The art of serious storytelling: using novel visual methods to engage veterinary practitioners in reducing infection risk during surgical preparation

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Abstract

Antimicrobial-resistant bacteria are a growing global healthcare threat. Uptake of appropriate infection prevention and control (IPC) measures is heavily influenced by human risk perception, consequent behaviour and the ways humans and animals interact within the environment. Effective IPC communication and teaching tools are necessary to ensure individuals' understanding and behaviours are in line with scientific recommendations. This chapter describes a novel approach to developing an IPC training tool to raise the perception and understanding of risk of infection to animal patients during routine veterinary surgical procedures. The researchers 'made the invisible visible', revealing bacterial contamination sources and their spread during preparation for surgery via a dynamic 3-layer interactive virtual model of a veterinary practice based on real-world data on human, animal and bacterial interactions. They used a serious storytelling approach, visualisation, simple gamification techniques and a collaborative design approach to engage students, nurses and surgeons from the veterinary community in the co-development of the tool. Participants were invited to identify risky behaviours, direct and indirect sources of bacterial contamination, and were prompted to reflect on the potential consequences of poor or improved IPC measures on the patient outcome and residual bacterial contamination in the practice environment. The study was conducted over two phases. Phase 1 achieved proof-of-concept: at evaluation, 92% of 51 trial participants stated an intention to change their behaviour and to implement infection controls that aligned with training objectives. In Phase 2, the tool was enhanced, and software was developed to a beta-version to enable self-paced training on web-based and mobile platforms. The co-development and evaluation process, importance of end-user engagement throughout and findings are discussed.

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1 Design for serious storytelling

Antimicrobial-resistant bacteria are a growing global healthcare issue (1,2). One counter-strategy is to reduce microbial contamination in the healthcare environment through effective infection prevention and control (IPC) measures, leading to reduced antibiotic usage, and ultimately contributing to reducing the risk of antimicrobial resistance (AMR) developing. Uptake of appropriate IPC measures is heavily influenced by human risk perception, consequent behaviour and the ways humans and animals interact within the environment (3, 4, 5, 6). Effective IPC communication and teaching tools are therefore necessary to ensure individuals' understanding and behaviours are in line with scientific recommendations. This chapter describes the development, over two phases, of a novel IPC training tool by an inter-disciplinary team from the Glasgow School of Art (GSA) and the University of Surrey (UoS), using serious storytelling, dynamic interactive three-dimensional (3D) visualisation and collaborative design methods. Across the two phases, team expertise included: co-design; antimicrobial resistance, microbial sciences and pathobiology; simulation, software coding and 3D programming; environmental psychology; veterinary practise; and e-learning and pedagogic development.

The team's intention was to improve veterinary practitioners' perception of risk of infection during surgical preparation and procedures, thereby promoting *"risk literacy"* to raise their awareness and inform decision-making (7). *"Well-designed visual aids can often dramatically improve risk communication, comprehension, and skilled decision making among diverse users"* (8, 9). Macdonald et al. discuss contemporary approaches to developing animal-related IPC training materials (10), such as mathematical modelling (11), bio-security procedures (12), and risk identification from video footage (13). However, there has been much recent and useful work in the area of serious games for health (SGH) worth acknowledging. Abt, quoted in Hill et al., defines serious games as *"games with a carefully thought-out educational purpose, but not lacking entertainment value"* (14, 15), In their systematic review Wang et al. state serious games are *"created for the purpose of imparting knowledge or skills, and which incorporate an element of scoring as well as challenging goals and engaging design"* (16). Maheu-Cadotte et al. review the efficacy of SGH to professionals' education (17), and Maheu-Cadotte et al. found that few studies in their systematic review reported end-user involvement in the SGH development process (18). Within the frame of SGH, the work described here is design for *"serious storytelling"*, i.e., *"storytelling outside the context of entertainment, where the narration progresses as a sequence of patterns impressive in quality, relates to a serious context, and is a matter of thoughtful process"* (19). This storytelling took the form of a narrative co-constructed through a collaborative design approach with substantial end-user involvement throughout.

2 Development summary

2.1 Phase 1 study: AMRSim

Responding to the global AMR challenge (1, 20), the Phase 1 study, AMRSim[2], took a novel inter-disciplinary and multi-method approach to achieve proof-of-concept for an IPC training tool to demonstrate visually how bacterial contamination can be spread during preparation for veterinary surgical procedures. The underlying hypothesis tested in this phase was that as practitioners interacted with the 3D tool, they would gain a greater appreciation for: 1) the impact IPC measures can have on infection control; 2) where weaknesses lie in current practise; and 3) how effective mitigations, through IPC, can disrupt the *status quo*, leading to a reduced risk of bacterial contamination and infection, and ultimately reduced reliance on antibiotics.

The AMRSim study's approach used interactive digital animation and visualisation, collaborative design and workshop methods deployed over a 24-month iterative 5-stage process with the involvement of end-user representative groups throughout. The study modelled the interactions between human and animal avatars and the practice setting, derived from actual video footage of risky procedures and behaviours to provide accurate and believable, evidence-based scenarios. 'Marley', the canine avatar being prepared for surgery, was central to the narrative. The Phase 1 prototype was delivered face-to-face, at each iteration, by an instructor (one of the research team), via laptop and large display screen to a small group of veterinary participants. Feedback indicated the tool enhanced the delivery of training content by making difficult and abstract contamination concepts easy to understand. At evaluation 92% of 51 participants agreed they would change their behaviour and stated an intention to implement infection control measures that aligned with training objectives. The

[2] AMRSim: A Microbial Reality Simulator for Veterinary Training and Practice. Arts and Humanities Research Council, AMR Theme 3b Grant Ref. AH/R002088/1.

development, evaluation and detailed findings from Phase 1 are described in Macdonald et al. (10).

2.2 Phase 2 study: VIPVis

Phase 1 participant feedback identified the desire for a self-standing, self-paced training tool available in both WebGL and Android app platforms, able to be deployed via phone, tablet, virtual learning environment (VLE) and Massive Open Online Courses (MOOC) as content for veterinary student curricula and for professional veterinary practitioner training. The objective of the Phase 2 study, VIPVis[3], was to develop and deliver these platforms and to further enhance the tool. Phase 2 development time was compressed, requiring the beta-version software to be ready-to-deploy within a 9-month timeframe. Unexpected restrictions due to COVID-19 required the switch from planned face-to-face (as used in Phase 1) to online participant workshops. Although this necessitated additional organisation and an adjustment to the planned process, it worked to the team's advantage in that successive iterations of the prototype were made available online or as a download for participants to work through, after which participants completed an online questionnaire in advance of workshops. This allowed the team to pre-identify issues and potential enhancement opportunities as topics for discussion during the workshops.

The 9-month timescale allowed for three stages of development and evaluation, using the following process: 1) recruitment and consenting of participants (students, nurses and professional surgeons [vets]) for each stage; 2) preparation of the latest version of the prototype tool; 3) making this version available to participants for evaluation and their anonymous feedback via an online questionnaire, requesting both Likert scale and free text responses; 4) collating responses from the participant feedback to determine a topic guide for the online workshop; 5) using the topic guide to explore issues during the workshop, introducing additional features for discussion, and recording feedback using a proprietary video conferencing tool; and 6) using both questionnaire and workshop feedback to guide the preparation of the next version of the tool. The workshop discussions were recorded and the audio transcripts from these used a coded identifier to preserve anonymity, while indicating their role as student (s), nurse (n) or vet (v).

[3] VIPVis: Veterinary Infection Prevention through Visualisation, Arts and Humanities Research Council Follow-on Grant Ref. AH/V001795/1.

2.3 Phase 2 user involvement

The team endeavoured to ensure the development of the tool took account of the potentially different sensibilities and training needs of the main constituent veterinary groups - students, nurses and professional surgeons (vets). Ethics permission for the study was obtained via both GSA's and UoS's standard ethical protocols. Student participants were recruited via the UoS VLE, year-group leads and advertisements during relevant lectures, and nurses and vets recruited via all-colleague emails within the Vet School. All were provided with an information sheet, and consents gained. Table 1 details participant numbers for each stage.

Table 1. Participant numbers at each stage of the Phase 2 study also showing the stage versions of the training tool evaluated.

	Stage 1		**Stage 2**		**Stage 3**	
Format	PowerPoint		WebGL		Android app	
Participant	Q'aire	Workshop	Q'aire	Workshop	Q'aire	Workshop
Student	3	2	1	0	6	5
Nurse	4	4	4	4	3	3
Vet	3	3	3	3	3	3
Total	**10**	**9**	**8**	**7**	**12**	**11**

2.4 Developmental framework

Macdonald et al. describe the developmental framework and iterative process used in Phase 1, summarised here in seven key stages, with stages 3 to 7 continuing into Phase 2 (10).

1. *Ethnography*: record and understand stages and detailed procedures in the patient pathway and the interactions between humans, animals and the environment through video ethnography.
2. *Risk assessment*: identify distinctive characteristics of contact and interactions in procedures and behaviours, selecting those which present greatest risk of infection and cross-contamination.
3. *Scenarios development*: select and develop scenarios from 1 and 2 which embody these risks, and present the best opportunities to reveal direct and indirect sources of infection and their effective mitigation through IPC measures, guided by the evidence from literature and practise experience.

4. *Serious story development*: develop an educational narrative around these scenarios with training objectives which poses questions and calls for reflection.
5. *Creation of dynamic visuals*: develop a series of accurate dynamic visuals of these scenarios to 'make the invisible visible', embodying the points to be conveyed, and showing mitigation through IPC measures through monochrome and coloured layers.
6. *Interaction*: develop opportunities for engagement, interaction, navigation, and 'reveal' through gamification.
7. *Co-construction of the visual and text-based narrative through iterative prototyping and testing stages*: engage participant groups in stages 4, 5 and 6, and evolve these synchronously through an iterative build, test and evaluation process, capturing the discussions.

This approach bears a similarity to Verschueren et al.'s framework, also used by Suppan et al. for a pandemic-related SGH to promote safe behaviours amongst health care workers and which proposed stakeholder input throughout (21, 22).

3 Co-constructing the narrative

The chapter now focusses on the process commenced in Phase 1 and continued throughout Phase 2, i.e. the careful co-construction of the narrative around Marley and of the potential threats to his welfare through infection risks during his preparation for surgery, and how these risks might be mitigated through appropriate IPC measures. The principle question driving the narrative was: '*What can be done to get Marley into theatre with as little contamination as possible, both on him and left behind in the prep room?*'

Developed initially in Phase 1, the set of 3D digitally animated sequences, originated from recorded video footage and incorporated observed risky behaviours (indicated in italics), were as follows: 1) opening scene showing the three human avatars (vet, nurse and auxiliary) and Marley; 2) nurse bringing Marley into the preparation area; 3) vet administering intravenous drugs to induce anaesthesia, with Marley being held by a nurse and assisted by an auxiliary on the floor (*Marley is lying directly on the preparation room floor while receiving treatment)*: 4) Marley being lifted onto the table (*Marley is in contact with the nurse's and auxiliary's clothing)*; 5) nurse holding Marley's head up and mouth open so that the vet can intubate (*Marley is held against the nurse's body during treatment, with the nurse touching hair and watch)*; 6) nurse attaching Marley to the anaesthetic machine for the maintenance of anaesthesia; 7) auxiliary shaving Marley's limb to remove hair, and cleaning and sterilizing the site for surgery (*using the hair clippers but with no effort to contain the hair)*; and 8) auxiliary and nurse wheeling the prepared Marley on a trolley into theatre.

3.1 Training content

3.1.1 Making the invisible visible – and readable

Schoffelen et al. refer to readability issues of texts and visualisations as discussed in Nilsson et al.'s psychological and educational studies: *"for the comprehension of text, readability is subclassified into the legibility, the reading ease, the interest value and the comprehension ease of a particular text"* (23, 24). Houts et al. review addresses the accessibility issue, finding that *"adding pictures to written and spoken language can increase patient attention, comprehension, recall and adherence"* and that they *"can help low literacy people understand relationships"* (25). Houts et al. also provide a number of implications for practice including: *"simplify language used with pictures"*; *"guide how pictures are perceived and interpreted by the viewer"*; *"be sensitive to the culture of the intended audience in creating or selecting pictures for use in health education materials"*; and that *"health professionals should be actively involved in creating the pictures"* (25). These were all points considered by the team working with participants in developing this intervention. On-screen text and video sequencing were continually modified as a result of participant feedback. The following example is from a stage 1 workshop discussion regarding a general point about the appropriate sequencing of text (in this case, questions) and animations.

> P3 (nurse): *... I'm not that great at reading. So, having just the sort of short, sharp kind of text and stuff, is much better for someone like me to learn, and take in a lot easier… Put too much writing and it kind of just goes into a big blur. So, I thought it was quite a good level of text on there….*
> Researcher: *And it was, I guess, around, yeah, the way that we use video, and the benefits, and potential challenges of having questions before a video, or after the video.*
> P3 (nurse): *I think if I'd had questions before, sort of, I tend to just look for those answers. I don't tend to then take in anything else that's said. So, you just sort of think, oh that's the answer, I can switch off to everything else. Whereas, I think if you have the questions after it makes you think back about what you just heard, or what you've just read.*

3.1.2 Technical development

As mentioned previously, in Phase 1 the narrative was presented face-to-face to a group of participants by one of the team, using animation sequences operated manually from a laptop, and interaction took place in 'live' tutor and group-participant mode. Therefore, the development of the Phase 2 stand-alone versions (app and WebGL) presented a number of technical challenges. Starting with the original Phase 1 'script' and the associated files that defined the specific interactions required, the early Phase 2 (stage 1) prototype was initially devised, for speed, as a sequence of Microsoft PowerPoint slides, into which were embedded the appropriate animation sequences, an optional voice-over (VO), and simple navigation and video-play functions. Further developmental iterations – developed in Unity – led to a WebGL version (accessed via a shared folder link) (stage 2) and an Android app (accessed via a bookable tablet) (stage 3). Stage 4 was used for technical refinement to ensure the tool worked on both WebGL and Android platforms. The coding, interface, and animations for these were developed with the assistance of a variety of freely available Unity graphical assets, i.e. furniture, dog model, and reworked and rigged humanoids.

The advantages of developing this in 3D software as distinct from, e.g., Millman et al.'s video approach were several, including: the ability to model and remodel the digital environment, the interactions between vet staff, the animal patient and the environment; the ability to introduce interactivity and gamification features such as 'contamination hotspots'; being able to recreate a digitally-rendered environment as a representative yet not a photo-realistic version, as a 3D monochrome 'canvas' devoid of extraneous visual clutter, into which the colour-coded indicators of contamination sources and spread, and mitigating IPC measures could be introduced (13).

3.1.3 Narrative Content

Narrative content comprised visual and text narrative components (the latter with an optional voice-over function). Visual content comprised the set of successive animation sequences described above, generated in a monochrome 3D model (Fig. 1). In broad terms, participants were asked to identify risks during procedures, potential contamination sources and their spread which were then revealed via a second, red-coloured layer (Fig. 2) and which finally, after being asked how best to mitigate these through IPC measures, were then revealed via a third, green-coloured layer (Fig. 3).

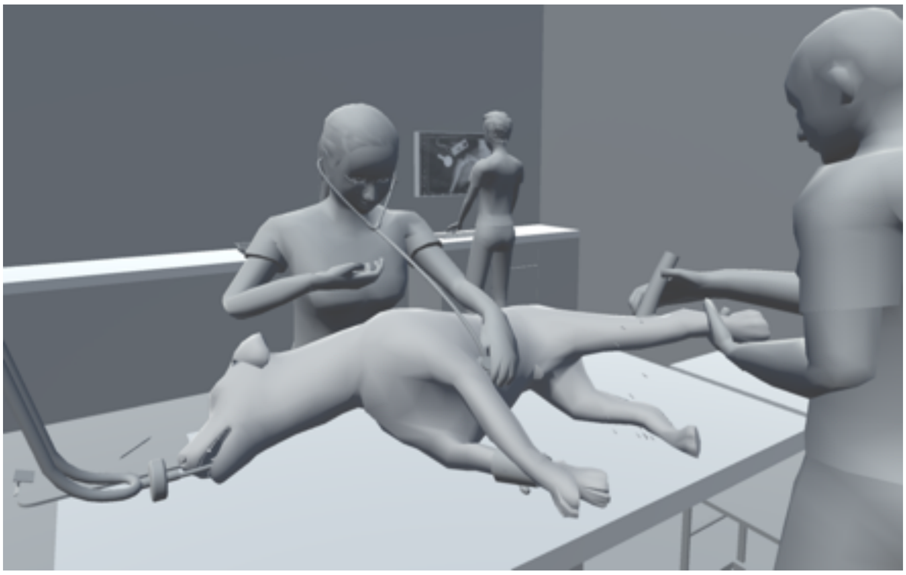

Fig. 1 Identifying potential infection risks from the animated sequences through the monochrome layer

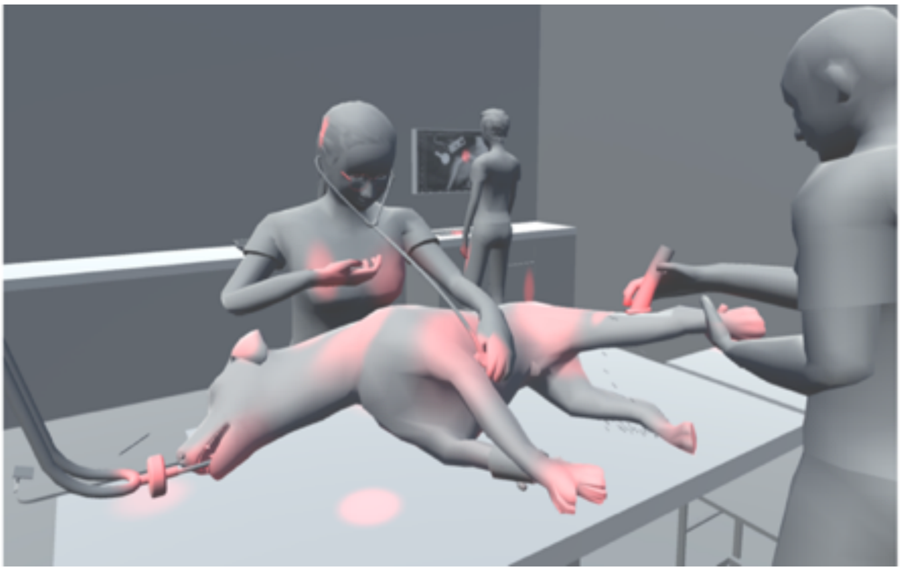

Fig. 2 Revealing potential direct and indirect contamination sources through the 'red' layer

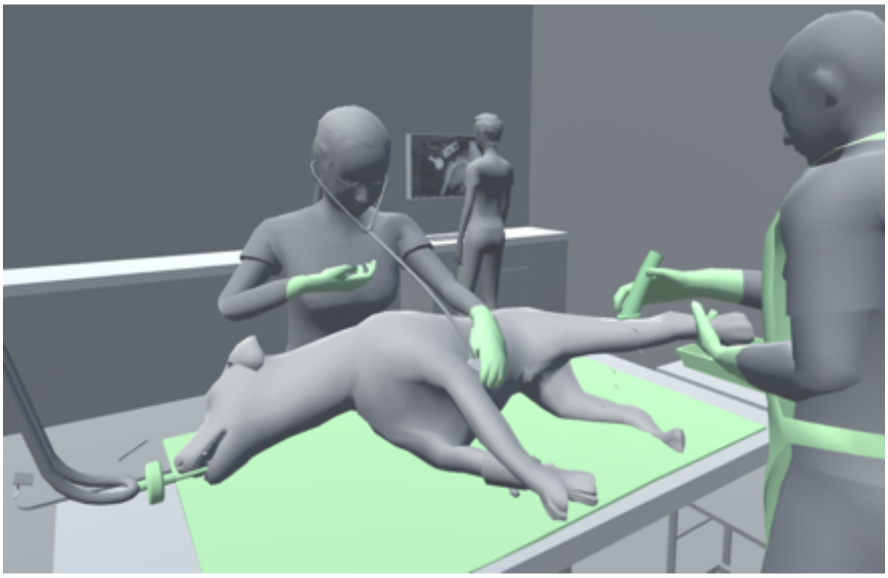

Fig. 3 Showing the positive mitigating effects of infection prevention and control measures through the green layer

Feedback from the Phase 2 pre-workshop questionnaires and during the online workshop sessions proved very useful in suggesting how proposed features might work effectively as well as additional features including: changing camera view (e.g., from front to aerial view); asking participants to identify a number of ‘contamination hotspots’; using the tool’s ‘show and reveal’ sequences; and then subsequently asking whether these were direct or indirect sources of infection. Feedback indicated these ‘gamification’ elements enhanced interaction and engagement.

The visually animated content was interspersed with on-screen text for which there was an optional VO feature. This text was adapted from the Phase 1 verbally-delivered ‘script’, and updated as new visual features were introduced and the narrative developed. For clarity and to allow for an easily readable screen font size, text was kept to an effective minimum. Two distinctly separate voices, a female and a male, were used in the VO, to maintain interest and to give audible clues that different types of information were being given: the first providing the ongoing narrative, the second with instructions or posing questions, e.g., asking the user to reflect on aspects of what they had just viewed.

4 Introducing additional features

During Phase 2, additional features introduced into the training tool were discussed with – or suggested by – participants both in terms of how these might add to the educational objectives of understanding infection risks, sources and their spread, and also technically, i.e., how best to make these features work practically and provide a good user experience. The following extracts relate to how one of the new Phase 2 interactive features was explored and developed, i.e. to identify a number of 'contamination hotspots' (Fig. 4) by touching/clicking locations on the scene where participants suspected these were likely to be present.

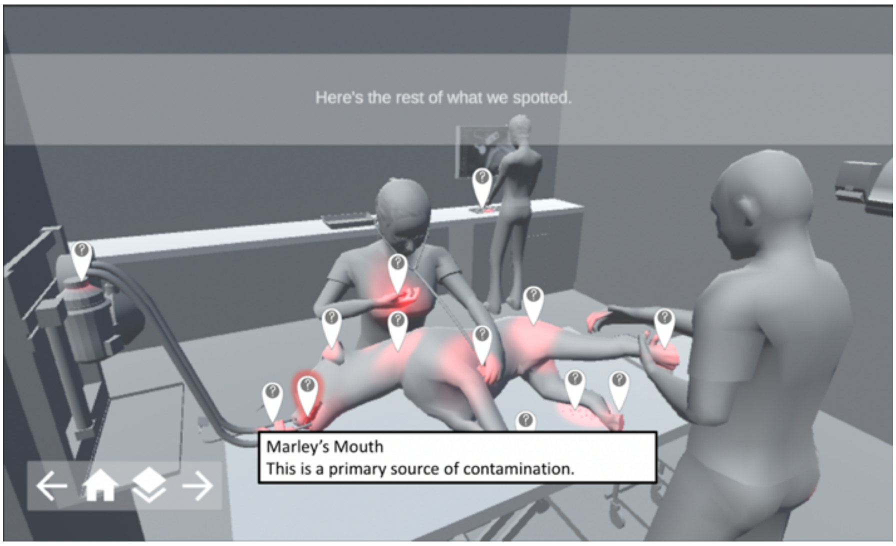

Fig. 4 An early screen mock-up of the 'contamination hotspots' exercise; clicking on correct sources shaded these red, and clicking further indicated whether this was a primary or secondary source of contamination (later renamed as direct or indirect).

The feature was first introduced in the stage 2 workshop as a demonstration 'mock-up' and then, with development guided by participants' feedback, embedded in the stage 3 prototype tablet-based app made available for evaluation pre-workshop 3. Participants, therefore, had the opportunity to guide the team on detailed aspects of the features, to see their suggestions become manifest in the next iteration of the tool, and to offer further critique of these via the online questionnaire and workshop discussions. The following extracts, from the stage 2 workshop transcript, illustrate the nature of the ongoing participant critique fostered by the team throughout the development process and which were prompted by the presentation of the demonstration mock-up of the 'contamination hotspots'.

> P6 (Vet): *...I think that's exactly what I would have wanted from this, is because I find the whole reflecting on your own quite difficult because I struggle motivating myself in that situation. Whilst if it's, like, a thing that's interactive, it's much easier to do and so I think that everything you've said sounds really, really great and it could also be a really interesting thing…way to…like, if you'd then be able to analyse where people*

click more commonly to then use that as potentially a way to almost do research in to which bits people miss more, which I'm sure you've already thought of.

P5 (Nurse): *I really…I like the idea of doing this. I guess the only thing I'd say is I'd prefer a number rather than a time, only because sometimes when you are doing this, depending on where you're doing it, it's quite easy to, you know, get distracted or an email pings up or somebody walks through the door or things like that. And I'd worry that if it's time based, you know, there's a chance you end up missing the whole thing because something's happened. So, I think probably having a number to choose rather than the time base thing would work better from my perspective.*

P1 (Nurse): *...agree, it's really good. I would definitely say I like the idea of being able to differentiate between the ones that you've picked and then the extra ones. I think that would…I definitely prefer being able to see…clearly see which ones I've missed, if that makes sense.*

At the next stage of the process, the following responses (shown collectively per cohort group also with Likert scores) were given to the online stage 3 questionnaire (Question 17) after participants had interacted with the stage 3 'Contamination Hotspots' feature in the on-tablet app. The team were trying to establish whether it was more useful if participants could themselves identify a number of 'hotspots', what number of these, and how, before all were revealed.

Q17, '*The 'Contamination Hotspots' exercise was helpful.*

(Students: 2/5 agree; 3/5 strongly agree): *"Easy to click on and great to show other hotspots after your selection." "It allowed you to really think about where contamination could be introduced." "Yes, it was helpful to verify our understanding of the possible contamination areas. However, it might have been more beneficial to allow the participants to identify more than 5 'hotspots' to further affirm our learning." "Many hotspots were very useful to know as in a clinical environment you generally don't think of them as contaminations." "It helped to recruit the knowledge learnt previously and apply it."*

(Nurses: 3/3 strongly agree) *"I think this worked really well. I would have liked the option to just 'undo' one spot I had clicked on rather than resetting the whole thing. I liked the 'info' points that were added on at the end but felt the content in them could have included more information. I also think an explanation of what is meant by a primary and secondary contamination source would be a good addition (sorry if this* *was somewhere and I missed it!).” “Allowed me to check that I was thinking along the right lines and to check on my understanding of the exercise.” “Really liked this feature. Really good to have the option to stop at 5 and be shown the rest or to find them yourself. Only thing I found was when you select 'close' to find all 13 yourself, once you have, then the continue button doesn't work. You either have to use the forward arrow at the bottom, or reset the finder, find 5, then select 'continue' instead of 'close'.”*

(Vets: 1/3 agree; 2/3 strongly agree): *“It was useful to stop and think about the points of contamination.” “helped interact.” “I love games and these pull you in well. Also, you could opt out so that if you hadn't found everything it wasn't frustrating. I feel like the minimum amount could have been slightly higher though.”*

5 Findings

This ongoing critique from participants, their suggestions for avenues for development, enhancement and engagement, and critique of prototype features and general usability, was fundamental to the study’s collaborative design approach, to the innovation process and to the careful co-construction and honing of the central narrative. Each prototype iteration together with the online questionnaires and workshop topic guides provided practical means of engagement and triggered valuable dialogue between the participants and the inter-disciplinary research team. While aspects of the questionnaires and workshop discussions were pre-occupied with technical details, such as camera view, orientation and navigation, analysis of the qualitative data from the online questionnaires and from the workshop transcripts highlighted the value of three particular aspects of the team’s visual narrative approach: ‘seeing’ the risk; the potential to influence behaviour through changed perception; and potential for applying lessons learned from one particular procedure to others.

5.1 ‘Seeing’ the risk

As reported above, from their Phase 1 findings, the team understood that their approach to visualisation was able to positively change the perception of risky behaviours and an understanding of how to mitigate infection risk. In the Phase 2 study the team were keen to understand, in further depth, how well their visual approach helped participants ‘see’ the contamination risks. Representative comments below were taken from responses to the stage 3 online questionnaire, also indicating their Likert response to each question.

Q7: The training app helps me better understand the risk of microbial contamination.

R2 (student): *Strongly agree: Clear diagrams showing the ease of spreading microbes. Consequences and risks outlined at the start.*

R7 (nurse): *Agree: This is something that I found to be widely covered in training etc but having a visual moving image to demonstrate it was helpful, especially for clarity.*

R11 (vet): *Strongly agree: I think the visual representation is really useful to actually appreciate where the contamination occurs and how it spreads. Also thinking about where the contamination occurs before seeing it and also imagining the changes before implementing them is really useful. Thinking about the consequences also puts it into perspective.*

Q11: The visual animations were helpful in 'seeing' the contamination risks.

R2 (student) *Agree: Extremely helpful with the patches of contamination highlighted and the difference between protection and no protection.*

R3 (nurse): *Strongly agree: Adds to clarity being able to see the areas that are contaminated and where this happens in the process.*

R6 (vet): *Agree: It was good seeing the animation before contamination was revealed and after. It showed areas where contamination exists which may not have been obvious.*

R11 (vet): *Strongly agree: Just thinking about a theoretical contamination is not as easy as seeing it.*

5.2 Potential to influence behaviour through changed perception

The team were interested in how better 'seeing' the contamination risk could potentially change perception and influence behaviour. The comments below were taken from responses to the stage 3 online questionnaire correlating, to an extent, with the findings from the Phase 1 evaluation.

Q19: How has this training app made you think differently about the role you can play in reducing infections and ultimately the need for antibiotics?

R5 (student): *The training app has taught me to consider the possible preventative measures to take, before handling an animal in a clinical setting, in order to reduce infection and the use of antibiotics (for this purpose).*

R8 (nurse): *For me, the app reiterates the requirement of PPE[4], cleanliness, reducing contamination etc, and will remind me not to become complacent when infections are not always seen.*
R6 (vet): *It has made me think about using PPE to avoid contamination.*
R9 (vet): *As a veterinary surgeon and educator it has helped* [me] *realise the need for more specific observance of these activities.*

5.3. Applying the principles to other procedures

Scenarios modelled in the animations were derived originally from Phase 1 video data documenting the preparation stage for TPLO[5], a specialist orthopaedic operation used to treat ligament rupture in the knee joints of dogs. These particular video data were collected from a large referral practice, a partner in the Phase 1 study. As many smaller veterinary practices do not have the facilities or expertise to conduct such orthopaedic procedures, the team were interested in the extent to which the learning outcomes from viewing this specific procedure could be applied to other more commonly practiced procedures, such as bitch spaying[6]. The following extended extracts are taken from the transcript of a dialogue in the stage 3 workshop to give a sense of the discussion about the transferability of educational principles, learnt through the approach taken in this training tool, to other procedures.

Researcher 1: *How well do you think this one example of the TPLO procedure will make you think differently about other procedures?*
P7 (vet): *Yes, I think it will, I think it'll make you think about all sorts of surgical procedures, about these areas of contamination that you don't really consider, so I think it has got a lot of, you know, reference to other procedures as well… I did a lot of surgery in my previous practice, and I think it would be very relevant to all procedures. It's just this whole concept of thinking about contamination from sources that you wouldn't consider.*
Researcher 1: *If we were to do this again with a different procedure, to pick up your point, what might be a useful procedure to subject to the same kind of treatment… that people could learn generically from in the same way that P7 has said, you know, you could transfer this to other procedures?*

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[4] Personal Protection Equipment

[5] Tibial Plateau Levelling Osteotomy

[6] Ovariohysterectomy

P5 (nurse) *A bitch spay … so pretty much every practice is going to do them, they're quite a regular surgery, quite a common surgery, but they do carry risks and things associated with them, they're often underestimated just how much of a big procedure it is …*

P7 (vet): *… the example I was going to use … abdominal surgery, they're slightly more forgiving in terms of infection than orthopaedic procedures when it's a healthy animal with no problems to start with, and it gets a serious infection like peritonitis, yes … it's absolutely devastating when that happen.*

Researcher 2: *I just find it quite interesting that you don't necessarily have to have the tool that shows the scenario that you're familiar with or working with, you can use this and then from a teaching perspective, you could then have a very useful workshop session, like a flip classroom type arrangement where you actually say, okay, what principles can we draw across to this scenario or that scenario*.

P10 (vet): *I've taught nearly 400 undergraduate students with this tool in its former version, AMRSim*[7] *… so when we did the first round of teaching, we realised the students weren't thinking outside small animal practice altogether, so … we asked the questions, can you think of other veterinary situations that you may not be in a controlled environment, but you still need to use your knowledge of IPC … We talked about standing castrations, supine, farm animal practice and surgeries on site, in the field, and then we also talked about daily life, visiting farms, cleaning your kitchen after cutting up a chicken with* Salmonella *or* E. coli *on it, so we used the tool and we sort of started the discussion using the same tool without having any other measures. And the students just, you know, caught fire, they started talking just like you did, I was listening, I was waiting to see what you guys would say.*

6 Conclusion

Is there an art to serious storytelling? In 1920 Klee stated *"art does not reproduce the visible, but makes visible"* (26). Not only is this work about making the invisible (hypothetical) pathogens visible that might make Marley seriously ill or worse, but it is about making clear sense of the potentially 'messy' environment of multifarious actors, causes and consequences

[7] While the Phase 2 study was underway, the Phase 1 tool was being evaluated in the teaching of undergraduate veterinary students in the University of Surrey's School of Veterinary Medicine.

within this setting - what Schoffelen et al. describe as a *"complex entanglement"* - transparent, accessible and readable (23).

This issue of preventing infection through effective IPC measures was of serious concern to the interdisciplinary research team, veterinary staff and students alike. Their individual and collective endeavour was '*how to get Marley into theatre with as little contamination as possible, both on him and left behind in the prep room'*. All knew that if the prevalence of AMR rises through poor IPC and hence an over-reliance on the use of antibiotics then future options for patient procedures and treatments would be seriously compromised.

Key to the study's approach were: the means and materials to bring together the interdisciplinary team and the participants in common pursuit of the study's objective; the collaborative framework which enabled this; and the way this narrative was co-constructed, and made readable and accessible to end-users. Stakeholder participation was essential from the outset: representatives of end user groups were involved from early in Phase 1 and throughout the whole Phase 2 development process, a factor vital to achieving the results in the Phase 1 evaluation and Phase 2 findings reported above. The mock-ups and working prototypes provided a point of common discussion between the team members themselves and between the team and participants. Table 1 indicates the extent of data collected via questionnaires and workshop transcripts (57 sets of written and verbal response).

Together, the research team and participants were *"individuals bound by a common cause"* (27), *"a dynamic organization of individuals and groups formed by the desire to address an issue"* (27) and to achieve the desired outcome. All had a vital role to play in contributing to the construction of and engagement with this serious storytelling endeavour.

7 Limitations

The colour-coding of bacterial contamination and IPC mitigation in the animation software uses the cultural convention of red (danger) and green (safe) as discussed in 3.1.3 above. However, this may prove problematic for certain types of colour vision defects (CVD). Following Phase 2 stage 4, the team did further work on developing recommendations for the use of appropriate colour-coding for those with CVD, which will be reported separately.

The TPLO procedure modelled would only be available to larger veterinary practices with the appropriate resources and facilities. However, as discussed in the Phase 2 findings above, the principles, understanding and insights gained from the modelled TPLO procedure show the potential for these to be applied to other procedures; other procedures common to all practices, such as abdominal surgery, could be modelled using the same approach and principles. A Phase 3 doctoral study[8] using the resulting application and WebGL from Phase 2 as a beta-version will allow not only an evaluation of any change in perception of risk in veterinary practitioners, but also any change in practitioners' behaviours, the rate of post-surgical infections, environmental contamination, and antibiotic prescribing compared to other forms of training. This is where the true and lasting impact will be felt.

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