Chapter 11
Lessons Learned from Building a Virtual Patient Platform

Olivia Monton, Allister Smith, and Amy Nakajima

Abstract  Virtual Patients (VPs) were a mandatory component of the surgical rotation at McGill University for medical students and focused specifically on the teaching of trauma. These cases, written by clinicians and clinical researchers with research experience in VPs, enabled students not only to acquire core knowledge in the identification and management of trauma, but also provided an opportunity to practise skills, such as clinical decision-making and communicating in emotionally challenging situations (e.g., approaching a family member to discuss organ donation). Both faculty and learners appreciate the significant advantage of using VPs: it is a teaching modality which provides meaningful educational opportunities to learners, without risk of harm to patients (Cook et al. in Acad Med 85(10):1589–1602, [7]; Voelker in J Am Med Assoc 290(13):1700–1701, [26]). The authors were inspired by their experiences with these VP cases and began to consider how they might be able to contribute to this field. They became convinced that they could expand on the service offerings that were available at that time, by developing a platform for medical learners. This chapter focuses on this journey. The authors (AS, OM), with another colleague, a software developer, approached faculty at McGill whose expertise was in developing and researching VP cases. This collaboration has led to the creation of the VP software platform, Affinity Learning, and a content-based VP company, VPConnect. In this chapter, we will discuss our experience partnering, as medical students, with members of academia, research, clinicians and industry to create a VP platform, specifically highlighting:
1. The virtual environment as an effective, safe, and cost-efficient way to educate medical trainees;
2. The requirements behind a successful VP platform;
3. The obstacles and challenges we faced in developing a medical education innovation; and
4. Our thoughts on charting a way forward.

**Keywords** Virtual patients · Virtual reality · Medical education

### 11.1 Introduction: Simulation and Virtual Patients

Simulation-based medical education (SBME) has long been recognized as an effective way to educate trainees at the provider-, team-, and systems-level, addressing different learning needs and fulfilling a variety of functions [1, 19]. Simulation at the individual-level promotes knowledge acquisition and skill-development of a healthcare provider, whereas systems-level simulation takes a broader view, exploring issues related to the components of healthcare, a complex, socio-technical system consisting of multiple and multiply interacting components, including the environment, the organization, the work itself, and persons, which include providers, patients and families [11, 16, 24].

One form of simulation that has traditionally addressed individual learning gaps is screen-based simulation (SBS). SBS is a form of simulation in which the clinical scenario is displayed on a digital screen and functions as an alternative to in-person simulation [9]. SBS facilitates experiential learning through the use of digital scenarios, emphasizing the key role that experience has in the learning process [9, 17]. SBS includes the following simulation modalities: VPs; virtual worlds; screen-based haptic trainers; and resource management simulators [9]. Interest in digital simulation, including SBS, has been growing, reflecting the shift towards online learning [22].

VPs is a form of SBS that has been associated with positive learning outcomes. They are interactive computer-based clinical scenarios that replicate the physician–patient encounter [7–9]. VPs provide opportunities for medical trainees to engage with a seemingly real patient, in order to practise data gathering, diagnostic, clinical reasoning, and clinical decision-making skills. They have proven to be an effective tool in healthcare professions education [8]. There are several advantages to VPs as a simulation modality, including their accessibility, portability, customizability, scalability, and sustainability [9, 10]. Furthermore, VPs allow for standardization and robust data collection [9].

One significant advantage of using VPs, as with other forms of simulation, is the preclusion of potential harm to patients, which is an inherent risk associated with providers acquiring competencies in the clinical environment [28]. This is especially true for surgical specialties, in which learning curves representing the acquisition of surgical and procedural skills over time, can have tremendous implications for
patients [15]. Additionally, utilizing VPs also eliminates potential harm to simulated patients, such as anxiety and fatigue; for example, in scenarios involving emotionally challenging themes, such as sexual abuse or domestic violence [20].

VPs provide an opportunity for trainees to gain knowledge in areas with limited clinical exposure and address common knowledge gaps in a patient-safe environment [12, 25]. While scheduling of rotations and electives are decided upon at the levels of the various departments and the programs, the learners’ actual exposure to patients and clinical conditions is opportunistic and cannot be perfectly anticipated nor ensured. Macro-level societal, economic, ecological and policy factors also influence clinical exposure [16]. For instance, falling birth rates in Canada may challenge the Obstetrics and Gynecology residency programs to provide sufficient clinical exposure to their trainees, and also challenge pediatric Surgery programs to provide adequate surgical volumes to trainees and staff [2, 23]. VPs may help address learning gaps due to a lack of clinical exposure.

As a form of online virtual simulation, VPs are a cost-effective simulation modality [14]. Though the development of a VP platform is associated with up-front financial and labour costs, these costs are relatively low when compared to the costs associated with the building, maintenance, and human resources required to operate a simulation center [18]. A recent study with nursing students, compared learning outcomes and cost-utility analyses for mannequin-based simulation and virtual simulation, and found no difference between the two simulation modalities in terms of learning or performance [14]. Furthermore, virtual simulation was found in a 2018 study, to be more favourable in terms of cost, with cost-utility ratios of $1.08 USD for virtual simulation, compared to $3.62 USD for mannequin-based simulation [14]. Leaders in medical education have advocated for an increase in the allocation of resources to support the use of instructional technologies, in addition to enhancing electronic infrastructure, through funding and leadership [22].

VPs can be used at all levels of medical education, including continuing professional development (CPD), in addition to undergraduate and postgraduate medical education. As a form of online education, VPs have the potential to fulfill multiple information needs, such as learning something new, expanding on existing knowledge, applying knowledge, and problem-solving [10, 13]. Additionally, by complementing in-person experiences, they present an opportunity for self-directed and blended learning [10]. At the undergraduate level, VPs may facilitate the development of clinical reasoning skills, and can be used to prepare trainees for simulation-based activities or clinical rotations [8]. Residents are motivated to use online resources and identify the delivery of safe and effective patient care as their motivation for engaging in online content [10]. With the current transition to competency-based medical education (CBME), VPs have been used in the development of entrusted-professional activities (EPAs) [21]. Physicians are receptive to using educational technologies to keep abreast of the latest advances and developments in their respective fields, thereby also fulfilling requirements for continuing medical education and professional development [6, 10]. In fact, one study found that physicians desire more online learning materials and simulation-based activities for continuing medical
education credits [6]. As such, VPs appear to be an effective learning modality for CPD.

In summary, VPs are a subset of SBS that have been used in medical education at all levels. Advantages of using them include patient safety, customizability, and cost-effectiveness.

11.2 Virtual Patient Platform Requirements

Recognizing the advantages of VPs to learners and educators, it is important that VPs be part of an environment to provide content generation and delivery. VPs cannot exist in a vacuum and require an ecosystem for learner engagement, case authoring development, and assessment of learner performance. To this end, the authors sought to create a VP platform that could lead to widespread distribution, opting to present the platform as a commercial product to best achieve this goal.

The platform seeks to create an incentive for clinicians to publish VPs relevant to their disciplines, and in response to changing guidelines or observed clinical knowledge gaps, while providing learners an avenue to build on their clinical knowledge and reasoning. Learners range from healthcare students to seasoned clinicians looking to maintain their competency in specific domains. Both educators and learners benefit from using a medium with the potential to provide content which is current and can be easily updated to reflect new information, as research expands on what is known and understood about a given topic [10].

With these goals in mind, we found through trial and error, that for a VP platform to be successful, it must be able to achieve the following:

- Reduce learner barriers to access,
- Provide clinician authors with the ability to story tell,
- Enable author responsibility for updating content,
- Increase learner immersion and connection to the patient, and
- Integrate and scale new technologies.

a. Reduce learner barriers to access

To reduce the friction between the learner and the application, the goal was to ensure that the VP platform is usable on any modern device and not require the installation of proprietary or ancillary software. Designing the application as a ‘mobile-first’ platform, wherein learners could use whatever device they choose (phone, tablet, desktop), ensured a uniform experience on all devices, and enabled flexibility, as learners could use the platform where and when they wanted. We discovered that learners tended to start and resume VP cases not just in scheduled blocks, but while on the go, such as during taking public transit.

As part of standard software design, we prioritized the incorporation of intuitive interfaces to drive an innate understanding of the application. This minimized the need for training materials or a learning period to understand how to navigate the
software. The intuitive interfaces also enable learners to focus on the case material at hand, allowing learned functionality of common applications to serve as the only requirement. To complement existing learning approaches, VPs allow a seamless embedding of didactic information, such as online lectures or screen recordings, into a clinical case. Incorporating different learning modalities, such as multiple-choice questions, text response entries, and case branching to allow exploration on different topics, encourages active learning and a personalized learning strategy.

b. Provide clinician authors with the ability to story tell

The use of narrative, whether incorporated into a lecture, a podcast, or an in-person simulation, is a powerful technique to immerse learners into a clinical scenario. The use of stories presents opportunities for learning, both about clinical conditions and about patient-centered care [5], and offers a medium for clinician authors to draw upon personal experiences. VPs facilitate learner engagement, by transforming clinical narratives into cases, and allowing learners to chart their own course through different learning modalities and elements. Our experience has shown that as clinician authors became more familiar with the variety of possible adjuncts that could be added to the clinical narrative, the more authentic the cases became.

c. Increase learner immersion and connection to the patient

In addition to narrative, other immersive features can help place the learner into the clinical context presented in the case. For example, in the setting of managing a patient in a motor vehicle collision, the inclusion of a dynamic Vital Signs panel, which is responsive to user actions in real time, elevates the learners’ awareness that the actions and choices they make within the scenario result in physiologic consequences sustained by the simulated patient. Clinical decision-making, such as whether to insert a chest tube, becomes less theoretical and more realistic, and entails responsibility for the VP’s well-being. The very real challenges of medicine in the real world become explicit and visible for learners using this medium.

While VP cases are generally useful to address individuals’ learning gaps, checkpoints can be designed and inserted by authors to deliberately prompt learner reflection and to provide a more faithful representation of how clinical problems unfold in the real world. The authors’ experience of cases written by the McGill Faculty members included difficult discussions with family members regarding organ donation. Even in the virtual environment, participating in such an emotionally fraught discussion, which students had not yet experienced in a real clinical setting, generated a very real emotional connection between the students and the simulated patient and family.

d. Include author responsibility for updating content

The ability to update online content also entails a responsibility to maintain that content, that is, to ensure that the content is kept current. This was most pertinent for the authors in developing COVID-19 VPs created for different specialties. The ever-changing landscape of a pandemic, in real-time, necessitated continual revisions
of published VPs to best represent practices and guidelines, which themselves were being continually revised.

VP cases that highlighted topics refreshed at more regular intervals, such as changes to specialty guidelines or updates in best practices, also require accountability and agreement on the content and the learning principles presented. When VPs are integrated as part of an institution’s curriculum, a review process must be developed and adopted to confirm that the content is reviewed and accurate, and to ensure that the stated learning objectives are appropriate, and that not only the material presented, but also the assessment metrics, correspond to those articulated objectives.

e. **Integrate and scale new technologies**

New technologies, whether augmented reality (AR), virtual reality (VR), or natural language processing (NLP) can provide new avenues to drive educational uptake. In building out each aspect of the VP platform infrastructure, the authors are provided with the flexibility to integrate new features into the platform as they become more widely adopted and feasible for widespread use. NLP is already showing promise in other studies focused on medical education [3] and is an active area of investigation for the authors.

### 11.3 Obstacles and Challenges

Innovation in medical education faces a variety of obstacles, including the need for collaboration of expertise from a variety of disciplines such as education, engineering, human factors and behavioural sciences [9]. When designing an educational tool for commercial use, an additional challenge is to fulfil the requirement to make the platform attractive for commercial sale. Within this section, we will outline some of the challenges we encountered in the partnering of industry with academia to develop a commoditized product for medical education.

The team, composed of members from academia and industry, as well as clinicians, was unified in our aim to improve existing VP cases by adopting an increasingly immersive and engaging environment. However, transforming an ideal vision to a sustainable financial reality was faced with multiple challenges.

The team identified several differences in perspectives, which required resolution in order to achieve our goals:

a. **Defining product specifications**

The industry approach of engineers and entrepreneurs is user-centric, focusing on the needs of users and catering to their requirements. Academia looks inward, toward proven, evidence-based publications to serve as a roadmap. These two approaches may not always be in alignment; when our team was initially starting out, we discovered that developing a unified roadmap was a challenge.
b. **Speed of release**

Academic pursuits necessitate careful configuration of control and intervention groups, and this approach can bleed into the approach to innovation. Academia and entrepreneurs ultimately can have different ideas surrounding risk.

c. **Exploration of new technology**

Similar to the speed of releases, experimentation in new, unfamiliar technologies can lead to differences of opinion between academia and industry innovators.

d. **Financial independence**

Perhaps the most crucial disconnect encountered by our team was divergent prioritization amongst the members regarding the need to generate a cash flow to sustain design and development. While being self-funded and using a bootstrapped approach to development, all members of the team understood costs would be carried internally prior to landing funding or sales. For the industry members, this created a pressing need to secure grant funding or to release a product for external sale, to provide a return on the investment of time and computing costs. Both clinicians and researchers, on the other hand, have primary income from their other research and clinical pursuits, and have research projects that reside in longer funding cycles.

e. **Transitioning to sales**

The divergent priorities regarding financial independence directly led to a difference of perspectives on marketing a sellable product. Academia and industry may agree on the requirement of partner organizations to beta test products; however, market analysis, competitor research, and ensuring a robust business model are not native to an academia perspective.

It became increasingly clear that resolving competing objectives would become more challenging. Academia is incentivized to make a product in accordance to their perceptions of the requirements, as viewed through their research lens. Software developers and entrepreneurs value commoditization to make a financially successful endeavour, focusing on both market demand and user input to identify what is important to the innovation.

To compensate for these differences in perspectives, it was ultimately decided to restructure the original team into two separate entities. The McGill Faculty members will continue to engage with clinician stakeholders using their evidence-based approach to VP cases and years of research experience in the domain. The authors (OM, AS), contributing to the product Affinity Learning, will continue to innovate and integrate new technologies to the VP platform and allow organizations from different spheres, within and beyond medicine, to access the platform and create their own use cases for the platform. We believe this allows parallel development to innovate VPs and will actually be more successful than proceeding with the single, originally proposed, entity.
11.4 Lessons Learned

We offer the following suggestions, engendered from our lived experience, to those planning on collaborating with a multidisciplinary team to develop a medical innovation:

a. **Establish clear roles**

As for any team-based endeavour, clear roles must be established and domains of expertise need to be respected and acknowledged. Perspectives from academia and industry are both valuable and need to be shared, but agreement on the principal decisions regarding the direction of the project and the product itself must be reached, in order to successfully scale up for widespread dissemination.

b. **Start with seed money**

Screen-based simulation is known to have “substantial up-front financial and labor costs” associated with its development [9]. While our venture was successful in being self-funded, which allowed us to control all aspects of ownership, this situation also concurrently created pressure to move from design and development to sales generation.

c. **Front load intellectual property agreements**

Akin to setting up authorship roles in a research publication, clearly identifying who and defining how they will contribute to an innovation should be established early in the development process.

d. **Start with a partner organization**

Our experience with screen-based simulation highlighted the importance of working with a partner organization. Besides being fertile ground for understanding the needs and actions of users, partner organizations can help validate the business approach.

e. **Include financial expertise**

While it is well known that a team composed of “programmers, designers, clinical subject matter experts, and experts in education” [9] is imperative for developing screen-based learning, we discovered that financial and marketing expertise are also necessary components of the skill set for launching an innovation product.

11.5 A Way Forward

In 2011, Robin et al. advocated for a shift towards, and the uptake of, the use of instructional technologies in medical education. They encouraged the adoption and use of technology as a means to enhance learner experiences and called for funding
and leadership support for establishing necessary infrastructure and the appropriate use of such technologies [22]. Changes in the technology landscape has now provided us the necessary tools to meet these objectives.

Our vision for the future extends beyond VPs. We envision a broad-based electronic learning platform, which could be applied to a variety of medical specialties and subdomains, and usable for all levels of training. This type of platform would be especially appropriate for facilitating the teaching and training of interprofessional competencies, such as collaborative teamwork [4, 27]. Our goal is to integrate new technology as it becomes available and accessible. We endeavour to continue expanding our natural language processing features, incorporate virtual reality, and other real-time features, such as heart rate monitors. To facilitate collaboration and connecting around online learning, we hope to integrate chat rooms associated with particular cases.

Acknowledgements The authors would like to thank Sean Doyle for co-founding and developing the Affinity Learning platform, as well as acknowledge Drs. David Fleiszer and Nancy Posel, for their contributions as case authors and owners of VPConnect.

References

1. Auerbach, M., Stone, K.P., Patterson, M.D.: The role of simulation in improving patient safety. In: Grant, V.J., Cheng, A. (eds.) Comprehensive Healthcare Simulation: Pediatrics, pp. 55–65. Springer, Berlin. https://doi.org/10.1007/978-3-319-24187-6_5(2016)
2. Barsness, K.A.: Trends in technical and team simulations: challenging the status quo of surgical training. Semin. Pediatr. Surg. 24(3), 130–133 (2015). https://doi.org/10.1053/j.sempedsurg.2015.02.011
3. Bond, W.F., Lynch, T.J., Mischler, M.J., Fish, J.L., McGarvey, J.S., Taylor, J.T., Kumar, D.M., Mou, K.M., Ebert-Allen, R.A., Mahale, D.N., Talbot, T.B., Aiyer, M.: Virtual standardized patient simulation: case development and pilot application to high-value care. Simul. Healthc. 14(4), 241–250 (2019). https://doi.org/10.1097/SIH.0000000000000373
4. Canadian Interprofessional Health Collaborative: A National Interprofessional Competency Framework. Retrieved from: https://ipcontherun.ca/wp-content/uploads/2014/06/National-Framework.pdf (2010)
5. Charon, R.: Narrative medicine: a model for empathy, reflection, profession, and trust. J. Am. Med. Assoc. 286(15), 1897–1902 (2001). https://doi.org/10.1001/jama.286.15.1897
6. Cook, D.A., Blachman, M.J., Price, D.W., West, C.P., Baasch Thomas, B.L., Berger, R.A., Wittich, C.M.: Educational technologies for physician continuous professional development: a national survey. Acad. Med. J. Assoc. Am. Med. Coll. 93(1), 104–112 (2018). https://doi.org/10.1097/ACM.0000000000001817
7. Cook, D.A., Erwin, P.J., Triola, M.M.: Computerized virtual patients in health professions education: a systematic review and meta-analysis. Acad. Med. 85(10), 1589–1602 (2010). https://doi.org/10.1097/ACM.0b013e3181e13edf1
8. Cook, D.A., Triola, M.M.: Virtual patients: a critical literature review and proposed next steps. Med. Educ. 43(4), 303–311 (2009). https://doi.org/10.1111/j.1365-2923.2008.03286.x
9. Chang, T.P., Gerard, J., Pusic, M.V.: Screen-based simulation, virtual reality, and haptic simulators. In: Grant, V.J., Cheng, A. (eds.) Comprehensive Healthcare Simulation: Pediatrics, pp. 105–114. Springer, Berlin. https://doi.org/10.1007/978-3-319-24187-6_9(2016)
10. Daniel, D., Wolbrink, T.: Comparison of healthcare professionals’ motivations for using different online learning materials. Ped. Invest. 3(2), 96–101 (2019). https://doi.org/10.1002/ped4.12131

11. Dubé, M.M., Reid, J., Kaba, A., Cheng, A., Eppich, W., Grant, V., Stone, K.: PEARLS for systems integration: a modified PEARLS framework for debriefing systems-focused simulations. Simul. Healthc. 14(5), 333–342 (2019). https://doi.org/10.1097/SIH.0000000000000381

12. Duque, G., Fung, S., Mallet, L., Posel, N., Fleiszer, D.: Learning while having fun: the use of video gaming to teach geriatric house calls to medical students. J. Am. Geriatr. Soc. 56(7), 1328–1332 (2008). https://doi.org/10.1111/j.1532-5415.2008.01759.x

13. Gottfredson, C., Mosher, B.: Are you Meeting all Five Moments of Learning Need? Learning Solutions. https://learningsolutionsmag.com/articles/949/are-you-meeting-all-five-moments-of-learning-need (2012)

14. Haerling, K.A.: Cost-utility analysis of virtual and mannequin-based simulation. Simul. Healthc. 13(1), 33–40 (2018). https://doi.org/10.1097/sih.0000000000000280

15. Harrysson, I.J., Cook, J., Sirimanna, P., Feldman, L.S., Darzi, A., Aggarwal, R.: Systematic review of learning curves for minimally invasive abdominal surgery: a review of the methodology of data collection, depiction of outcomes, and statistical analysis. Ann. Surg. 260(1), 37–45 (2014). https://doi.org/10.1097/SLA.0000000000000596

16. Holden, R.J., Carayon, P., Gurses, A.P., Hoonakker, P., Hundt, A.S., Ozok, A.A., Rivera-Rodriguez, A.J.: SEIPS 2.0: a human factors framework for studying and improving the work of healthcare professionals and patients. Ergonomics 56(11), 1669–1686 (2013). https://doi.org/10.1080/00140139.2013.838643

17. Kolb, D.A.: Experiential Learning: Experience as the Source of Learning and Development. Prentice Hall, Englewood Cliffs, NJ (1984)

18. Lin, Y., Cheng, A., Hecker, K., Grant, V., Currie, G.R.: Implementing economic evaluation in simulation-based medical education: challenges and opportunities. Med. Educ. 52(2), 150–160 (2017). https://doi.org/10.1111/medu.13411

19. Petrosoniak, A., Brydges, R., Nemoy, L., Campbell, D.M.: Adapting form to function: can simulation serve our healthcare system and educational needs? Advances in Simulation 3(8) (2018). https://doi.org/10.1086/s41077-018-0067-4

20. Plaksin, J., Nicholson, J., Kundrod, S., Zabar, S., Kalet, A., Altshuler, L.: The benefits and risks of being a standardized patient: a narrative review of the literature. Patient 9(1), 15–25 (2016). https://doi.org/10.1016/j.spa.2016.07.002

21. Posel, N., Hoover, M.L., Bergman, S., Grushka, J., Rosenzveig, A., Fleiszer, D.: Objective assessment of the entrustable professional activity handover in undergraduate and postgraduate surgical learners. J. Surg. Educ. 76(5), 1258–1266 (2019). https://doi.org/10.1016/j.jsurg.2019.03.008

22. Robin, B.R., McNeil, S.G., Cook, D.A., Agarwal, K.L., Singhal, G.R.: Preparing for the changing role of instructional technologies in medical education. Acad. Med. J. Assoc. Am. Med. Coll. 86(4), 435–439 (2011). https://doi.org/10.1097/ACM.0b013e31820dbee4

23. Statistics Canada.: Crude birth rate, age-specific fertility rates and total fertility rate (live births). https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310041801 (2020)

24. Stone, K.P., Huang, L., Reid, J.R., Deutsch, E.S.: Systems integration, human factors, and simulation. In: Grant, V.J., Cheng, A. (eds.) Comprehensive Healthcare Simulation: Pediatrics, pp. 67–75. Springer, Berlin. https://doi.org/10.1007/978-3-319-24187-6_6 (2016)

25. Tellier, P.P., Bélanger, E., Rodríguez, C., Ware, M.A., Posel, N.: Improving undergraduate medical education about pain assessment and management: a qualitative descriptive study of stakeholders’ perceptions. Pain Res. Manage. 18(5), 259–265 (2013). https://doi.org/10.1155/2013/920961

26. Voelker, R.: Virtual patients help medical students link basic science with clinical care. J. Am. Med. Assoc. 290(13), 1700–1701 (2003). https://doi.org/10.1001/jama.290.13.1700
27. World Health Organization: Framework for action on interprofessional education and collaborative practice. https://www.who.int/hrh/resources/framework_action/en/ (2010)

28. Ziv, A., Wolpe, P.R., Small, S.D., Glick, S.: Simulation-based medical education: an ethical imperative. Acad. Med. J. Assoc. Am. Med. Coll. 78(8), 783–788 (2003). https://doi.org/10.1097/00001888-200308000-00006