study is to compare two systems in the perspective of their use for capacity building in low-resource settings of Sub-Saharan Africa.

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1. Materials and methods

1.1. Materials

Virtual Internet Patient Simulation. VIPS [6] is a web application based on a relational database (MYSQL) and originally developed for improving skills of general practitioners in Switzerland. VIPS pedagogical model uses the paradigm of “blank sheet” [7], and the reflective practitioner theory (Donald Schön) [8]. It contains all the sections of medical consultation including the history, physical examination, diagnostics tests and decisions. All these sections have items ('questions') that have default answers or results with neutral values ('noise' response). The modification of the “noise” response and its score value (positive or negative) matching a clinical scenario, leads to the “signal” response.

MedBiquitous Virtual Patient Standard. MVP [1] standard architecture consists of structured XML components. The Virtual Patient Data (VPD) contains the narrative, demographic and clinical data of the virtual patient. The Media Resource (MR) manages the multimedia files associated with the clinical scenario. The Data Availability Model (DAM) creates the aggregations (DAMNode) among the VPD and the MR within a virtual patient case in order to reference them in the Activity Model (AM). The Activity Model (AM) handles the learning activities and the learner's interactions [1,9]. Through a system of rules, this component enables to create pathways. Finally, the MVP Player introduces the virtual patient to the learner, collects and analyzes his data inputs. In order to facilitate the exchange and the reutilization, all the files belonging to a given MVP are aggregated in a SCORM data packet. In addition to these five components, there is a set of other external applications attached to them.

1.2. Methods

The methodology in this study consisted in four steps. First, the complete reading of the documentation (specifications, scientific papers) related to each application. Then, the exploration of the data models of the two applications, based on the datasets representing the virtual cases. For MVP, the datasets were taken from the collection of the eViP European project (<http://www.virtualpatients.eu/referatory>). Then, several virtual patient cases were performed through the respective players. Finally, some specific questions were asked to the designers and the developers of the two systems.

2. Results

2.1. VIPS and MVP concepts

The complete medical consultation is the single learning activity of the VIPS simulator, while MVP authorizes many learning activities namely, medical consultation, clinical observation, diagnosis formulation or decision making. In the design of virtual patient cases, VIPS combines “noise” and “signal” responses which are accessible by the learner during the learning activity. On the other hand, a MVP case only contains the data (items and answers) destined to a given clinical scenario. Besides, the notion of

uncertainty is central to VIPS (information is provided only in response to questions). Its pedagogic model is based on the “problem solving” [10] (unstructured activity) and “blank sheet” models [7]. MVP for his part, is based on “narrative” [10] model (structured activity with a temporal relation).

2.2. VIPS and MVP functioning

VIPS and MVP are both web applications (table 1). They can also be executed without Internet. Unlike VIPS which is only a stand-alone application, MVP can function in a stand-alone mode or be integrated in a learning management system (LMS).

For interoperability, VIPS uses the data in a tabular format whereas the MVP uses the XML format, as well as the specifications of the SCORM for healthcare and Healthcare LOM standards to represent the data into SCORM format.

Table 1. Comparison between VIPS and MVP functioning

| Criteria | VIPS | MVP |
|-------------------------|----------------------------------|----------------------------------|
| Application Type | Online, Offline | Online, Offline |
| Execution Environments | Stand-alone | Stand-alone, LMS |
| Interoperability | Tabular text format (CSV) | XML, Healthcare LOM, SCORM |
| Activity Topology | Unique | Multiple |
| Player Access to Data | Direct | DAM, AM |
| Data Displaying | Focused on Operational Context | Focused on User's Interactions |
| Player Types | Unique | Multiple |
| Interaction's Users | Conversational, Graphic | Graphic |
| Feedback and Evaluation | Short/Long Debriefing, Formative | Debriefing, Formative, Summative |

For the progression in the case during the learning activity, VIPS has a unique topology which is branched: the learner has access to any section or to any item from the beginning of the activity. The access to VPD and to MR is done directly without an intermediate component. On the other hand, MVP has many topologies, based on the AM and the DAM: unitary, linear, semi-linear or branched [1, 11].

VIPS and MVP also differ in the way of displaying the VPD. In VIPS, the displaying of the response or result associated to one item is based on operational approach, either during the present consultation or during the next consultation. It only concerns the items of the diagnosis test and the decision sections. The items of the history and the physical examination are displayed immediately. In MVP, the displaying of the VPD is centered on the users' interactions and handled through the *Display* attribute of the DAM. It can be, *immediate*, *ontrigger*, *delayed* or *ifrequested* [12]. VIPS has only one player while MVP has many players such as *Casus* (linear); *Campus* and *Web-SP* (semi-linear); and *OpenLabyrinth* (branched) [11].

In terms of user interaction, VIPS associates both the conversational mode in which the learner interacts with the virtual patient through the natural language and the graphic mode (clicks) in particular for physical examination. MVP only uses the point-and-click mode.

The two applications propose different ways for feedback and evaluation of the learner's performance. Both propose a “short debriefing” at the end of the activity, explaining the final diagnosis, the education objectives and the main points of the clinical case scenario. VIPS also reports in detail what were the good decisions, those that should have been taken, as well as the non-contributive or potential dangerous

decisions that were made. In addition, it integrates a “long” debriefing” presenting a state of the art on the topic and evidence from the published and grey literature. VIPS is only based on a formative approach (clinical pathway) while MVP combines formative and summative approaches (practical application of acquired knowledge or skills).

3. Discussion

Both applications aim to develop the learners’ clinical reasoning [2]. From the real clinical scenarios, the learner must be able to organize the acquired knowledge and to integrate it to prescribed actions in order to improve his skills in the management of diagnosis or decision problems [2]. The differences observed between the two applications are due to the pedagogic models, the used technologies, the types of interactions, the type of feedback and the learner’s performance evaluations.

The implementation of a learning activity based on a virtual patient simulation must be supported by an adapted pedagogic model [13]. The problem solving model used by VIPS requires the cognitive analytic and non-analytic processes related to the learners in order to formulate the right questions, to establish the best diagnostic hypothesis and decisions [14]. This model is the closest one to real clinical situations. The narrative model used by the MVP, is based on the decision trees which focus on the decision making and the results of these decisions. During a learning activity on a MVP case, the learner navigates through the interconnected activity nodes by rules. The learner is oriented through explicit questions asked to him by the end of each step. It is known that the new learners learn better from a structured teaching which is associated to some examples while the most advanced ones attach more interest to practical problems [2]. It is also known that learners have a low diagnostic accuracy rate in the problem-solving model compared to clinical vignette model (based on narrative model) [7]. This suggests that VIPS is more adapted to experienced learners while MVP is more adapted to inexperienced learners. However, in addition to the knowledge already acquired, the association of a narrative model with a problem solving model seems to be the most efficient means for the learner to elaborate “scripts of disease” [15].

Technically, the respective architectures of both systems (web application, possibility to locally run the clinical case) have been designed to operate in any type of context, including in developing countries (connectivity problems, lack of digital learning environment). However, the real challenge lies in the relevance of knowledge representation for learning in each virtual patient system and the implemented clinical scenarios with the context in which this activity will be deployed.

The different approaches for the data displaying and the learner’s interactions may have effects on the learners’ performances. It is known that physical interactions stimulate the mental interest and the learners’ involvement in a learning activity [16]. It is recommended to design virtual patients in which the data exploration is privileged [17] but it’s more appropriate to the experienced learners [18]. However, the use of natural language to interact may pose the user’s input processing problems for an application. This requires the implementation of efficient algorithms for retrieving items with a high precision.

Finally, the feedback and the evaluation of learners through virtual patient simulation should be both formative and summative. The formative approach aims at associating the educational objectives; reviewing the essential points of the virtual patient case; and insuring the transfer of acquired skills towards the real clinical

situations. This computerized feedback should be completed by the human feedback. In the summative approach, instead of dealing with knowledge acquisition, the focus is on the effectiveness of diagnosis and the critical thinking or at least, on the application of the knowledge acquired during the learning activity [2]: multiple choices questions [19], concordance of scripts tests [20].

4. Conclusion

This study suggests that a learning activity based on virtual patient system should consider the educational objectives, the learners' level of, the expected outcomes, the awaited type of interactions and the technical environments in which these virtual patients will be played.

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