3 Virtual Patients in Health Professions Education

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Abstract

Health care professionals must not only have knowledge, but also be able to organise, synthesise and apply this knowledge in such a way that it promotes the development of clinical reasoning. Panels of Virtual patients (VPs) are widely being used in health professions education to facilitate the development of clinical reasoning. VPs can also be used to teach wider educational outcomes such as communication skills, resource utilisation and longitudinal patient care. This chapter will define virtual patients and examine the evidence behind their use in health professions learning and teaching. The chapter will discuss virtual patient design, such as gamification. Finally, the chapter will discuss where this pedagogical innovation is best integrated into assessment and potential barriers to implementation into existing curricula.

Keywords

Virtual patient · Clinical reasoning · Virtual reality · Augmented reality · Health professions education

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Abbreviations

VP Virtual Patient
VPs Virtual Patients

3.1 Introduction

By 2020, the doubling time of medical knowledge will be just 73 days (Denson 2018). Health care professionals must not only have knowledge, but also be able to organise, synthesise and apply this knowledge in such a way that it promotes the development of clinical reasoning (Eva 2005; Norman and Eva 2010). Clinical reasoning has been defined as the thinking and decision-making processes associated with clinical practice and is a critical capability in the health professions that forms their professional identity (Higgs et al. 2019). Traditional didactic pedagogical approaches do not allow the opportunity for the deliberate practice with real patients required to develop expertise in clinical reasoning (Boyle et al. 2016). While authentic, patient involvement in medical education has been become increasingly challenging because of the differentiated nature of patient case leading to increasing complexity with multiple morbidities that obscure the key clinical experience to be learned (Urresti-Gundlach et al. 2017), patient safety (Muller and Ornstein 2007), availability of student placements

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and willingness of patients to participate (Hardy and Brown 2010).

Panels of Virtual patients (VPs) are being increasingly being used in medical education to facilitate the development of clinical reasoning by overcoming reducing the randomness of patient cases as well as facilitating a cognitive apprenticeship through situated cognition as well as experiential learning in a safe and permanently stable learning environment (Brown et al. 1989; Consorti et al. 2012; Cook et al. 2010a, b; Kolb 1984; Lave and Wenger 1991). While VPs are widely used in health professions education, particularly in North America and Canada (Berman et al. 2016), barriers to implementation of VPs include resource, cost (Pantelidis et al. 2018), educator computer literacy (Berman et al. 2006), and uncertainty as to where exactly virtual patients are best integrated into the medical curriculum (Marei et al. 2018). VPs may also have a role in assessment in medical education, potentially eliminating some of the variables associated with standardised patients and actors in clinical examinations (Khan et al. 2013).

3.2 What Is a Virtual Patient?

The term "Virtual Patient" (VP) has been used extensively in publications in medical education. Indeed, the definition of VP has been heterogeneous leading to confusion about what constitutes a VP as well as their application in medical education. While the term VP generally refers to software facilitated case based learning, VPs has actually been applied to a wide range of technology, with the first virtual patient encounter being described in the 1960's with the PLATO computer system being used to teach nursing students about heart attack management (Bitzer 1966). The Association of American Medical Colleges (AAMC) makes three distinctions in terms of technology in medical education (Cook et al. 2007):

1. Computer-aided Instruction
2. Virtual Patients
3. Human Patient Simulations

While there is a large overlap between the three distinct groups suggested, the AAMC go further by describing VPs as "A specific type of computer-based program that simulates real-life clinical scenarios; learners emulate the roles of health care providers to obtain a history, conduct a physical exam, and make diagnostic and therapeutic decisions". Begg (2010) argues that a VP can in fact take many forms: "computer simulations of biochemical processes, physical simulators such as manikins, data sets representing actual patients (so that, in effect, we might ourselves conceivably be considered as virtual patients), and electronic case studies delivered via interactive computer applications" (Begg 2010).

Talbot et al. (2012) has subsequently suggested a more inclusive approach to the taxonomy for VPs consisting of several categories in which to group VPs. These include case presentations, interactive patient scenarios, games, high fidelity software simulations, human standardised patients, high fidelity manikins and virtual standardised patients. This classification was further refined when Kononowicz et al. (2015) linked each domain to the predominant competency, predominant technology and published research (Fig. 3.1). Both interactive patient scenarios and virtual patient game mapped to clinical reasoning with the largest body of published work focused on developing clinical reasoning using multimedia systems.

Such VPs generally include information about the patient such a history, examination findings and data from observations or investigations that may branch to different realistic paths and multiple outcomes depending on the learner interaction. Learner interaction can incorporate different components of clinical reasoning from information gathering, data interpretation, hypothesis generation, diagnostic justification, management and prognostication (Daniel et al. 2019). The learner then assesses the VP (typically multimedia software on a computer screen) by requesting information or selecting questions before being expected to make a commitment to diagnosis and management (Cook and Triola 2009).

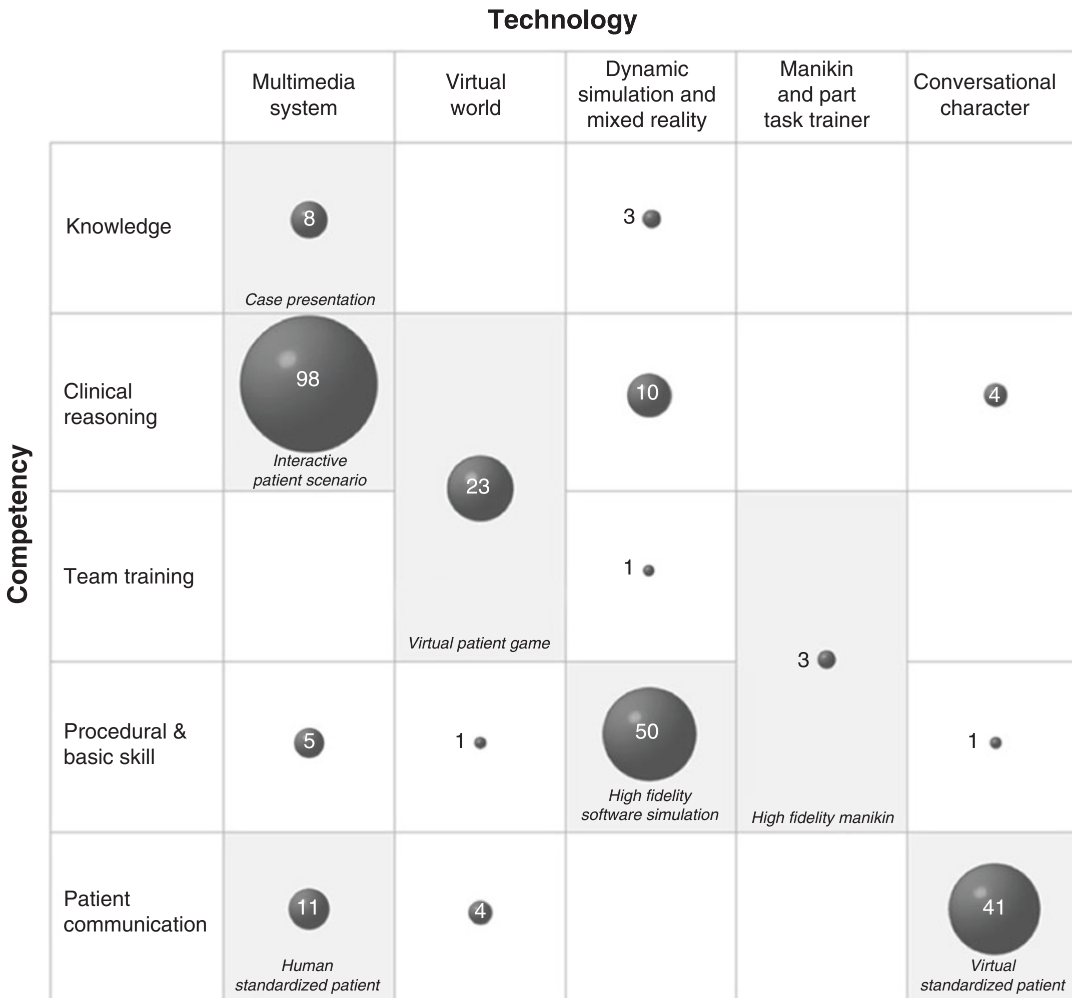

Fig. 3.1 The quantity of virtual patient studies grouped by the virtual patient technologies (columns) and the competency they are aiming to assess or develop (rows) as of 2015 (Kononowicz et al. 2015)

3.3 Virtual Patients in Learning & Teaching

The first question that must be asked is whether there is evidence for the use of VPs in learning and teaching in health professions education? Educators have used VPs in a variety of ways; core knowledge, clinical reasoning, communication skills and blended with simulation (Berman et al. 2016).

A pivotal critical literature review by Cook (2009) using the AAMC definition of VPs found indirect evidence that they were particularly suitable to the development of clinical reasoning skills. Cook (2009) VPs allow learners to participate in controlled immersion in a large number of different cases; with the opportunity to think and do in a variety of content areas and environmental contexts. Cook et al. argue that expertise in clinical reasoning is case specific and VPs allow the learner to develop expertise in clinical reasoning through deliberate practice by emphasising pattern recognition and the development of a library of rich and detailed "illness scripts" (Schmidt and Rikers 2007; Charlin et al. 2007).

Cook et al. subsequently completed a systematic review and meta-analysis of the effects of VPs on learning outcomes in health professions education (Cook et al. 2010a, b). This work found that, while there was a significant positive effect compared to no intervention, the effect compared with non-compute instruction was small. Limited by the quality and quantity of available studies, Cook et al. concluded that further work was required to clarify how to effectively implement VPs.

Again limited by the small number of cases, a subsequent meta-analysis by Consorti et al. (2012) focussing on VPs in medical education found a clear positive pooled effect when VPs were both compared to a traditional method or as an additive resource. When grouped for the type of outcome, the pooled effect size was greater for clinical reasoning when compared with communication skills and ethical reasoning. There were important methodological differences in the meta-analyses; Consorti et al. only selected papers from the year 2000 onwards, whereas the analysis by Cook et al. was performed on papers from all years, followed by a further analysis of papers from 1991 onwards only. The analysis by Consorti et al. was also limited to solely medical rather than healthcare professions education and their inclusion criteria as to what constituted a VP was more inclusive than that given by Cook et al.

Another important question is where are VPs best integrated into health professions education? This question remains largely unanswered. Cook et al. found that while students enjoy VPs they feel that they should not replace real patient encounters with the right balance of virtual to real unknown (Cook 2009). Ellaway et al. (2015) have suggested several broad ways in which VPs can be used in health professions education, such as synchronous group activities, or standalone reference activities. Berman et al. have recently shown that VPs can be integrated in massive online open course (Berman et al. 2017). A recent study of VP use on undergraduate dental students by Marei et al. (2018) separated undergraduate dental students into groups using a VP either before or after a traditional didactic lecture individually, or after the lecture in small groups. The collaborative deductive group had higher levels of knowledge acquisition and retention compared to other groups. These results have been replicated at the University of Dundee (Heng and Anbarasan 2018). Berman et al. (2009) have found that orientating students to VP cases, eliminating what redundant aspects of the curriculum and inclusion in assessment leads to a greater feeling of integration by students. Having trialled various integration strategies, Hege et al. have demonstrated that utilisation of VP cases was poor if they were introduced as independent and voluntary exercises, not mapped to examination content (Hege et al. 2007). Huwendiek et al. (2013) have also suggested the importance of aligning and sequencing VPs with other activities and assessments.

3.4 Virtual Patient Design

3.4.1 Extraneous Cognitive Load and Complexity of Cases

Extraneous cognitive load is the impedance to learning caused by excessive and unnecessary factors associated with the way in which information is presented to the learner (Marei et al. 2018). Essentially, the more of the working memory that is devoted to unravelling how information is presented, the less that is available to process the key learning points. Most textbook diagnoses are actually slightly more complex in day-to-day patients, with some tests and examination findings contradicting the correct final diagnosis. Moreover, many patients have more than one diagnosis, further complicating the picture. Such complexity can overwhelm novice students by producing an enormous amount of extraneous cognitive load. (Marei et al. 2018). Therefore, the majority of VPs involve a single, first presentation of illness (Urresti-Gundlach et al. 2017). These virtual patients may then have an advantage in that they can simulate textbook presentations of diseases, reducing extraneous cognitive load, and enabling novice students to learn easier than interacting with a complex, multi-morbid patient. A caveat to this is that, at some point, students must learn to engage in more complex patients they will encounter in clinical practice. VPs can therefore be tailored to their short, medium and long-term goals; providing uncomplicated history and examination findings to the novice student, whilst having a variability and complexity for developing skills over time.

3.4.2 Resource Utilisation and Gamification

Generally in order to obtain a blood result in hospital, the following must happen: a healthcare practitioner requests the blood using software that must be purchased and maintained; a phlebotomist is employed to take the blood sample, which can be painful for the patient and may require more than one attempt using a variety of disposable materials; the sample must then be delivered to the lab, analysed, and then interpreted by the clinician (Litchfield et al. 2015). It is now common practise to order routine tests for patients, regardless of the clinical question being asked and what value they may add to prognosis and treatment, due to availability of tests and a cultural practice of defensive medicine (Feldman et al. 2013). This is costly in terms of both materials and workforce time and can be termed as low-value care. Moreover, it can be a source of unnecessary pain to patients and, should results show incidental anomalies, can lead to unnecessary invasive investigations and delayed discharges, costing more money (Feldman et al. 2013). Promotions such as the International Choose Wisely Campaign aim to highlight low-value care (Levinson et al. 2015). Interestingly, unnecessary test ordering can be reduced when physicians are confronted with the cost of each test as they order it (Feldman et al. 2013).

VPs represent an interactive way in which healthcare professionals, and students in particular, can be taught the value of resource utilisation. Zhou et al. (2018) developed six VP scenarios concerning rheumatological diagnoses and resource utilisation. Some tests, for example a specialised antigen blood test HLA-B27, are expensive and only recommended to be performed when there is strong suspicion of specific pathology in the history and examination or radiologically. Students were tasked with reading a patient vignette and ordering the most appropriate tests given the history, examination, and investigation findings. Free-text criticism from participants was that, although it was valuable to receive feedback on what tests were unnecessary and expensive, there was no cost-limit for tests during the scenario and no penalty for over-ordering. Gamification is a way in which resource utilisation in VP scenarios can be rewarded. Gamification involves introducing aspects of games to VP scenarios, such as point scoring, rewards, and swift feedback, and can harness innate competitiveness in students and doctors in order to make the scenario more engaging. McCoy et al. (2016) detail several games relevant to health professions education in their review, categorising each for advantages such as real-world application and swift feedback. One interesting example, Septris, is a free online VP game developed and hosted by Stanford University, which tasks the player with the investigation and management of sepsis (Evans et al. 2015). Tests have a lag time between being ordered and results, and the patient's vital signs change in real-time, mimicking the time critical nature of sepsis management.

Foldit is an interesting online game where players are rewarded with points for realistically folding protein structures (Kleffner et al. 2017). Arguably, any software such as this, which mimics an aspect of human biology, can be considered a VP. This game is unique in that it is both useful for the user by visually demonstrating aspects of protein folding such as hydrogen bonding and to the developers in the sense that they can use data on how users attempt to fold proteins to better inform computer algorithms in modelling the process This can lead to improved insights into the educational needs of students. Moreover, the majority of research in health professionals education is conducted by single institutions with modest funding and no long-term follow up. Using data harvested from VPs, multi-institutional collaborations can produce more rigorous and longitudinal work (Cook et al. 2010a, b).

3.4.3 Clinical Reasoning and Diagnostic Error

Diagnostic error is a major cause of morbidity and mortality in all healthcare settings. (Singh et al. 2016). A number of factors contribute to diagnostic error, one of which is inadequate clinical reasoning (Singh et al. 2016). This is a concept of diagnostic skill which combines theoretical medical knowledge with clinical experience and is developed over the course of the professional career (Hege et al. 2018). VPs allow for autonomous practice and learning from diagnostic error in a safe environment (Hege et al. 2018).

In terms of developing virtual patients to fully enhance the development of clinical reasoning, realistic branch points are considered effective (Posel et al. 2014) (see Fig. 3.2). These are distinct junctions in the VP storyboard where the scenario can take several different directions depending on the user input. Klein et al. (2018) assessed whether prompts in the form of open-ended reflections or multiple-choice questions helped foster clinical reasoning. Interestingly, such prompts only stood to add extraneous cognitive load and so unsupported worked examples in VP games may be favoured, where the learner is simply informed of where they went wrong and why, rather than explicitly being tasked to reflect on their error.

Van Bruggen et al. (2012) have analysed the various question types that can be used in VP scenarios aimed at large groups of students and conclude that extended matching questions and comprehensive integrative puzzles are most useful in developing clinical reasoning skills. The latter involves students building a comprehensive patient history, examination and investigation results based on a final diagnosis, effectively working backwards from the end-point of the patient work-up.

3.4.4 Longitudinal Care and Combatting Clinical Inertia

As discussed, many VP scenarios focus primarily on the initial diagnosis and management of a condition, when patient management realistically involves dealing with more chronic conditions (Urresti-Gundlach et al. 2017). May branches of medicine a hospital consultant or involve the

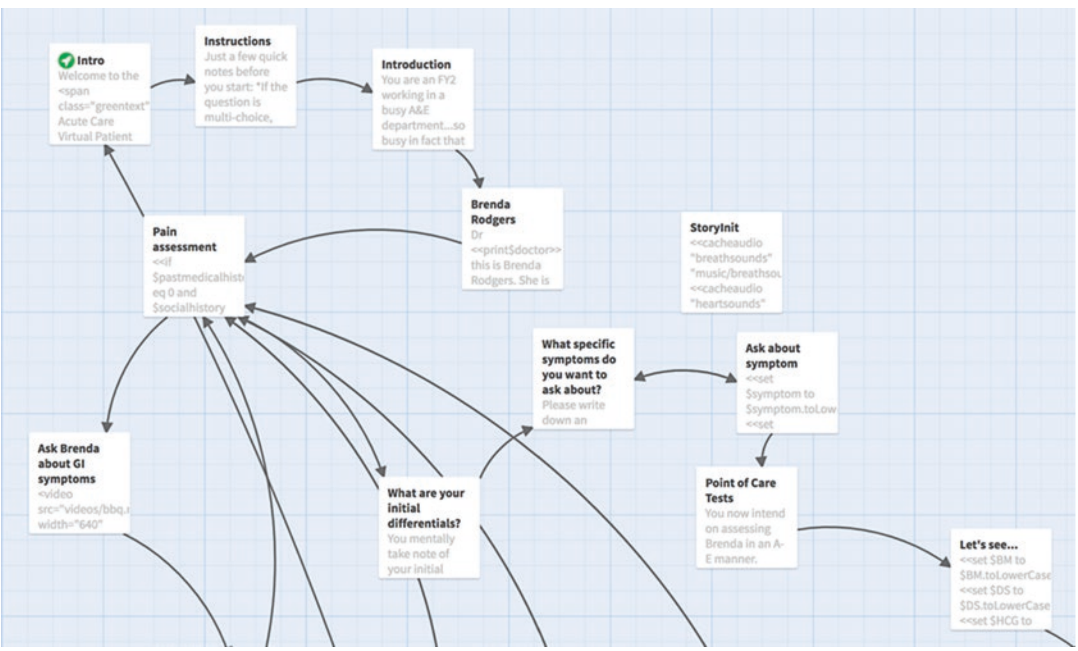

Fig. 3.2 A storyboard created using open-source Twine software shows a branching virtual patient scenario (Quail et al. 2018)

management of people with chronic conditions over a period of years. Junior doctors in the UK tend to rotate training posts every 4–6 months (Harries et al. 2016). Although this allows a multitude of skills to be built in different clinically settings, it does not afford much practise in managing chronic disease longitudinally learning from decisions made in this management. Sperl-Hillen et al. (2013) have piloted longitudinal VP in diabetes management where doctors can apply their treatment plan and follow up their VP over a 180-day period in an attempt to achieve physiological targets such as optimal blood pressure or blood glucose. Such VPs afford much needed practice in managing chronic illness and may also help combat clinical inertia.

3.4.5 Augmented and Virtual Reality in Skills Training

Augmented reality (AR) and virtual reality (VR) are two concepts that are becoming increasingly popular in health professions education (Pantelidis et al. 2018) and general popular culture with the advent of technologies such as smartphones. A notable example being the Pokémon Go worldwide phenomenon in 2016 (Marquet et al. 2017). AR differs from VR in that artificial images are layered over the natural environment of the user, rather than an entirely separate environment being created (Pantelidis et al. 2018). AR and VR lend themselves well to task-based training in health professions education. The philosophy of see one, do one, teach one, when it comes to clinical skills is one which is out-dated and unsafe (Seewoonarain and Barrett 2017). Satava (2006) suggests a multi-step process that could utilise VPs in order to teach clinical and surgical skills. This involves teaching the anatomy involved in the procedure didactically and through physical or even virtual models. Errors made while learning the task should also be explored, before learners test their psychomotor skills on the simulator. The progression from novice to expert can then be tracked using unique signatures created by the user each time they perform the task.

Pantelidis et al. (2018) have recently compiled a descriptive list of VR and AR simulators being used in speciality teaching, with more examples being published since their list was compiled. For example, a pelvic ultrasound VR simulator demonstrating pathology such as abnormal adnexal masses has recently been described (Arya et al. 2017). Although an exciting prospect, there are still several issues associated with implementing such technology in health professions education. The first is cost, although smartphones and tablets are making AR more readily accessible (Pantelidis et al. 2018). Physical reactions of users such as headaches and dizziness are common and limit usage time compared to traditional didactic teaching (Moro et al. 2017). A third potential issue is that any aspect of poor programming resulting in the simulator not reflecting real practice, or a lack of instruction as to correct technique, could lead to maladaptive skills being learned (Pantelidis et al. 2018). Finally, variability is key to mastering skills (Hatala et al. 2003). Simple variability in, for example, interpreting laboratory results can be introduced using very basic random number generation (Quail et al. 2018). More complex programming is needed to introduce the necessary variability in anatomical and pathological presentations in order for the user to begin to master the skill.

On the variability of simulations for skills, Norman (2014) discusses his thoughts from a recent hospital admission: "For IV insertion, you can run the gamut from a pig's foot, to a static plastic simulator, to a virtual reality simulator, to SimMan and its variants; the cost ranges over many orders of magnitude. But NONE of the simulators addresses the perceptual skill that the nurse displayed in scanning for veins… Similarly for heart sounds. A student has a vast choice of simulations, from free heart sounds downloaded from the Web, to Harvey (a heart murmur simulator), at $50,000…to achieve mastery he was going to have to listen to a great many heart sounds. Harvey has 29—one of each condition.

3.4.6 Virtual Patients and Communication Skills

VPs can also be used to teach communication skills. Although perhaps less effective than scenarios aimed at enhancing clinical reasoning (Consorti et al. 2012), scenarios can be tailored to teach specific points about communication, such as empathetic opportunities (Motz et al. 2018). If empathetic opportunities are acted upon in consultations, they can lead to a more thorough and accurate patient history being obtained. Since empathetic opportunities may very between custom and local dialect, VPs may represent a unique way in of training communication skills in a safe environment.

3.4.7 Collaborative Development of Virtual Patients

The Electronic Virtual Patients Programme is an online resource that is partially funded by the European Union (European Virtual Patient 2019). It combines submissions from various European medical schools to form a vast and varied learning resource. Collaborations such as this allow students to observe variations in practise between institution and, importantly, learn from presentations that may be rare in their own geographical area (Hardy and Brown 2010). As technology improves in real-time accurate translation in text, even audio description or video-based patients may be utilised by a variety of countries.

3.5 Virtual Patients in Assessment

Educators have used VPs to assess learners' progress. Using VPs as tools for assessment of basic theoretical and practical competencies is an interesting concept, bringing both advantages and disadvantages. Objective Structured Clinical Examinations (OSCEs) were introduced to healthcare professional assessment in order to eliminate variability between patients and examiners (Khan et al. 2013). A scenario with a script is constructed that a patient or actor will adhere to, and marks are awarded when the trainee either enquires about a specific point when taking a history, performs a certain examination technique, or answers a question correctly. There are several ways in which variability between stations can occur (Khan et al. 2013). For example, patients may have signs to find such as heart murmurs which are slightly easier to auscultate than others; patients may give a detailed history easily or only when asked very specific questions; or patients may take longer in answering questions, giving the trainee less time in the station. Variation may also occur between examiners when ambiguous answers are given to questions and they are tasked with deciding whether they award a mark or not. Various quality control steps aim to mitigate, but not eliminate, this potential for variability (Khan et al. 2013). Using VPs either in conjunction with, or in replacement of, OSCE scenarios may help eliminate some of the variability mentioned. A limited number of patients, actors, and examiners available for OSCEs can also cause several problems, which having standardised virtual patients may help solve. One of which is a difficulty in re-scheduling exams at short notice due to events such as adverse weather. Further, if large groups of students are to be examined, quarantining may be necessary in order to prevent collusion (Noonan et al. 2018). Fully converting OSCEs to VP assessment would be unwise, since OSCEs must assess real authentic patient scenarios (Khan et al. 2013). Lin et al. (2018) have successfully integrated VPs and regular human standardised patients into their OSCE for pharmacists, using standardised patients for communication stations and virtual patients for data-related scenarios. Assessing in this way can ensure graduates have a good degree of computer literacy, which is increasingly necessary for jobs in the healthcare sector.

3.6 Barriers to Integration

There are several barriers inhibiting the integration of virtual patients into health professions education. Cost of designing high fidelity simulators (Pantelidis et al. 2018) and computer literacy of designers and educators (Berman et al. 2006) are both important factors. Basic VP games can be created using open-source storyboard software such as Twine (Fig. 3.2) but this requires a great deal of computer literacy and time to complete. Conversely, outsourcing to create high fidelity VP is extremely costly (Quail et al. 2018). Open-source collaboration networks such as the European Electronic Virtual Patients Programme (Electronic Virtual Patients 2019) are useful in sharing resources between medical schools could make integration of VP into the curriculum far easier.

3.7 Conclusion

VPs play a useful role in medical education in developing skills such as clinical reasoning and practical skills. They may also be useful in substituting patient encounters in order to simplify and standardise encounters for novices, allow long-term follow-up to be practised virtually, or when patient availability or cost is a barrier to clinical experience. As technology and health professions education literature continues to advance and grow, VPs may play an increasing role in the learning, teaching and assessment of healthcare professions education. Future research should be focussed on how to fully integrate VPs within health professions curricula medical curriculum, and how best to design VP in order to maximise their use in acquiring and improving clinical reasoning. Collaboration is desirable, and perhaps essential; between academic centres both in the creation of VPs resources, and the collection and analysis of VP data in order to better understand educational needs.

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