Designing, Developing and Implementing Branched-Narrative Virtual Patients for Medical Education, Training and Assessment

A guide for authors of virtual patients

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INTRODUCTION

This guide is for healthcare educators developing or considering developing branched-narrative virtual patient simulations for medical education, training and assessment. A virtual patients is a type of computer simulation where the learner plays the part of a healthcare provider by interacting with an on-screen patient to obtain a history, conduct a physical exam, and make diagnostic and therapeutic decisions [AAMC 2007]. A "branched-narrative" virtual patient (VP) is one in which the virtual patient experience progresses as a story. The story changes as the learner makes critical decisions and those decisions have direct consequences on the patient's outcome.

The success of a virtual patient-based educational initiative, whether it be for clinical correlation in a medical student basic science course or a multihospital multidisciplinary training program to decrease medication errors, hinges on a few key factors – 1) reliable, scalable and easy to use technology; 2) adoption by teachers; 3) perception of value by learners; and most important, 4) a high-quality learning experience. This guide focuses on the last element, specifically, how to design, develop and implement virtual patients that effectively meet your learning goals. The recommendations that follow are based on generally accepted educational theories and adult learning concepts, eLearning concepts supported in the literature and the experience of the author.

The following terms are used in this guide:

virtual patient (VP) = a computer program that simulates real-life clinical scenarios in which the learner acts as a healthcare provider obtaining a history and physical exam and making diagnostic and therapeutic decisions

branched narrative = a virtual patient design that affords multiple narrative paths with more than one outcome

nodes = a step along a branched narrative story, typically represented by a single screen or web page; leaner progresses from one node to the next based on his/her decisions

student, learner = the person(s) using a virtual patient for education or assessment

author = the educator who conceives and principally creates a VP

expert = person(s) with knowledge and skills specific to the content and desired outcomes for a specific VP

facilitator = an educator who helps guide students to their learning goals, but not necessarily the creator of the educational content

Key educational characteristics of virtual patients

Virtual patients possess unique characteristics making them valuable educational tools for healthcare professional education. Simulations in general have the ability to engage the learner in repetitive and deliberate practice in a safe and reproducible environment with personalized expert feedback [Issenberg 2005]. Patient simulations also allow curriculum administrators to fill gaps in clinical exposure and introduce learners to unusual and rare conditions [Tworek 2010]. Virtual patients offer some practical and educational advantages when compared to other popular simulation technologies like mannequin-based physical simulators and human actors posing as standardized patients. VPs delivered over the Internet are relatively inexpensive to distribute and update compared to their physical counterparts. Because they are story-based

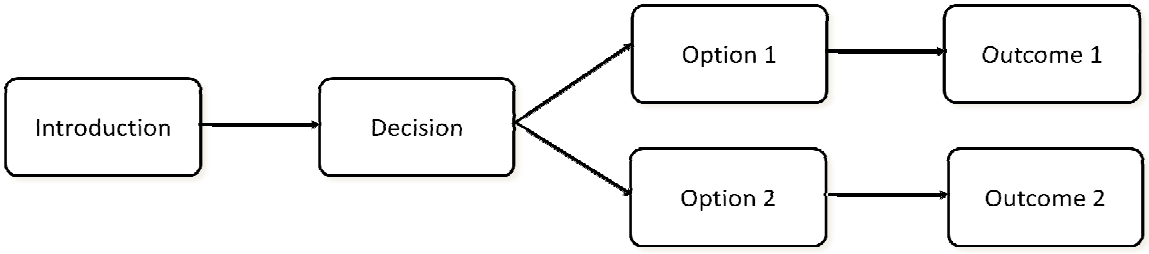
they can describe nearly every known disease state and can provide immediate and personalized feedback without requiring co-location of teacher and learner.

Branched-narrative virtual patients offer the ability to teach clinical decision-making skills and observe the consequences of those decisions while receiving adaptive feedback. The decision→consequence relationship is cited as an educationally valuable VP characteristic, particularly well suited for teaching clinical reasoning skills [Cook 2009]. St. George's University in London uses web-based branched-narrative VPs to replace traditional linear paper-based medical student problem-based learning cases. Educators there observe "deep learning" and "critical thinking" related to the key decision points in their VP cases.

Despite their educational value virtual patients were until recently regarded as too expensive and time-consuming for the average educator to use. Larger institutions wanting to utilize VPs developed their own systems, which can exceed $20,000 per case [Huang 2007]. The recent availability of easy to use web-based authoring applications has decreased development time by ten-fold based on observations at the University of Pittsburgh (http://vpSim.pitt.edu). Release of the virtual patient technical specification by the MedBiquitous organization in 2010 will allow sharing and repurposing of existing VP cases, further bringing down the time and cost of introducing VPs into a curriculum [MedBiq 2010].

Anatomy of a branch-narrative virtual patient

In its most basic form, a branched-narrative virtual patient contains the following components:



Basic Branched-Narrative Virtual Patient

Using this model, a VP author can develop an interactive experience with multiple choices and their associated outcomes and feedback. Often a case begins with an introduction to the patient and a clinical scenario followed by choices to collect data, make a diagnosis and institute therapy. The results of the learner's decisions are reflected as the case unfolds in the form of clinical findings, diagnostic test results and improvement or decline in the VP's clinical status.

CREATING A VIRTUAL PATIENT SIMULATION

The development process to create a virtual patient case can be broken down into three phases, 1) preparation, 2) design and development, and 3) implementation.

Preparation	Design and Development	Implementation
• list learning outcomes • define the audience • assess the environmental factors • perform due diligence	• select a pedagogic model • tell a good story • set rules and expectations • define the critical path • add branches aligned with learning outcomes • complete narrative and clinical data • add feedback • add multimedia • test the case with learners • validate the case	• create motivation • distribute the case • evaluate the case • maintain the content • report performance

Phase I – PREPARATION

List learning outcomes

All effective learning programs begin with a clear definition of the intended outcomes or "learning objectives." While the tendency can be to begin with the narrative for a new virtual patient, stopping and explicitly listing learning outcomes early will pay dividends throughout the development and implementation process. A list of learning outcomes is critical to focusing work and communicating with collaborators and other educators who may use the case.

When developing learning outcomes ask questions like, "what [educational] problem am I solving?" What behaviors need to change? What skills are being taught? Ultimately, how will the learner be different after he or she completes this virtual patient?

Well-written learning outcomes are explicit, action-oriented and measurable. A learning objective such as "understand nosocomial infections" is less effective than defining based on outcome, "decrease nosocomial infections in the ICU by 30%." The most effective learning outcomes are those that are clear, concise and can be validated by objective measures [Mager 1975].

Define the audience

Selecting a specific audience for a virtual patient aids greatly when defining content, clinical decision-making questions, inline quizzes and summative assessment. The audience can be defined in multiple ways

1) level of training – medical student, resident, CME,
2) healthcare discipline – pharmacy, nursing, dental,
3) geographic – a single school, within a hospital network, international
4) on-site versus distance learning

5) synchronous (lesson and communication are live) versus asynchronous

Many new authors initially intend to create virtual patients that apply across many levels of training and disciplines. It is advisable to be specific at the outset, which facilitates the many content decisions required. Then consider whether or not a VP is appropriate for other audiences.

Assess the environmental factors

The characteristics of the environment where learners interact with the VP affect early decisions regarding design and content.

What technology is available to your learners?

Technology factors may play a role in the design and scope of your virtual patient. What type of computer, network/internet access and software is required? Some control or at least knowledge regarding the type of computer hardware, operating systems, web browser software (including plug-ins), and web access speed is mandatory. Carefully select your VP authoring and playback software tools based on anticipated student capabilities. Ideally, the technical aspects are tested before development begins.

Time requirements for the student

When will the VP be used and for how long? Is this an optional, extracurricular exercise or mandated program for everyone in your intended audience? Considering the time and resources required for creating a virtual patient, it should be regarded as required learning or as an accepted part of the curriculum. To this end, VPs should be integrated into the curriculum so that the time is set aside for the learner to complete a virtual patient and perform any external work to meet the learning goals of the case.

Time requirements for the author

In our experience, much energy and enthusiasm is expended at the beginning of the authoring process for virtual patients. Unfortunately, the final editing and evaluation do not typically enjoy as much attention. “Getting it done” is a common problem for authors of all varieties of educational programs. The asynchronous nature of most virtual patients may make the problem more common. As opposed to a lecture with a defined time and place, developing VPs is easier to postpone and delay with comparatively less associated public scrutiny. This is especially true for VPs created as optional learning materials and why we do not recommend that approach.

Limitations of time and money

Another preparatory step involves assessing potential organizational barriers. The most prominent are classically related to 1) time, 2) money, and 3) politics. Most authors are troubled by not enough of the first two and too much of the third.

An assessment of the cost of developing a VP can be made by adding the following: a) startup costs such as software licenses, content licensing, computer hardware, and networking resources, b) maintenance costs of the software and network resources for the perceived duration of the program, and c) personnel time.

Even if the content experts and educators are "donating" their time, estimating the true costs regardless if the work is performed on nights and weekends, is essential when eventually calculating the "value" of your virtual patient.

Broad participation and buy-in by the primary stakeholders in any new program utilizing VPs can generate enthusiasm and smooth the implementation process. An author may perceive himself/herself as the owner of a VP but the students and associated experts, facilitators, reviewers and administrators are also invested to some degree. Giving key stakeholders an opportunity to participate in setting the learning goals, developing content and reviewing the product can go a long way toward lowering barriers and managing the inevitable changes needed after initial deployment of any new educational program.

Perform due diligence

Is there already an available VP that meets similar learning objectives? While virtual patient simulation is a relatively new educational tool, as of January 2010 there are XYZ virtual patients in the MedEdPortal database (www.aamc.org/mededportal). Another 350 cases are anticipated from the eViP consortium (www.virtualpatients.eu) in the summer of 2010. These cases will all be in the MedBiquitous VP standard (www.medbiq.org) enabling reuse and repurposing by standard- compliant authoring systems. A recent review of the literature by Cook and Triola compiles and analyzes research regarding virtual patients [Cook 2009]. A literature search of PubMed (www.pubmed.gov) revealed 152 matches to the term "virtual patient." Authors should take advantage of these resources when planning and developing VPs.

Phase II – DESIGN AND DEVELOPMENT

Select a pedagogical model

Branched-narrative virtual patients can employ various pedagogical models regarding how the learner and teacher interact. An author should consider which of these models best fits his or her local curriculum and goals.

Pedagogic Models for Virtual Patients	
Self-directed learning	Freestanding case accessed by individual learners and completed with limited interaction with the case author, educators or experts
Problem-based learning	Small group learning with a facilitator where the student access and engage as a group with the VP case
Distance learning	Learner independently access an online VP case but has remote synchronous (chat) or asynchronous (discussion board/email) access to the to the expert/author
Sequenced or blended learning	The learner engages with a VP in conjunction with supportive didactic instruction, small group discussion, or other simulation exercises
Assessment	Learner is assigned a VP for formative or summative assessment of skills

Experience from various institutions has shown success with a variety of designs. Small groups of three or four students working together are often better than independent case solving [Gesundheidt 2009]. Asynchronous communication between students via email or discussion board is generally more convenient than live interaction but can detract from the learning flow due its intermittent nature.

Special consideration should be made to how students will seek and receive help making a diagnosis and solving the clinical problems. In a live case-based teaching setting the instructor can adapt his/her teaching based on the students progress (or lack of). In contrast, an asynchronous case and self-directed virtual patients may have to contain all of the necessary assistive didactic materials. Alternatively, an author can direct students to external sources, but this is inherently unpredictable and typically less desirable to students.

Nine steps for efficient and effective VP design and development

1 **First, tell a good story**

The educational value of a virtual patient relies heavily on the power of the narrative. Learners respond to compelling, engaging stories [Polkinghorne 1988, Schank 1995]. Narrative-style VPs have been shown superior to 'problem-solving' style in teaching communication skills and positive perception of learning has been found using rich-narrative PBL cases [Bearman 2001, Bizzocchi 2009]. Medical professionals rely on stories to process memories and later recall and apply to related problems. Memorable characters, unique settings, unexpected events, and clever twists in the plot all add to the level of learner engagement and retention [Hunter KM, 1996, Laurillard 1998].

Authors should write a short narrative before beginning the design process for a VP. Using a real life case is usually easier and more accurate than making up the case from scratch. However, to adequately engage the learner and meet all desired learning objectives, embellishing the case is both necessary and recommended.

A story should always have a ***beginning, middle and an end***.

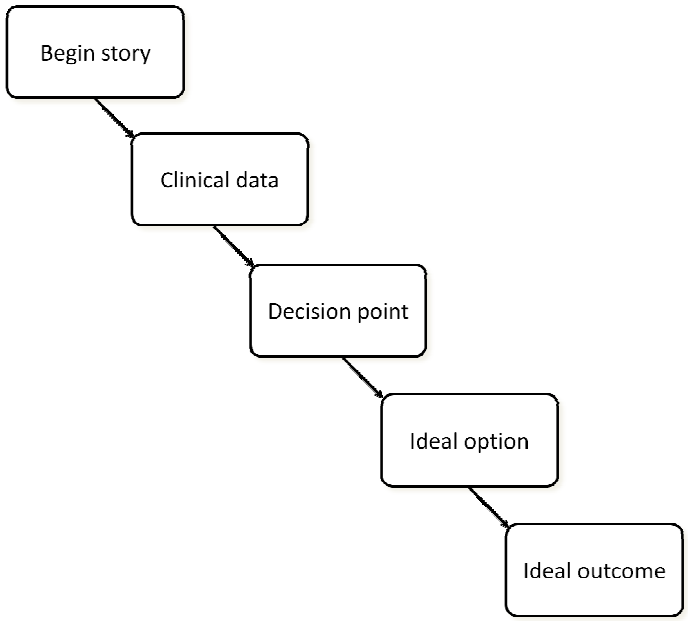
a. *Beginning* – set the scene, develop the characters, set up the ground rules
b. *Middle* – develop the "conflict" that relates to the clinical problem at hand, usually this is the patient's medical complaints and/or problems
c. *End* - resolve the conflict by revealing the diagnosis, ideal therapy and clinical outcome to the learner.

2 **Set the rules and expectations**

Explain to the learner things like what role the learner is playing (doctor, nurse, pharmacist, etc.), how long the case will take, what the learner is expected to do, and how performance will be assessed.

3 **Define the critical path**

This is the sequence of events (nodes) that define an ideal storyline where the learner makes all the right decisions from beginning to end and the patient has the best possible clinical outcome [Conradi 2007]. Flip charts or a whiteboard may be used to brainstorm and map the case at these early stages. Many start the diagram with a beginning "node" in the upper left corner of a whiteboard or computer screen and extend down to the lower right to the ideal outcome or "terminal node."



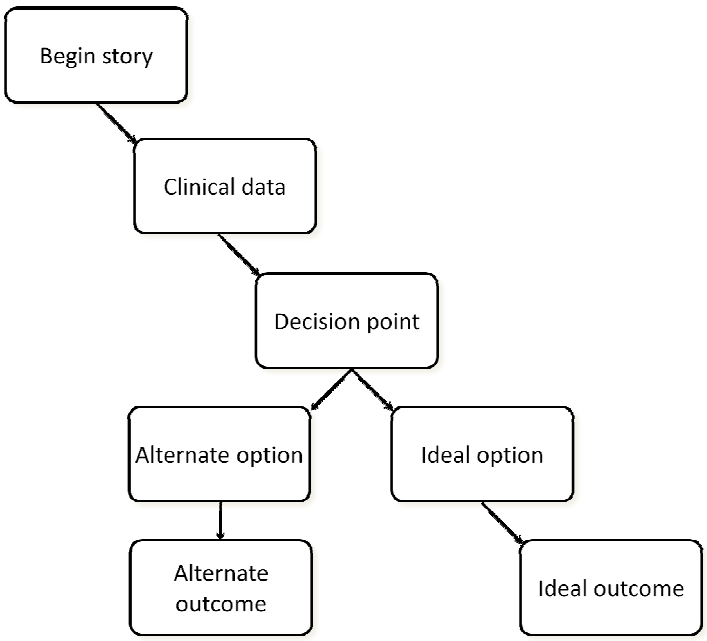
Critical Path (node map)

(nodes = a step along a branched narrative story, typically represented by a single screen or web page; leaner progresses from one node to the next based on his/her decisions.)

4 **Add branches at critical clinical decision points aligned to learning outcomes**

Branches in the case take place at the primary decision-making nodes and should correlate with case's learning objectives. These nodes are challenge points where learning tension develops. If of sufficient difficulty, a student should pause at a branching node and think critically and deeply before making a decision. The effectiveness of a branched-narrative virtual patient is highly dependent on the appropriateness of these branched decision points.

Based on experience, critical decision nodes are often not challenging enough to stimulate deep thinking. Authors should test how learners respond at these branch points using the "think aloud" technique [Lewis 1982].



Branched Path (node map)

5 **Complete the narrative and clinical data**

Once the various nodes, paths and outcomes are laid out, fill in the necessary story and clinical data on each node with text and multimedia. Nodes are added as needed to complete the narrative and provide feedback and alternative paths as selected by the learner.

Attention should be paid to format and quantity of text and multimedia on each page. More than one media element (image, video, animation) can be distracting and contribute to cognitive overload. Allow what graphic designers refer to as "white space" to give the leaner a chance absorb new data process his/her thoughts.

6 **Add feedback**

There are many ways to provide feedback to the student during and at the end of a virtual patient experience.

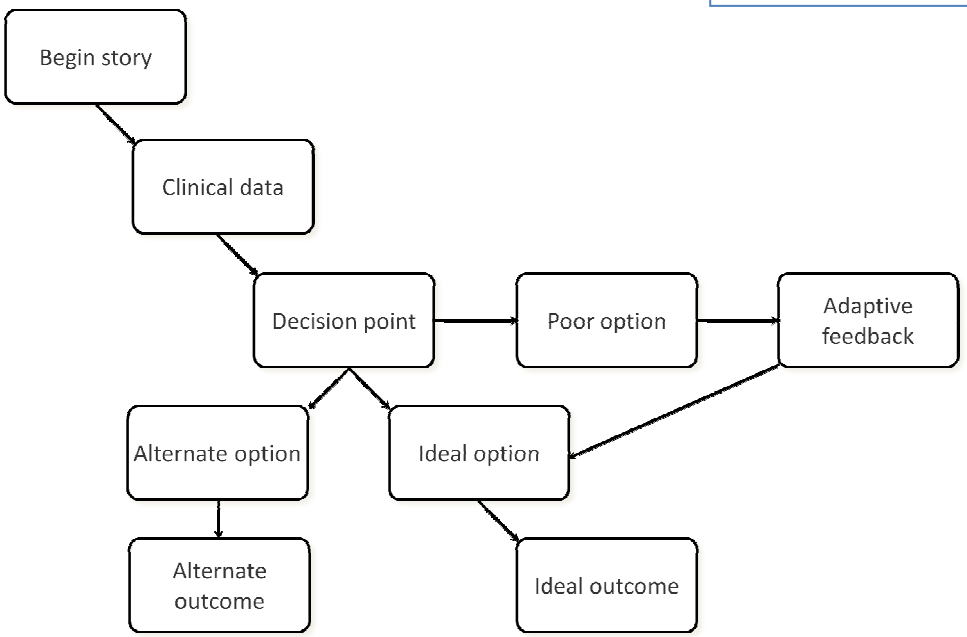
a. Author comments based on branching – As a student makes selections at branch points, subsequent nodes can provide author feedback regarding the clinical decisions made. These comments take both qualitative, "I don't think it is a good idea to give your patient epinephrine now…" and quantitative "that dose of epinephrine increased your patient's blood pressure to 160/98…" forms.
b. Patient and author responses to questions – Some VP authoring programs allow more than one question on a single node, for example, interviewing a patient, ordering diagnostic tests, and multiple choice knowledge questions. Either a response from the patient ("that hurts") or author ("that therapy has greater risk than equal alternatives") tells the student how he or she is progressing.
c. Counters – Numerical values can be associated with decisions made by the learner and reported either on-screen during the case, periodically at key points or summatively at the end. These can include relative performance scores as designated by the author and dollar values associated with various diagnostic and

therapeutic choices. Guiding comments may be triggered that inform the learner regarding guidelines, policies and best practices.

d. Clinical outcomes – The most powerful feedback can be the virtual patient's clinical condition. The learner's choices and performance are reflected in the virtual patient's clinical status that either improves or declines. At key points, the author can provide feedback regarding the expected clinical status and even allow the learner to back up and try again.
e. Facilitator comments and guidance – Cases that are conducted with a live small group and facilitator benefit from his or her guiding comments. If a facilitator has content expertise then he or she can on-the-fly adapt teaching to students' performance. Note that this approach can take less time to develop since it doesn't require the author to anticipate and write a comment about every decision but does require space and faculty when compared to self-directed learning.
f. Group discussion – Students typically benefit from discussing the case with their peers and making decisions as a team. This may take place live or via an online chat. Preferably this occurs synchronously since asynchronous communication via email or discussion board may be complicated if students progress at different rates through the case. Electronic approaches provide a transcript of the thinking behind the decisions and can be used by the author to better understand students' learning process.
g. External resources – An author may direct a student to specific external resources like journal articles, textbooks or decision support tools.

Adaptive learning with branched-narrative VPs

Branched narrative VPs enable authors to develop learning experiences that can change based on the learner's performance during a case. Adaptive choices can be positioned at the beginning of a case by asking the learner what level of training he or she has and then branching down paths of varying complexity. Or, the case can include multiple-choice questions that assess the learner's comprehension and then progress to either a higher level or a remediation path. While branched-narrative/adaptive learning VPs are more complex than a linear design, they make for a more efficient and personalized learning experience.



Adaptive Feedback

7

Add multimedia – Images, audio, video and animation can add to the educational and perceived quality of a VP [Bizzocchi 2009]. As noted, VPs rely on the power of an engaging narrative to suspend disbelief and create an immersive simulation experience. Adding visual and auditory data, when done well, likely adds to the "suspension of disbelief" however has not been demonstrated to consistently add to the educational value and when in excess can detract from learning due to cognitive overload.

Static images and video can be helpful in setting the scene and establishing a mental image of characters in the story. Multimedia is especially valuable when used to demonstrate specific historical, physical and diagnostic findings.

Locating media for a virtual patient presents a challenge for many authors. While searching using online resources like Google Images (http://images.google.com) is fast and convenient, nearly all resulting images are copyright protected and cannot be used in your virtual patient without permission. Copyright laws, fair use guidelines, and patient confidentiality need to be taken seriously. Detailed review is beyond the scope of this guide but refer to following for more on these important topics:

Copyright law: http://www.copyright.gov/
Fair-use guidelines: http://www.copyright.gov/fls/fl102.html
Health information privacy: http://www.hhs.gov/ocr/privacy/

Online, shareable collections of images and video do exist – MedEdPortal (www.aamc.org/mededportal) and Health Education Assets Library (www.healcentral.org) are two good starting places for medical education-related media. General online repositories that offer sharable images and video based on Creative Commons licensing can be helpful for non-medical images [Flickr (www.flickr.com), Picasaweb (picasa.google.com)]. Also consider edited professional images resources where for a small fee the quality is generally better [Images.MD (www.images.md), Getty Images (www.gettyimages.com)].

More on scores, counters, and rules

Counters in a branched-narrative virtual patient are applied at decision points and associated with metrics such as the cost of a diagnostic test, time required to complete a history, or even a pain scale. The simplest use of scores and counters is to display them to the student and report at the end of the case. This should be accompanied by a comment from the author regarding the possible and expected range for each score/counter or discussion in a small group about how the scores relate to clinical decisions and patient outcomes.

Rules may be applied to a counter that triggers an event or change in the narrative while progressing through the case. This can be in response to exceeding a spending limit, or reaching a positive or negative score that is outside a target range. When a rule is triggered, the user jumps to a node where the author can give feedback and/or the patient's condition changes to reflect this event. The author can direct the user to back up and try again, give remediation or end the case abruptly.

Rules can apply to a case in general (global) or only be active within a specific node (local). They have hierarchy with local rules taking priority over global and can cascade from one to the next. When one rule fires it can change the value of another counter that in turn triggers another rule. As demonstrated, rules can make case design complicated. Judicious, purposeful use of rules is recommended.

8 ***Test with students*** – When enough of the case content is developed and all of the critical decision branches and their consequences have been created, have one or more representative students work through the case. The student should receive only minimal instructions and prompting. As mentioned above, use the "think aloud" method where the students describe aloud what they are thinking as they make decisions and the case unfolds. These sessions can be quite revealing.

9 ***Validate the case*** – The case needs to be valid in regard to both content and user experience. A case can seem complete and coherent to the author but when placed in front of another subject matter expert or the anticipated target audience, it may result in unpredictable, undesirable outcomes. Even worse, students may experience frustration or inability to complete the case. Every possible path, along with its resulting clinical outcomes, scores, and feedback, must be investigated. As mentioned above, testing is essential.

Regardless of an author's level of expertise in a particular topic, including others in the authoring and reviewing process typically results in a more effective learning experience.

Phase III – IMPLEMENTATION

Establish motivation

A sustainable virtual patient curriculum must establish the motivation for learners to engage with and complete virtual patient cases.

Active learning that simulates a clinical encounter and provides dynamic feedback will be more compelling than many other forms of learning. Branched-narrative VPs can be especially motivating at key decision points, with game-like positive and negative reinforcement. The learning experience is even more engaging when the learner is challenged, makes a mistake and the patient's status declines thus creating a powerful "teaching moment."

VP's relative novelty can attract students initially but wanes unless a strong perception of value is established from the first case onward. As outlined above, educational value comes from having a high-quality engaging case that achieves its learning outcomes. To this end, an effective VP should strive to tell a compelling story with valid clinical events that occur in response to the learner's decisions. Authors should refine their cases based on testing prior to release, and from observing student's reactions and performance after implementation.

Distributing VP cases

Virtual patients are either stand-alone software applications, network applications (accessed from an institutional server) or web-based. Stand-alone VPs benefit from not requiring the user to be connected to a network but updating, version control and tracking user's activity is far easier with web-based applications. Software-as-a-service or "cloud computing" is gaining popularity because it requires only an internet connection and web browser to both access and author cases and eliminates the need for local technical support and maintenance. Web-based distribution is particularly popular since it makes virtual patients available on-demand from all over the world.

Commonly used methods for distributing web-based VP cases include:

1. Emailing a link to the case – This is a convenient mechanism since most people check email daily. Therefore the case is unlikely to be missed.
2. Embed a link to the case on an institution's web page.
3. Direct the learner to a third-party VP application web page – After logging in the user will see the cases to which he or she has access or has been assigned.
4. Embed a link within a learning management system (LMS) – Authentication and identification of the user can be passed directly from the LMS without having to log in again. This will ensure the users are identified correctly and their progress is tracked and reported back to the LMS.

Large educational programs that use a number of VPs will want to use a VP software application that enables them to manage access and distribute cases to groups of learners, such as an entire medical student class or hospital department. Sophisticated tracking and reporting tools become essential when managing dozens of cases of hundreds of medical students or thousands of CME users.

Case metadata

Meta-data refers to information about a case that is not necessarily included in the case content that the student sees – for example, the author's name, institution, date of creation and date of last update. Keywords, target audience, topics covered and other indexing terms should be included in the metadata so that others can search and find the case and use this metadata to determine if it will fit their learning needs, without having to review the entire story.

A case's learning outcomes (objectives), a short case description, and teaching notes can go a long way toward helping others determine if a case will fill a particular educational need. These can include what educational setting (environment) it was created for, how students access the case, its typical duration, and advice on how to use it integrate it in a curriculum.

Ongoing evaluation

After release of a VP case authors should seek feedback from both students and the educators that interact with those students, such as small group facilitators and course directors. At a minimum ask if the case was coherent, engaging and produced a generally positive learning experience. Were the learning goals met? Did the case seem authentic? Analysis of paths selected by learners and scoring patterns can inform authors about the target audience's performance and areas of weakness and even demonstrate practice patterns among individuals and groups.

Surveys and focus groups can be useful during the post-production refinement of a case. Further objective analysis can include observations of behavior change and patient outcomes, although these will likely require dedicated educational research programs.

Maintenance and growth

A well-constructed and educationally valuable VP case may be used for many years and therefore require updating. VP software applications require version tracking so that as clinical and didactic information is updated, students always access the latest version while administrators can still look back and view older versions and their associated student

performance data. A case may be adapted for different learning outcomes and audiences, making version tracking even more critical.

Creating a high-quality VP case is a significant scholarly activity therefore educators should consider submitting it for peer review by MedEdPortal and sharing the case using the MedBiquitous VP (MVP) data standard (www.medbiq.org). A VP authoring program can facilitate this process by exporting the case using this international ANSI-approved standard (www.ansi.org) which then can be imported into any MVP-complaint VP software application for reuse and repurposing.

Reporting

Reporting learner performance can range from a simple list showing who successfully completed a case to sophisticated decision maps showing how an individual learner's management compares to an expert's path through a case. Typical VP reports show scores, money spent, time spent and other counter data along with information about what decisions a learner made and where the case ended. Programs with many cases and students will want to export case data using common spreadsheet and database formats. This raw data can then be imported and processed as needed.

EXAMPLES OF TYPICAL VP IMPLEMENTATIONS

Virtual patients meet a wide range of educational goals. Some common methods of implementing virtual patients are listed here.

- PBL model – learners explore the simulation in small groups with a facilitator; navigation is relatively free-form allowing learners to investigate on their own; learners set their own learning goals based on the challenges presented in the case
- Self-directed learning model – learner works independently with a VP case; feedback is provided using both inline ? and adaptive techniques; scores, money spent and other metrics provide performance data; compare learner's management and case outcomes to expert's; can loop back to try again
- Embedded model – an interactive VP exercise is embedded in traditional lectures or small group workshops
- Case workshops – small group sessions with a facilitator; group interacts with the case stopping to discuss decisions and outcomes; can blend with didactics related to case
- Bedside supplement – engage trainees with VPs having similar conditions before, during or after bedside rounds; facilitated discussion based on both actual and virtual cases
- Blended simulation – used in conjunction with mannequin simulators, part task-trainers or standardized patient actors; narrative can extend from one simulation technology to another; combine independent learning with the VP case and group session with mannequin followed by debrief on both
- Assessment model – individual use; invisible scores; can receive feedback and quantitative scores at the end; may be used during (formative) or at the end of an organized curriculum (summative)
- CE/CME model – independent learners access the VP as-needed based on personal and externally mandated learning goals; access based on their own schedule; completion or

competency can be based on scores, case outcome or time to complete; can include option to try over to achieve a passing score
- Training model – training materials are delivered in a case-based format and widely distributed; can be managed from one central location including user access control and detailed reporting of performance and completion status
- Just-in-Time learning – timely topics are provided on-demand or triggered by clinical events and decision-support systems
- Distance learning – web-based VPs can be distributed worldwide and accessed on-demand; adaptive learning provides a platform to deliver customized content to a wide variety of learners with differing levels of expertise
- Quality assurance – uses cases to assess practice patterns and clinical decision-making behaviors; adaptive learning triggers reinforcement or remediation

CONCLUSIONS

Teaching with cases whether live or simulated comes naturally to both healthcare educators and learners. Newly available virtual patient authoring tools extend these methods to the Internet to efficiently deliver and share case-based learning anywhere and anytime. Now, any motivated educator has the potential to develop his or her own virtual patients with engaging narratives and clinical reasoning challenges in a safe, consistent environment supplemented with adaptive feedback and performance tracking.

Despite technologic advances, authoring VPs still requires a few new skills to ensure adoption by learners and positive learning outcomes. These techniques are covered in the above guidelines including proper preparation, step-by-step design and development, and creative and sustainable ways of implementing VPs in diverse curricular settings.

As more educators take advantage of these new tools and the depth and breadth of VP cases expands, so must the educational research to define and demonstrate when and how best to use VPs. Virtual patients will never completely replace real patients and the ideal mix of live clinical encounters, traditional learning methods, and simulation is the subject of future research. It is the hope of the author that learners in all areas of healthcare who hone their clinical reasoning skills with well-designed branched-narrative virtual patients will be shown to provide improved clinical care and, most importantly, have better *real* patient outcomes.

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