An XML Standard for Virtual Patients: Exchanging Case-Based Simulations in Medical Education

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Abstract: Virtual Patients are computer-based simulations of a clinical encounter where the user plays the role of a healthcare provider while receiving in-context instruction. This unique pedagogical approach enables active case-based learning for learners. Academic institutions around the world have developed high-quality virtual patients using many different authoring and playback technologies. However, sustainability and scalability have proved challenging due to the number of cases needed and production costs. In an effort to promote sharing of Virtual Patients and broader adoption into medical education at all levels, MedBiquitous organized an international working group to create an XML-based “MedBiquitous Virtual Patient Standard” (MVP) describing a common structure for virtual patient content and activities. The MVP enables virtual patient exchange across systems, modification, and display within conformant player software.

INTRODUCTION

The fundamental structure of medical education has remained unchanged for decades. Yet during this time, there have been dramatic changes in the environment in which students and house staff are being taught. The rapid growth in medical knowledge and the changing structure of health care have challenged medical schools to teach an ever-expanding range of knowledge and treatment options. At the same time, the shift of medical care from inpatient to outpatient settings has reduced the time students are able to spend with patients, severely limiting the traditional model and causing the hospital to become a vanishing classroom (1,2). In an effort to adapt to these changes, many medical schools are shifting away from structure and process driven curriculum towards more competency-based and case-based education, facing increasing pressures from accreditation and licensing agencies to demonstrate clinical competency of students (3).

Virtual Patients have worked well to simulate concrete and predictable topics such as physiological processes and performing procedures. More recently they have been used to model the patient interview and are being used to teach clinical interviewing skills. Previous work has included the development of virtual patient cases designed to teach bedside competencies of bioethics, basic patient communication and history taking, and clinical decision-making (7,8,9). Combining VPs to create more realistic simulations of procedures or the effects of medications has also been explored (10). In evaluations of objective measures of performance,
knowledge, and diagnostic abilities, VPs have been shown to be as effective as traditional standardized patients (11).

Though they are more scalable and reusable than traditional live cases, the process of creating quality VP cases is both expensive and time consuming. A recent survey of 142 US Medical Schools found that one third of the virtual cases cost more than $50,000 and 80% cost more than $10,000, with a median production time of 17 months. The VP cases tended to focus on primary care disciplines and had limited racial or ethnic diversity. (12)

The resource intensive nature of this approach has led many faculty to believe that the most efficient use of these cases is for different institutions to exchange, edit and reuse them, creating a pool of cases for general use. This resource would give access to high quality Virtual Patient simulations to all of the medical education institutions, many of whom do not currently have the resources to develop that capability.

Early attempts at exchanging these cases found several challenges (13,14). The first challenge is that the standards that exist for interchange of educational content and learning objects fall far short of the functionality of sophisticated VP cases. An additional challenge is the significant regional variations in naming conventions, test units and even diagnostic decision making; there existed no way to allow local authors to modify imported cases to adapt them to a local context.

METHODS

Creation of the MVP standard

To overcome these challenges a Virtual Patient Working Group was established by MedBiquitous, a non-profit organization accredited by the American National Standards Institute to develop information technology standards for healthcare education. This group first convened in 2005 with the goal of creating a technical standard for easy electronic interchange of virtual patients across schools. The working group’s founding members included representatives from the Karolinska Institute, New York University, Tufts University, the University of Edinburgh, and the University of Pittsburgh, all of which have developed their own virtual patient authoring and delivery systems. The Working Group has had several in-person meetings at national conferences, holds regular conference calls, and solicits consensus from content experts and other medical education stakeholders.

This group has been collaborating on developing an XML-based standard that builds upon existing e-learning interchange definitions. XML was chosen for its wide compatibility with existing standards and ease of integration into the technical architecture of the participating institutions.

Components of the MVP Standard

The MedBiquitous Virtual Patient (MVP) Standard consists of five components that are designed to be integrated and interpreted by ‘player’ software that would be used at a local institution to display the case to learners. (Figure 1)

1. Virtual Patient Data (VPD) Component

The VPD provides the patient’s personal and clinical data that is relevant to the clinical scenario being simulated. The VPD is analogous to a medical record, containing patient demographics, the medical history, physical examination, laboratory and radiology data, procedure and outcome data as well as differential and final diagnoses. Narrative text that provides the context or story for the Virtual Patient is included as well.

The XML model developed for this component enables a flexible approach to the data. Data is tagged with identifiers so that patient data can be referenced from other parts of the architecture, disclosed to the learner all at once, or disclosed iteratively in response to specific learner requests. The XML encodes both the request and the response information for different types of patient information:

- Medical History: questions and answers
- Physical Examination: examinations and findings
- Diagnostic tests: tests and results
- Interventions: interventions and outcomes
- Differential diagnoses: diagnosis and likelihood

The organization of data is separated from the data itself. Once interview questions, physical examinations, diagnostics tests, and other data have been enumerated, they may be referenced within a separate hierarchical structure that facilitates importing VPD data into other authoring systems. This structure provides a flexible way to create sections of virtual patient data. For example, the Medical History section, may include subsections for present illness, past history, family and social history, etc.
Most of the VPD data is provided in unstructured text, but certain sections may be highly structured and encoded with healthcare terminologies (RxNorm for medications and SNOMED for allergies, problems, and procedures). If this encoding is present, it could enable the learner to interact with clinical decision support systems during the learning activity.

2. Media Resources (MR)
Media resources are all of the images, animations, videos, and audio files that are associated with the virtual patient at any point during the simulated patient scenario. As with the specific portions of the VPD data, the media resources are tagged with identifiers so that they can be made available at the right time to the learner. IMS Content Packaging is used to catalogue media resources and provide unique identifiers (15).

3. Data Availability Model (DAM)
This component enables the grouping and progressive disclosure of data encoded in the VPD and associated media resources. The DAM acts like a linking table, referencing the identifiers within the VPD and the multimedia resources included with the case to display appropriate components to the learner as they progress through a case.

4. Activity Model (AM)
The AM structures how the learner will fundamentally interact with the VP case. A number of different learning activities are possible with the same underlying virtual patient dataset, and the activity model component encodes the pedagogical structure of each. Examples of activity models are:

1. Observation: The learner is presented with a 'page turner' and is allowed to observe how a clinical scenario unfolds. This is a more passive and expository mode that could be appropriate to an initial introduction to a disease state.
2. Free Navigation: The learner is presented with the patient’s clinical data set linked to a variety of references (journal articles, books, data sets, decision support systems, etc) that they are free to navigate in an unrestricted fashion.
3. Diagnosis Formulation: The learner is asked to formulate a differential diagnosis at each stage of the progressive disclosure of the clinical scenario.
4. Decision Making: The learner is asked to make clinical decisions based on current information and acquires new information as a result of different treatment or diagnostic decisions.

For each of these activity models, the corresponding Data Availability Model must be designed to support the activity, and these two components will typically work closely together. For example, the observation activity listed above would work with a Data Availability Model that was linear, whereas the decision making activity would require a Data Availability Model that is selective and branching, revealing only appropriate content to the learner at each step.
5. Global State Model (GSM)
This component provides the top-level modeling of the student activity and the logic for the allocation and regulation of activities across virtual patient cases. It is only relevant for more advanced kinds of applications, such as integrating a case into a Learning Management System, sequencing VP cases into a learning activity, or how a particular VP interacts with other VPs in a multi-player educational game.

RESULTS
The MVP working group has submitted the draft standard to ANSI for official review (16). The public review and comments will be addressed by the MedBiquitous Executive Committee, following which the activity will be formally assigned to ANSI for guidance through the standards development process. The MVP working group will continue specification development; voting and formal comments will take place within the ANSI Standards Committee. Four institutions (NYU School of Medicine, University of Pittsburgh School of Medicine, Tufts University, Karolinska Institute) are currently implementing the draft standard within the VP functionality of their learning management systems.

The process of reaching consensus on the contents of the standard has highlighted the fact that ‘virtual patient’ is a diverse term and the types of learning activities and functionalities that the standard must encompass are considerable. In early implementation tests among the author’s VP systems, the MVP standard has proven flexible enough to be used without significant modifications. Given that many of the existing VP systems are not XML-based, most of the early adopters are adding import/export functionality rather than rewriting their applications to use the MVP internally. This approach has also worked well during the development phase of the standard; any necessary changes need only be made to the importer/exporter engine and not the underlying application.

Early discussions among working group members revealed that some faculty were reluctant to create a standard that facilitated sharing of cases but did not convey how they should be used for teaching. This could be a particular problem for institutions that need to use VP cases but have little experience in implementing online simulations into a curriculum. The Activity Model and Global State Model components of the MVP have the unique benefit of ‘embedding’ the pedagogical intent of the original case author into the case. These features were developed to enable authors to exchange not only the cases themselves, but also their educational context and intent.

Tufts University has begun to develop a platform-independent open source player (17). In an effort to provide a metric for certification of MVP use, this application will validate the XML and give feedback on compliance with the standard. In addition, the application will also allow virtually any institution to use available VP cases without having a sophisticated infrastructure or requiring significant development resources. Institutions will be able to download a VP case which would include all the needed data, multimedia, and the Tufts player application wrapped in an IMS compliant package for local use.

CONCLUSIONS
The MVP standard represents the collaborative effort of more than a dozen international faculty and content experts, with input from national societies, accreditation groups, and others in medical education. All of the faculty and institutions involved have expressed an interest in sharing cases and many have already submitted versions of their cases for public use to resources like the AAMC MedEdPortal and the Health Education Assets Library. This demonstrates that when the MVP standard is fully realized and implemented, the promise and potential of sharing valuable and effective educational resources will become a reality.

The planning process has highlighted issues of pedagogy, practice and diagnostic variations, all of which informed the creation of an extremely flexible and open standard. This project will make available new tools for competency-based teaching and assessment that will help us overcome the new challenges facing medical education and accelerate the transition to education in a new era.

More information and resources can be found at: http://medbiq.org/working_groups/virtual_patient/

References
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