

# Intersecting Virtual Patients and Microbiology: Fostering a culture of learning

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## ABSTRACT

**Background:** The use and integration of Technology Enhanced Learning (TEL) resources in medical education has attracted considerable commentary and support. “Virtual Patients” are one such resource. Whilst evidence exists supporting the benefits of these resources, there has not been specific consideration of their implications for teaching microbiology; nor attention paid to both the internal and external factors that influence learner engagement with virtual patients. The principle aims of this study are to identify factors that explicitly and implicitly influence the student’s interaction with a microbiology virtual patient resource and how these interactions reflect upon the use of the resource.

**Methods:** A mixed method quantitative (online questionnaire; n=161) and qualitative (student focus groups; N=11) study was undertaken amongst third year medical students enrolled at Queen’s University Belfast in the academic year 2012 – 2013.

**Results:** The results supported prior evidence that virtual patients are a useful learning tool (mean score of 5.09 out of 7) that helped them to integrate microbiology principles with clinical experiences. How students used the virtual patients and the depth of the subsequent benefits was dependent upon their perception of the importance of the resource. This was influenced by a number of factors including how the resources were presented and positioned within the curriculum, whether they were formally examined or timetabled and the importance attributed by peers who had already completed the examinations.

**Conclusion:** Integration of virtual patients into the microbiology curriculum is widely endorsed and may even be considered superior to other methods of teaching. How students use these resources is dependent upon a positive perception of their importance. Educators should be aware of the factors that shape this perception when integrating TEL resources into curricula.

**KEY WORDS:** Virtual Patients, Technology Enhanced Learning, e-learning, education, microbiology

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## INTRODUCTION

Virtual patients (VPs) are one of many Technology Enhanced Learning (TEL) resources that educators may utilise in their teaching. They have been defined as “[a] computer 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 decisions and therapeutic choices”<sup>1</sup>. In practice, VPs endeavour to replicate a clinical experience in which the student can assume a doctoring role whilst being guided by expert interpretation of the presentation, diagnosis and treatment of key medical conditions. Cook and Triola<sup>2</sup> provide a coherent review of the literature relating to the use and incorporation of VPs into the curricula.

Whilst a positive correlation has been observed between the integration of VPs into other medical curricula and students application of clinical skills<sup>2,3</sup>, electronic resources are considered to be context specific and therefore evidence of utility in one discipline should not be directly inferred for other subjects<sup>4</sup>. Further, it has increasingly been recognised

that the VP resources themselves cannot be appreciated on a technical level alone but additionally in the social context in which they are framed to students<sup>5</sup>.

Student dissatisfaction in the teaching of microbiology using a traditional lecture format has been found to leave them feeling overwhelmed by abstract principles and microbial nomenclature.<sup>6</sup> This has been posited as a reason for superficial, assessment-driven learning<sup>7</sup>. It has been suggested that medical students prefer using TEL resources in microbiology<sup>8</sup> and that VPs can induce benefits such as the development of clinical reasoning<sup>2</sup>. However, there remains a need for research to question *how* VPs teach, *who* learns from them and how VPs can be applied most effectively within microbiology curricula.

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The current study attempts to identify explicit and implicit factors that influence student interaction with a microbiology VP resource to identify how VPs may be better integrated into the microbiology curriculum.

## METHODS

### Study setting

The study was conducted within the School of Medicine, Dentistry and Biomedical Sciences at Queen's University Belfast (QUB). The medical degree programme at QUB follows an integrated spiralling curriculum with a focus on clinical studies in years 3-5. Data were collected from Third Year Medical Students, the first cohort to be granted access to the microbiology VP resources. Ethical approval was obtained in advance of the study.

### Virtual Patients

VPs were introduced into the 2012 – 2013 third year curriculum as part of the "Scientific Basis of Clinical Practice" module. They explored the presentation, diagnosis and treatment of seven scenarios: urinary tract infections, gastroenteritis, pyrexia of unknown origin, meningitis, respiratory tract infections, childhood exanthems and blood-borne viruses. The VPs blended images, audio and video to provide a more stimulating learning experience (Figure 1).



Fig 1. Screenshot of Fictitious Patient from Microbiology VP

A mixed method study was undertaken. In phase 1 an online questionnaire was used to derive initial themes relating to utility of VPs and ability of the resource to facilitate knowledge transfer. These results were subsequently used to guide the approach taken in the phase 2 student focus groups.

### Phase 1

All third year medical students (n=278) were invited by email to complete an online questionnaire at the end of the academic year. The online questionnaire was intended to guide preliminary evaluation of student perceptions of the Microbiology VP resource.

A pilot questionnaire was developed by the research team and reviewed by an educational theorist and a sample of year 4 students not involved in the study. Alterations to

layout and readability were made before the final 32-item online questionnaire was distributed. The questionnaire was designed to provide demographic information and to investigate the key themes of resource utility and the facilitation of knowledge transfer. Answers were recorded using a 7 point Likert Scale for responses (1= Strongly Disagree, 7 = Strongly agree) or through free text responses (incorporated to provide opportunities for students to illuminate themes that had not been considered by the authors). Simple descriptive statistics were used to analyse data and identify trends to guide focus group discussions in Phase 2 of the study.

### Phase 2

Focus groups were used to gain a deeper understanding of student experiences in using the online resource. An email inviting participation was sent to all year three medical students (n=278). Written consent was obtained from volunteers. Participant numbers were limited to a convenience sample but a sampling grid was used to purposely select students on the basis of gender, age, graduate status and VP usage to ensure a representative spread of demographic characteristics. Each group was designed to include at least one participant that had not used the VP resource.

The focus groups were moderated to encourage guided discussion. The principle investigator was excluded from acting as a moderator to reduce potential bias. To aid moderation, key themes derived from analysis of Phase 1 data were used to create a focus group guide. After two focus groups had been completed, iterative thematic coding was undertaken to inform and develop a further focus group guide for the third and final group.

Focus group discussions were audio-recorded and transcribed verbatim. Transcription was checked against audio recordings to ensure accuracy. One author (DMC) identified preliminary codes from transcripts before all authors convened to review and compare the codes and to derive overarching themes. Preliminary coding was then recoded using a final agreed scheme with any discrepancies resolved by consensus. The themes were then reviewed and agreed upon by all members of the research team.

## RESULTS

### Phase 1

Of a third year medical student population of 278, 197 responded to the online questionnaire of which 161 (57.9%) consented to their responses being used for this research (Table 1). 59.0% of these respondents were female, 17.5% were graduates prior to entry to the course and 22.4% were originally born outside of the United Kingdom. The demographic details of consented participants were broadly representative of the third year student population as a whole. Of the total respondents who consented, 58.4% had used the VPs at some stage during the course.

TABLE 1:

*Demographic details and use of VP resources amongst the third year student population and online questionnaire participants*

		Characteristics of third year group (n = 278)	Characteristics of online questionnaire participants (n = 161)
Characteristic	Response	N (%)	N (%)
Gender	Male	134 (48.2)	66 (41.0)
	Female	144 (51.8)	95 (59.0)
Age range	22 or below	212 (76.3)	124 (77.0)
	23-30	63 (22.7)	36 (22.4)
	31 or above	3 (1.0)	1 (0.6)
Previous Education	Non-graduate	238 (85.6)	132 (82.5)
	Graduate	40 (14.4)	28 (17.5)
Nationality	U.K.	231 (83.1)	125 (77.6)
	Other E.U.	17 (6.1)	23 (14.3)
	International	30 (10.8)	13 (8.1)
Used VPs	Yes	-	94 (58.4)
	No	-	67 (41.6)

TABLE 2:

*Descriptive coding of respondent feedback from online questionnaire relating to utilising VPs*

Descriptive code (coding instances, n)	Exemplar comments
Prioritisation of other learning activities due to perceived lack of time (6)	<ul style="list-style-type: none"> <li>No time - I have other work to be doing that is important for clinical attachments</li> </ul>
Need for better integration into clinical teaching and assessment (5)	<ul style="list-style-type: none"> <li>I think there needs to be better integration with the whole curriculum . . . I find it hard to devote so much time to something that is likely to only form a small part of my assessment.</li> </ul>
Implied that VP was “non-essential” resource as compared to e-lectures (5)	<ul style="list-style-type: none"> <li>No specific time allocated; any time spent on the online resources was using the lectures only. I haven’t got as far as using VPs</li> </ul>
Students see VPs as a revision tool (9)	<ul style="list-style-type: none"> <li>I have chosen to save the virtual ward patients as a revision tool closer to the exams and believe this will be more valuable once I have properly learnt the material</li> </ul>

*Questionnaire responses*

For those who used the VP resource there was overall support for the use of VPs as a useful learning tool (mean score of 5.09 out of 7) with 34.8% returning to complete the same case more than once. Respondents supported the assertion that using VPs had helped them to appreciate the

clinical relevance of microbiology (mean of 5.06 out of 7). When comparing student satisfaction with VPs against other methods of teaching such as textbooks, e-lectures and student attachment, VPs were considered a more enjoyable resource (mean score of 4.53 out of 7). When asked what design feature of the VPs was most useful, students reacted favourably to the integration of Multiple Choice Questions (52.3%), Case Histories (20.5%), Images (10.2%) and Open Questions (10.2%). When asked about their least useful features, the integration of Audio files (29.6%) and Guidelines predominated (21%).

Respondents’ answers to the open questions provided greater insight into the VP learning experience (Table 2). The major themes proposed by the students related to time management, prioritisation of learning activities, integration of materials and how these impact upon perception and use of the resource. These themes were explored further in Phase 2.

TABLE 3:

*Descriptive coding of respondent feedback from online questionnaire relating to facilitating student learning*

Descriptive code (coding instances, n)	Exemplar comments
VPs provide a structured link from lectures to the clinical context (5)	<ul style="list-style-type: none"> <li>Put what you have learnt in the lecture into clinical context</li> <li>The Virtual Ward resource allowed a logical work through presenting symptoms, investigations, diagnosis and treatment of clinical scenarios</li> </ul>
Improving clinical relevance of microbiology (4)	<ul style="list-style-type: none"> <li>It was good to see theory used in an appropriate clinical context, as it made it much easier to understand and see the relevance</li> </ul>
Provide a memorable and interactive learning experience that could be applied in future assessment (3)	<ul style="list-style-type: none"> <li>Made the topics we are learning more interactive and easy to remember</li> <li>They are helpful scenarios to aid preparation for the exams.</li> </ul>

Analysis of the student response to how the VP resource facilitated learning highlighted a number of perceived benefits (Table 3) that were considered further in Phase 2.

*Phase 2*

Fourteen students volunteered to take part in the focus groups of which twelve were chosen to participate. One participant failed to attend their session. The participants were largely representative of the medical student population as a whole.

In transcription analysis we identified 78 distinct descriptive codes. These codes were used to derive overarching themes. The overarching themes must have been discussed in two separate focus groups before it could be included in final

TABLE 4:

*Qualitative themes drawn from focus group participants' responses*

Theme (coding instances, n)	Descriptive Code	Exemplar Interview Excerpt
Theme 1- Perception of importance of VP: Formal curriculum (6)	The extent to which VPs were integrated into other microbiology resources and other aspects of the curriculum.	S1: The big word comes back again to integration; making sure that we bring it alongside that information so that instead of having to roam
Theme 2- Perception of importance of VP: Null curriculum (18)	How the relative importance of a subject or a resource can be <i>implied</i> by students. Factors include the ordering in which the learning materials are to be studied, incorporating timetabled teaching sessions and exam weighting.	S5: If you see something that's more important, it is brought into the curriculum in a more obvious way, instead it was just left on the website.  S1: It was almost the way it was laid out . . . you had lectures at the top then you had the Virtual Patient cases at the bottom then it was almost laid out in that the Virtual Patient was almost be used as a formative assessment mechanism.
Theme 3- Perception of importance of VP: 'Hidden curriculum' (12)	The centrality of peer influence in creating a culture of use and promoting integration of the VPs into the student learning experience.	S7: Definitely if the year above kind of approves of something you definitely think you need it.  S4: Everyone I've told I've said to use them. Like people I'm working with now have said use them cause . . . they take questions from it.
Theme 4- Prioritisation of course demands (7)	The perception that VPs were considered to be a non-essential learning resource within a time pressured course.	S4: I know friends of mine who said "we are not going to cover microbiology." That's going to be like a sacrifice, you know a collateral damage.
Theme 5 – Confusion as to whether to approach VPs as a tool for primary learning or revision (7)	How VPs were used influenced student perception of VPs. The majority viewed VPs as a revision aid.	S1: It goes back to the purpose of the Virtual Patients. I was using it as a revision tool I would want to spend half an hour on it at the end of my revision session, whereas if it was designed as a primary learning tool, then I might have spent more time on it.
Theme 6 – Application of knowledge (5)	Students applied knowledge gained from VPs in both examinations and on clinical attachments.	S8: I can remember being on the ward and there were several patients we would see and it was, I think it was UTIs. I remembered from Virtual Patients that I applied what I had learned from that to what was going on in the ward.
Theme 7 - Student perceived benefits (30)	Students perceived VPs to emphasise and integrate principles from basic science into clinically relevant learning experiences and provided a memorable 'patient' experience that they could apply in the future.	S3: You have all this information but when you actually see someone you think 'I don't know what to do first' and for me that's what VPs are really good for.  S2: I just think it's a lot more memorable than having a fact down on a piece of paper . . . even though it's not a real patient I still think it helps you remember things cause it's more like what you face every day when you go on the wards.

analysis. From this we identified 7 key overarching themes before reviewing the descriptive codes across all transcripts to ensure they related accurately to our preliminary interpretation (Table 4).

## DISCUSSION

Our findings suggest that student engagement with VPs is not simply based on the quality of the VP resource but how these are perceived as beneficial to the student in relation to both educational and clinical attainment. To promote the role of VPs to the student population it is important for educators to firstly appreciate how VPs are perceived, and secondly to facilitate early student engagement with the resource. We will therefore discuss important aspects of the student feedback with regards to these two considerations.

### *Themes 1-3: Factors influencing Perception of VPs and*

### *prioritisation of demands*

It was not surprising that participants commented on the time pressured environment in which they manage competing learning needs. Whether these demands are from other subject areas within the curriculum or deciding which microbiology learning resource to prioritise, the perception of the relative importance of a resource influences the student's decision to engage on a deep level of full integration, as a superficial revision tool or not to use it at all.

Our results highlighted three facets of the curriculum that may have determined how a student engaged with VPs. Failure of faculty to integrate and relate VPs to other course materials and its clinical relevance to other specialties within the course (Theme 1 – Formal curriculum) could promote a perception that VPs are not a resource that requires focus. How the resource is presented to students, reinforced through

timetabled sessions and the extent to which it is formally examined *implies* the resource's value and the extent to which it can be dismissed (Theme 2 – Null curriculum). Our findings also suggest that the 'Hidden curriculum' (Theme 3), a recognition of the relative importance of the resource which is emphasised through student to peer interaction, also has a significant impact on how VPs were used. Peer opinion, particularly that of students who had recently passed the related exams or from the year above, profoundly impacted upon the perception of any given resource. For our cohort, the 'Hidden curriculum' exerted a *de facto* negative impact as they were the first year to use the VPs and so endorsement from earlier year groups was not possible. We were pleased to note that those who positively engaged with the VPs promoted their use to students in their own year and the year below.

These perceptions were also seen to contribute towards how and when students engaged with the resource. When students perceived the VPs as a revision aid, their engagement was at a superficial level with the expectation that the resource should be brief and directive. When students engaged with VPs as primary learning tools they engaged prior learning and used the resource to associate their current knowledge with what was being presented to them, integrating this knowledge in a more effective manner than if they used other learning tools<sup>3</sup>. In this manner VPs derive a greater benefit than simple didactic learning.

#### Themes 6 & 7: Application of Microbiology in practice

Students reported that the use of VPs helped them to develop their ability to apply microbiology principles to clinical scenarios in a safe learning environment whilst also providing a memorable learning experience. In keeping with other studies<sup>9</sup>, it was found that incorporating clinically relevant media such as x-rays, hospital charts and patient images with multiple choice questions helped the student to integrate the key principles of microbiology and related to what they experienced on the wards. The key design features required to successfully create VPs for this purpose have been described elsewhere<sup>10</sup> but it is important to note that participants provided examples when they recalled answers or envisaged actual images used in the VPs when asked to apply these principles. Students reported instances in both the clinical and examination situations where they relied on their learning experience with the VP to form their response. In doing so, they perceived a benefit from engaging with the resource and were more inclined to recommend their usage to other students.

#### VP Learning Experience

Our results suggest that there is a cyclical learning experience (Fig. 2) relating how the student interacts with the VP to the environment in which the resource is presented and perceived.

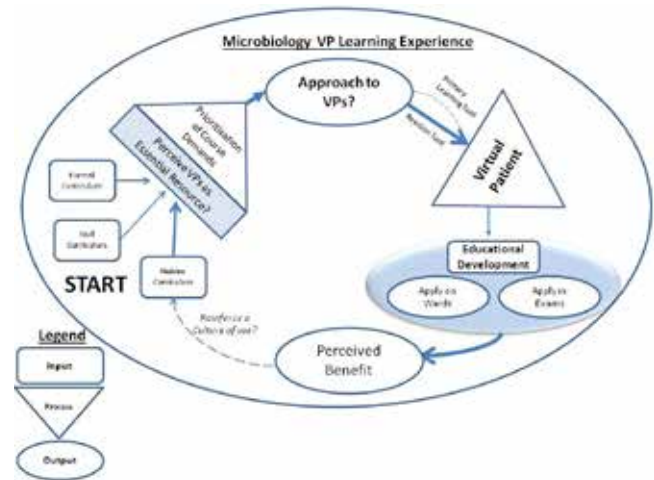


Fig 2. Schematic representation of Student Learning Experience using Microbiology VPs

The student learning experience in relation to microbiology VPs begins with an initial evaluation of whether the resource is an essential resource. It appears that a range of extrinsic and intrinsic influences act upon a student's perception of the resource, the benefits derived and the extent to which it must be prioritised in a demanding course. This perception determines whether the VPs are used early in the course with maximal engagement as an overarching primary learning tool or, as we found more commonly, as a superficial revision resource close to examination time. We noted many examples where students applied knowledge gained from their engagement with the VP in examinations and in clinical contexts to derive a perceived benefit. This perceived benefit was then fed back to their peers and the members of the year below. It is suggested that this positive feedback can have a significant impact upon their peers' decision to use the resources in the future and may encourage a culture of use.

#### LIMITATIONS

This study only explored one cohort of medical students in one institution so results may not be generalisable to other microbiology undergraduate curricula. It is possible that students who volunteered to participate in the focus groups may have held more positive views on VPs than those who did not volunteer. In an effort to ensure representative groups we purposively selected volunteers of diverse demographic characteristics. Although we recruited a relatively small sample size in phase 2 we believe that we achieved thematic saturation relatively quickly. The triangulation of results identifying and supporting similar themes between both phases of data collection would uphold the veracity of our findings.

#### CONCLUSION

Student perceptions of curriculum innovations are informed by a number of factors; some are within the control of the teaching institution and some are not. For microbiology education to fully utilise the substantive benefits of VPs, attention has to be paid to their holistic integration into

the curriculum with integration at an early stage of student learning. With microbiology considered by students to be a topic that is difficult to engage with and apply in a clinically relevant manner, it is crucial to engage with all aspects of the student learning experience to derive the greatest benefit from VP resource integration. Whilst we recognise that further research is required to explore other factors that may be involved in the student learning experience, educators should be mindful as to how they integrate the VP resource with a focus on student perception. It is vital to consider how VPs are presented to students, their implied importance in relation to assessment and feedback, and most significantly how to positively engage peer perception to support a culture of use. We believe that where rounded integration is achieved, students have shown a greater willingness to engage with the resource and an application of its use in clinical scenarios.

#### REFERENCES

1. AAMC Institute for Improving Medical Education. Effective use of educational technology in medical education. Colloquium on educational technology: recommendations and guidelines for medical educators. Washington, DC; Association of American Medical Colleges: 2007.
2. Cook DA, Triola MM. Virtual patients: a critical literature review and proposed next steps. *Med Educ*. 2009; **43**(4): 303–11.
3. Botezatu M, Hult H, Tessma MK, Fors U. Virtual patient simulation: knowledge gain or knowledge loss. *Med Educ*. 2010; **32**(7): 562-8.
4. Kononowicz AA, Stachon AJ, Guratowska M, Krawczyk P. To start from scratch or to repurpose: that is the question. *Bio-algorithms Med-sys*. 2010; **6**(11):57-63.
5. Ellaway R. Virtual patients as activities: exploring the research implications of an activity theoretical stance. *Perspect Med Educ*. 2014; **3**(4):266-77.
6. Beyliefeld AA, Struwig MC. A gaming approach to learning medical microbiology: student's experience of flow. *Med Teach*. 2007; **29**(9): 933–40.
7. Osborne J, Simon S, Collins S. Attitudes towards science: a review of the literature and its implications. *Int J Sci Educ*. 2003; **25**(9):1049-79.
8. Desai N, Philpott-Howard J, Wade J, Casewell M. Infection control training: evaluation of a computer-assisted learning package. *J Hosp Infect*. 2000; **44**(3):193–9.
9. Huwendiek S, Reichert F, Bosse HM, de Leng BA, van der Vleuten CP, Haag M, *et al*. Design principles for virtual Patients: a focus group study among students. *Med Educ*. 2009; **43**(6):580–8.
10. McCarthy D, O’Gorman C, Gormley GJ. Developing virtual patients for medical microbiology education. *Trends Microbiol*. 2013; **21**(12): 613-5.