Baillie, S., Christopher, R., Catterall, A., Kruydenberg, A., Lawrenson, K., Wonham, K., Kilfeather, P., & Warman, S. (2020). Comparison of a silicon skin pad and a tea towel for learning a simple interrupted suture. *Journal of Veterinary Medical Education*, 47(4), 516-522. <https://doi.org/10.3138/jvme.2018-0001>

Peer reviewed version

Link to published version (if available):
[10.3138/jvme.2018-0001](https://doi.org/10.3138/jvme.2018-0001)

[Link to publication record in Explore Bristol Research](#)
PDF-document

This is the author accepted manuscript (AAM). The final published version (version of record) is available online via University of Toronto Press at <https://doi.org/10.3138/jvme.2018-0001> . Please refer to any applicable terms of use of the publisher.

University of Bristol - Explore Bristol Research

General rights

This document is made available in accordance with publisher policies. Please cite only the published version using the reference above. Full terms of use are available: <http://www.bristol.ac.uk/red/research-policy/pure/user-guides/ebr-terms/>

Comparison of a silicon skin pad and a tea towel for learning a simple interrupted suture

Authors:

Sarah Baillie PhD, PFHEA, MRCVS is Emeritus Professor of Veterinary Education, Bristol Veterinary School, University of Bristol, Langford House, Langford, Bristol BS40 5DU, UK. Her interests include curriculum development, educational quality assurance, clinical skills laboratories, simulation and assessment. E-mail: sarah.baillie@bristol.ac.uk

Rachel Christopher AFHEA, RVN is a Senior Teaching Technician Clinical Skills Lab, Bristol Veterinary School, Langford, Bristol, BS40 5DU, UK.

Alison J. Catterall AFHEA, is a Specialist Technician in the Clinical Skills Lab, Bristol Veterinary School, Langford, Bristol, BS40 5DU, UK.

Adam Kruidenberg BVSc, MRCVS is an equine veterinarian working in practice in the UK.

Karen Lawrenson BVSc, MRCVS is a small animal veterinarian at Bristol Veterinary School, Langford, Bristol, BS40 5DU, UK.

Katharine Wonham BSc, BVSc, PhD, MRCVS is a veterinarian working in practice in the UK.

Peter Kilfeather BSc, BVSc, MRCVS is a veterinarian and PhD student at the University of Oxford.

Sheena Warman DSAM, DipECVIM-CA, SFHEA, NTF, MRCVS is a Reader in Veterinary Education at Bristol Veterinary School, University of Bristol. Her educational interests include feedback, reflection and workplace-based teaching and assessment.

ABSTRACT

There has been rapid growth in the range of models available for teaching veterinary clinical skills. To promote further uptake particularly in lower income settings and for students to practice at home, factors to consider include cost, availability of materials and ease of construction of the model. Two models were developed for teaching suturing: a silicon skin pad and a tea towel (with a check pattern) folded and stapled to represent an incision. The models were reviewed by seven veterinarians who considered both suitable for teaching, with silicon rated as more realistic. The learning outcome of each model was compared after students trained to perform a simple interrupted suture. Thirty-two second year veterinary students with no prior suturing experience were randomly assigned to three training groups: silicon skin pad or tea towel (both self-directed with an instruction booklet) or watching a video. Following training, all students undertook an Objective Structured Clinical Examination (OSCE) placing a simple interrupted suture in piglet cadaver skin. The OSCE pass rates of the 3 groups were: silicon skin pad 10/11, tea towel 9/10 and video 1/11; there was no significant difference between the model groups, but the model groups were significantly different from the video group ($p < 0.017$). In conclusion, the tea towel was as effective as the silicon skin pad but was cheaper, simpler to make and the materials were more readily available. In addition, both models were used effectively with an instruction booklet illustrating the value of self-directed learning to complement taught classes.

Key words: surgical skills, suturing, simulation, low-fidelity, models, clinical skills

INTRODUCTION

Teaching basic surgical skills, including suturing, is a fundamental part of any veterinary course. These skills underpin many of the routine procedures students are expected to be able to perform by graduation (Bok et al. 2011; Smeak et al. 2012; Cary et al. 2017) and contribute to the 'Day One' competences described by accrediting bodies around the world (including for example RCVS, AVMA, EAEVE and BVC; references 3-6). Ensuring that students learn basic surgical skills in a timely manner is important, enabling them to be more involved during operations whether in a teaching hospital, during extramural studies (RCVS EMS) or on a shelter rotation (Smeak 2008). However, suturing and surgery have been identified by students as areas for which extra learning opportunities are needed (Rösch et al. 2014).

Mastery of any skill depends on repeated and deliberate practice (Ericsson 2004; Campbell et al. 2014; Carroll et al. 2016). Veterinary colleges are encountering a number of challenges when trying to provide sufficient opportunities for students to learn and practice clinical skills. Cohort sizes have tended to increase, teaching budgets continue to be under pressure and the case profile of veterinary medical teaching hospitals has shifted more towards tertiary and referral level care (Smeak 2008; Langebæk et al. 2012a; Dilly et al. 2017). Additionally, there can be difficulties sourcing cadavers and there are ethical and animal welfare considerations around the use of live animals in teaching (Martinsen and Jukes 2005; Knight 2012).

The approach used to teach surgical skills has been based on an apprenticeship model for many years (Halsted 1904) where the trainee observes and assists the surgeon in theatre. Although still an important part of the learning process, this approach has been increasingly complemented by other methods. Following medicine's example, the use of models has become more commonplace in veterinary training (Scalese and Issenberg 2005; Baillie 2007) and in recent years more and more veterinary colleges are opening clinical skills laboratories (Dilly et al. 2017). There are many associated benefits for learners including a safe environment where mistakes do not carry serious consequences; this can also help to reduce student anxiety and stress (Langebæk et al. 2012b; Langebæk et al. 2012c). Students can use models to practice as often as required and at times that are strategically aligned with their learning needs, for example prior to starting a surgery rotation. Increasingly

veterinary curricula include a formal clinical skills program which provides structured teaching, skill acquisition and assessment (Read & Hecker, 2013).

Veterinary educators have been resourceful in utilizing simulators originally designed for medical training (Scalese and Issenberg, 2005) and in creating their own innovative and often low-cost bespoke models for a range of skills (e.g. Lumbis et al. 2011; Eichel et al. 2013; Fox et al. 2013; Aulmann et al. 2015; Williamson et al. 2016) including surgery (Smeak et al. 1991; Smeak et al. 1994; Langebæk et al. 2015; Read et al. 2016). The community has also demonstrated a willingness to share experiences and ideas online e.g. via the 'Veterinary Clinical Skills & Simulation' group in NOVICE.^a

Even though the benefits of using models and simulators are well established in medical training, when trying to extend their use in lower income contexts there are a number of factors to consider (Puri et al. 2017). These include cost, availability of materials (locally or imported) and ease of construction of the model. The level of uptake of simulation-based education is still limited but there is a growing interest in addressing the challenges and promoting more widespread use in low- and middle-income countries because of the potential to reduce errors and improve patient outcomes (Puri et al. 2017). In our experience, similar challenges were encountered when delivering a veterinary clinical skills workshop in association with an animal welfare and education charity based in Africa and the Middle East (Catterall et al. 2016) and when students wish to have a model for extra practice at home. Some very low-cost options have been explored including using fruit: a banana for teaching suturing to medical students (Singhal et al. 2013) and a clementine for laparoscopic skills (Andreatta et al. 2014), both of which are likely to be available and affordable in any context. There is evidence that lower fidelity models can be as effective as more sophisticated simulators (Grober et al. 2004; Norman et al. 2012). However, from a student perspective the degree of realism in relation to the look and feel of the model may influence the perceived educational value (Langebæk et al. 2012a) and developers still have a responsibility to demonstrate the validity of their model by evaluating the impact on learning.

The aim of our study was to determine if training on a low-cost, easy to make suturing model (a tea towel) would result in the same learning outcome as a higher-fidelity model (a silicon skin pad). The rationale for developing the tea towel model was that the silicon skin

pad may not be a feasible option for educators in lower income settings, or for students to buy or make to practice with at home. The ability of students to have learned a simple interrupted suture using one of the models or watching a video (the control group) was determined using an Objective Structured Clinical Examination (OSCE), a well-established method for measuring skill development (Davis et al. 2006). The study received ethical approval from the University of Bristol Faculty of Health Sciences Research Ethics Committee (ID 43961).

METHODS

Making the Models

The silicon skin pad was made in a rectangular mould (14.5cm x 13cm) and consisted of two layers. The skin layer was made first using Ecoflex 00-20 silicon^b; 25ml of Part A was mixed with 25ml of Part B and a few drops of flesh color pigment were added. The mixture was poured into the mould and left to dry for a minimum of 2 hours (or overnight) before the next layer was added. The subcutaneous layer was made using 30ml of Ecoflex 00-20 Part A mixed with 30ml of Part B and a few drops of red color pigment. This was poured into the mould and a piece of power mesh fabric^c was embedded by gently pressing with a paint brush. A foam pad (12mm in thickness)^d was placed on top and held down with a wooden block. Once the subcutaneous layer was dry, the skin pad was removed from the mould and an 8-10cm incision was cut in the center. The pad was mounted in a jig (Figure 1) and the skin surface was dusted with talcum powder to remove any stickiness. The time to make the pad (not including drying time) was 20-30 minutes with an approximate cost of \$20.

The tea towel model was made using a check pattern tea towel (dish cloth). The tea towel was cut in half (as there was enough material to make two models) and a gauze swab (10cm x 10cm) was placed in the center. Two sides of the tea towel were folded towards the middle over the swab. The two folded edges were then stapled to create an incision approximately 8-10 cm in length, while ensuring that the check pattern was still aligned on either side of the incision. The tea towel was then attached to a clip board (Figure 1). The model takes about 5 minutes to make and the total cost for materials is < \$5. The detailed instructions for making the model are available in an online booklet 'CSL_S00 Simple Interrupted Suture (tea towel)'.^e

Slight modifications were made to both models following the feedback from the veterinarians (see Results section for details of the final versions that were used in the study).

Figure 1: The silicon skin pad and tea towel suturing models

Instruction Booklets, Video and OSCE Checklist

During the study the models were used with an instruction booklet rather than having a teacher present to remove variability in the student:teacher interaction as a factor in skill acquisition. Booklets were developed for each model by the project team; each step of the skill was photographed and accompanied by a text description. The booklets are freely available under a Creative Commons License on a Bristol Veterinary School website.^e A video was used for the control group: 'CSL: Simple Interrupted Suture'^f developed by the Clinical Skills Lab, University of Veterinary Medicine, Hannover, Germany (Schaper et al. 2013) with the English voiceover provided by a member of staff at the University of Bristol. The OSCE for the study was based on a station that has been part of our 3rd year clinical skills summative assessment for several years. The checklist steps were reviewed to confirm alignment with both the instruction booklets and the video.

Comparison of the Suturing Models by Veterinarians

A group of seven experienced small animal clinicians was recruited by email to compare the silicon skin pad and the tea towel. Each clinician was provided with a project information

sheet and asked to sign a consent form. The clinicians performed a simple interrupted suture on each model and then provided written feedback, answered questions and commented on each model's suitability for use by students, level of realism including appearance (look) and tactile properties (feel), good points and areas for improvement.

Comparing Student Skill Development with the Models and Video

Students with no prior experience of suturing were recruited from the 2nd year of the 5-year veterinary (BVSc) program at the University of Bristol. Basic surgical skills, including suturing, are taught and assessed as part of the formal curriculum in Year 3. An email was sent to the whole cohort with an information sheet detailing the study. Students indicated their willingness to participate by completing a short online survey with questions about previous experience of suturing, gender and whether right- or left-handed. All eligible students (having no prior suturing experience) were allocated to a training group (silicon skin pad (S), tea towel (T) or video (V)) using a stratified random approach based on gender and handedness (to distribute males and left-handers across the groups - the latter because the instruction booklets and video illustrated a right-handed approach). Participants were sent a consent form to read, which was signed at the start of the training session.

Groups S and T had the relevant model, instruments (needle-holders, rat-tooth forceps, suture material, needle and scissors) and were given 30 minutes to self-teach a simple interrupted suture using an instruction booklet ('CSL_S00 Simple Interrupted Suture (silicon pad)' or 'CSL_S00 Simple Interrupted Suture (tea towel)')^e. Group V, acting as the control, were given 30 minutes to watch the video^f but had no instruments or model. Immediately after the training each student was assessed placing a simple interrupted suture in the skin of a piglet cadaver in an OSCE. The OSCE marksheet consisted of a 23-item checklist, each item scored 1 or 0, and a global rating scale (bad fail, just fail, just pass, good pass). All students were assessed by an experienced OSCE examiner who was blinded to the student's training group.

Statistical Analysis

The OSCE pass mark was calculated using borderline regression (Boursicot et al. 2007) with the cut score halfway between 'just fail' and 'just pass' (which is used for all stations in our 3rd year OSCE). Statistical analysis was undertaken using commercially available software.^g

Data included the pass rates and checklist scores for each group. Statistical testing included assessment of correlation between checklist scores and global rating scores (Pearson's correlation), and non-parametric tests for comparison between groups S, T and V. Mann Whitney and Kruskal Wallis tests were used to compare continuous variables (checklist scores); Pearson Chi-square tests with Bonferroni corrections were used to compare categorical variables (pass/fail). A p -value of ≤ 0.05 was considered significant.

RESULTS

Comparison of the Suturing Models by Veterinarians

The two suturing models were compared by seven veterinarians. When asked whether the model would be useful for students to practice suturing prior to their first live animal, both received positive ratings ('Yes': silicon skin pad 7/7, tea towel 6/7). The appearance (look) of the silicon skin pad was considered realistic whereas the tea towel was not realistic. When comparing the tactile properties (feel) of each model, some issues were identified: for the silicon there was too much 'drag on the needle'; the tea towel did 'not have artificial drag' but one comment noted its 'lack of elasticity'. When asked about the positive aspects of the silicon skin pad comments related to 'appears realistic' and for the tea towel comments related to being 'cheap' and the value of the check pattern was mentioned several times e.g. 'nice to have material with lines to check that sutures are not creating shear across the wound'. Areas for improvement focused on reducing the drag of the silicon and therefore the model was remade with thinner layers. The final version contained 20% less silicon in the skin layer (20ml Part A and 20ml Part B) and 50% less in the subcutaneous layer (15ml Part A and 15ml Part B). When tested again by two of the clinicians the drag was considered to have been reduced to an acceptable level. For the tea towel the appearance was the main issue and although as a comment acknowledged, 'Probably can't 'improve' a tea towel much!', it was suggested that being skin colored would be better and the final version used in the study was dyed red while ensuring the check pattern lines were still clearly visible.

Comparing Student Skill Development with the Models and Video

Thirty-two students participated in the study: 11 in the silicon skin pad group S (including 1 male and 1 left-handed female), 10 in the tea towel group T (including 2 males and 1 left-

handed female), 11 in the video group V (including 1 male and 1 left-handed female). The checklist total score was 23 and the OSCE pass mark was 19.55. There was good correlation between checklist scores and global rating scale scores (Pearson's correlation; $R^2 = 0.88$). The numbers of students passing the OSCE for the 3 groups were: S = 10/11, T = 9/10 and V = 1/11 (Figure 2, depicts the percentage of students passing and failing in each group).

*, ** = statistically significant difference between groups (Fisher's Exact test, $p < 0.017$)

Figure 2: Percentage of students in each group achieving pass/fail in OSCE

Using Pearson Chi-Square, differences were apparent in the proportions of students achieving a pass or fail between groups ($\chi^2 = 20.4$, $p < 0.001$, likelihood ratio 22.4). Post hoc Fisher's Exact tests comparing groups demonstrated that there was no significant difference between the two model groups (S vs T, $p > 0.999$). Both of the model groups were significantly different to the video group (V) after corrections for multiple comparison ($p < 0.017$)

There was a significant difference between groups when checklist scores were compared (Kruskal Wallis, $p < 0.001$). Post-hoc testing (Mann-Whitney U test) identified that there was no significant difference between the two model groups (S vs T; $p = 0.654$) but each of the models was significantly different to the video group after corrections for multiple comparisons ($p < 0.017$) (Figure 3).

Figure 3: Box and whisker plots of raw scores for students in each group

DISCUSSION

Models are increasingly used in veterinary clinical skills training. The number and variety of models have grown in recent years, with much innovation and the development of low-cost alternatives to those often used in medicine (Scalese & Issenberg 2005; Dilly et al. 2017). Further opportunities have been identified for the use of models in teaching in lower income countries and by students wishing to practice at home. However, in those

circumstances there may be additional challenges: is 'low-cost' low enough, can the materials be locally sourced (or easily imported), and is construction relatively simple (especially if individual students are making their own models)?

In the current study we compared two models for learning a simple interrupted suture. Initially feedback was gathered from veterinarians who considered that both models were suitable for use by students and also suggested minor modifications, illustrating the value of expert feedback as part of the model design process. Both models were then shown to be effective for novice students learning to perform a simple interrupted suture, with a pass rate $\geq 90\%$ when subsequently assessed in an OSCE. Additionally, the study has demonstrated that instruction booklets can be used with models by novice students for self-directed learning. In comparison, for the video group the pass rate was $<10\%$. The video was primarily used as a control as this group of students did not have access to a model or instruments to practice the skill. In reality, it would be more typical for a video to be used with a model to complement practical hands-on learning in a clinical skills laboratory or when preparing to assist with an operation. Students are known to value videos as learning resources enabling them to visualize the steps of surgical procedures (Langebæk et al. 2016a, Langebæk et al. 2016b). Videos also provide an overview of the whole procedure, perhaps giving a more complete picture than a series of photos and text descriptions in a booklet. However, it is easier for a learner to locate a step that needs to be revisited or checked in a booklet than on a video. Therefore, as both videos and booklets provide valuable instructional support, ideally learners would use both to accompany 'learning by doing' with a model.

There are certain limitations of the study including only comparing the models for one type of suture i.e. simple interrupted, which was chosen as it is typically the first suture students learn. For other commonly used skin sutures such as cruciate, it could be argued that the tea towel would also be effective although further work would be needed to investigate the suitability for learning subcutaneous suture techniques. The differences between the layers and tissue properties of each model also needs to be acknowledged as a limitation in extrapolating from the study findings as the tea towel represents only the surface layer of the skin while the silicon pad is multilayered and also firmer. Another consideration is that the generalizability of the findings beyond the study group (who were volunteers and from

one veterinary school) and the transfer of the skills to the real situation (suturing during an operation) has yet to be proven, although piglet cadaver skin was considered a reasonable representation and practical alternative. There is also a risk that students may not take the tea towel as seriously as the more life-like silicon skin pad and that could have an impact on their engagement with the model and subsequent learning. Although the veterinarians considered both models suitable for learning, students are known to perceive a link between realism and successful development of skills (Langebæk et al. 2012a). However, as students are aware of the value of research findings, citing this study in the tea towel instruction booklet may be helpful as well as highlighting the educational value of the check pattern in developing a good technique, whereby the lines remain aligned across the incision.

The main aim of the study was to compare the learning outcome of training on a silicon skin pad with a lower-cost model (tea towel) that would be feasible for students to make for extra practice at home and to support veterinary training in lower income countries - a need that has been further highlighted in a recent project where our team will be running clinical skills workshops for veterinary schools in Bangladesh (UFAW 2018). The UFAW project has also provided an opportunity for future work as we will be gathering data on the use of the low-cost models (including the tea towel) made by delegates during the workshop. Another consideration is that students will still need to be able to access instruments which could present a barrier. Relatively low cost basic surgical kits are available, sometimes bought as a batch by student clubs, and access to discarded instruments, if appropriately processed and sterilized, may be an option as single-use packs become more commonplace in human and veterinary hospitals.

The study has shown that self-directed learning using an instruction booklet with a model was effective. One of the benefits is that students will be able use the models and booklets to complement taught classes for additional practice, which is important when mastering any skill (Ericsson 2004). Additionally, students could access the booklets to revise suturing at strategic times e.g. before surgery rotation, while on a work-placement. An instructor was not involved in the study to remove the potential that differences between groups represented variability in the level of teaching provided. However, feedback is crucial in simulation-based training, without which there is a risk that the learner will develop poor

technique and there may be delay in the development of competence (McGaghie et al. 2010). Therefore, as an area of future work, the team is exploring ways to provide feedback while continuing to capitalize on the benefits of self-directed learning. Options include adding a section to the instruction booklet or developing a new resource, such as a video, that would illustrate common mistakes and demonstrate how to correct them.

In conclusion, a tea towel suturing model that was cheap and easy to make using readily available materials was as effective as the more realistic, but potentially less feasible (in terms of sourcing materials, affordability and ease of construction) silicon skin pad. The study also demonstrated that self-directed learning using a booklet was effective, which would also provide a form of instruction for students when undertaking extra practice at home and on their own in the clinical skills laboratory to complement taught, supervised classes.

ACKNOWLEDGEMENTS

The authors would like to thank the clinicians and students who participated in the study from Bristol Veterinary School, University of Bristol, UK and Melanie Hezzell for assistance with the statistical analysis. The silicon skin pad was based on a recipe originally described during a workshop delivered by Marc Dilly and John Rosenthal, University of Veterinary Medicine, Hannover, Germany. The current project was supported by a Teaching Development Grant as part of the university's educational enhancement initiatives.

NOTES

- a. NOVICE <http://www.noviceproject.eu>
- b. Ecoflex silicon: <https://www.benam.co.uk/products/silicone/addition/ecoflex/>
- c. Powermesh: https://www.amazon.co.uk/POWER-MESH-NET-FABRIC-STRETCH/dp/B01DMDK63W/ref=sr_1_1?ie=UTF8&qid=1515750317&sr=8-1&keywords=powermesh+fabric
- d. Foam: <http://www.directfoam.com/>
- e. Bristol Veterinary School Clinical Skills Instruction Booklets (silicon skin pad & tea towel) <http://www.bristol.ac.uk/vetscience/research/comparative-clinical/veterinary-education/clinical-skills-booklets/sutures/>

- f. YouTube TiHoVideos 'CSL: Simple Interrupted Suture'
https://www.youtube.com/watch?v=8RhWtaJ6_Zw
- g. IBM SPSS Statistics for Windows, Version 24.0, Armonk, NY.

REFERENCES

1. Bok HG, Jaarsma DA, Teunissen PW, van der Vleuten CPM, van Beukelen P. Development and validation of a competency framework for veterinarians. *J Vet Med Educ*. 2011;38(3):262–9.
2. Smeak DD, Hill LN, Lord LK, Allen LC. Expected frequency of use and proficiency of core surgical skills in entry-level veterinary practice: 2009 ACVS core surgical skills diplomate survey results. *Vet Surg*. 2012;41(7):853–61.
3. Cary JA, Farnsworth CH, Gay J, Carroll HS. Stakeholder expectations regarding the ability of new veterinary graduates to perform various diagnostic and surgical procedures. *JAVMA*. 2017;251(2):172-84.
4. Royal College of Veterinary Surgeons Day One Competences (2014)
<www.rcvs.org.uk/document-library/day-one-competences/> [Accessed 27th September 2018].
5. American Veterinary Medical Association CoE Accreditation Policies and Procedures: Requirements.
<<https://www.avma.org/ProfessionalDevelopment/Education/Accreditation/Colleges/Pages/coe-pp-requirements-of-accredited-college.aspx>> [Accessed 27th September 2018].
6. European Association of Establishments for Veterinary Education (EAEVE)
http://www.eaeve.org/fileadmin/downloads/SOP/ESEVT__Uppsala__SOP_May_2016.pdf [Accessed 29th September 2018].
7. Bangladesh Veterinary Council (BVC) Standards for Veterinary Education
<http://bvc.gov.bd/bvc-standard-for-veterinary-education/> [Accessed 29th September 2018].
8. Royal College of Veterinary Surgeons [RCVS]. Extra mural studies (EMS).
<<https://www.rcvs.org.uk/lifelong-learning/students/veterinary-students/extra-mural-studies-ems/>> [Accessed 29th August 2018].
9. Smeak D. Teaching veterinary students using shelter animals. *J Vet Med Educ*. 2008;35(1):26-30.
10. Rösch T, Schaper E, Tipold A, Fischer MR, Dilly M, Ehlers JP. Clinical skills of veterinary students – a cross-sectional study of the self-concept and exposure to skills training in Hannover, Germany. *BMC Vet Res*. 2014;10:969.
11. Ericsson KA. Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains. *Acad Med*. 2004;79:S70-S81.

12. Campbell RD, Hecker KG, Biau DJ, Pang DSJ. Student attainment of proficiency in a clinical skill: the assessment of individual learning curves. *PLoS One*. 2014;9(2):e88526.
13. Carroll HS, Lucia TA, Farnsworth CH, Hinckley MM, Zeugschmidt EL, Cary JA. Development of an optional clinical skills laboratory for surgical skills training of veterinary students. *JAVMA*. 2016;248(6):624-8.
14. Langebæk R, Berendt M, Pedersen LT, Jensen AL, Eika B. Features that contribute to the usefulness of low-fidelity models for surgical skills training. *Vet Rec*. 2012a;170(14):361–8.
15. Dilly M, Read EK, Baillie S. A survey of established veterinary clinical skills laboratories from Europe and North America: Present practices and recent developments. *J Vet Med Educ*. 2017;44(4):580-9.
16. Martinsen S, Jukes N. Towards a humane veterinary education. *J Vet Med Educ*. 2005;32(4):454–60.
17. Knight A. The potential of humane teaching methods within veterinary and other biomedical education. *Altex Proc*. 2012;1(12):365–75.
18. Halsted WS. The training of the surgeon. *Bulletin of the Johns Hopkins Hospital*. 1904;15(162):267-75.
19. Scalese RJ, Issenberg SB. Effective use of simulations for the teaching and acquisition of veterinary professional and clinical skills. *J Vet Med Educ*. 2005;32(4):461–7.
20. Baillie S. Utilisation of simulators in veterinary training. *Cattle Pract*. 2007;15(3):224–8.
21. Langebæk R, Eika B, Tanggaard L, Jensen AL, Berendt M. Emotions in veterinary surgical students: a qualitative study. *J Vet Med Educ*. 2012b;39(4):312–21.
22. Langebæk R, Eika B, Jensen AL, Tanggaard L, Toft N, Berendt M. Anxiety in veterinary surgical students: a quantitative study. *J Vet Med Educ*. 2012c;39(4):331–40.
23. Read EK, Hecker KG. The development and delivery of a systematic veterinary clinical skills education program at the University of Calgary. *J Vet Sci Tech*. 2013;Suppl4:4.
24. Lumbis R, Gregory S, Baillie S. Evaluation of a dental model for training veterinary students. *J Vet Med Educ*. 2012;39(2):128-35.
25. Eichel J-C, Korb W, Schlenker A, Bausch G, Brehm W, Delling U. Evaluation of a training model to teach veterinary students a technique for injecting the jugular vein in horses. *J Vet Med Educ*. 2013;40(3):288-95.
26. Fox V, Sinclair C, Bolt DM, Lowe J, Weller R. Design and validation of a simulator for equine joint injections. *J Vet Med Educ*. 2013;40(2):152-7.
27. Aulmann M, März M, Burgener IA, Alef M, Otto S, Mülling CKW. Development and evaluation of two canine low-fidelity simulation models. *J Vet Med Educ*. 2015;42(2):151-60.

28. Williamson JA, Dascanio JJ, Christmann U, Johnson JW, Rohleder B, Titus L. Development and validation of a model for training equine phlebotomy and intramuscular injection skills. *J Vet Med Educ.* 2016;43(3):235-42.
29. Smeak DD, Beck ML, Shaffer CA, Gregg CG. Evaluation of video tape and a simulator for instruction of basic surgical skills. *Vet Surg.* 1991;20:30-6.
30. Smeak DD, Hill LN, Beck ML, Shaffer CA, Birchard SJ. Evaluation of an autotutorial-simulator program for instruction of hollow organ closure. *Vet Surg.* 1994;23:519-28.
31. Langebæk R, Toft N, Eriksen T. The SimSpay—student perceptions of a low-cost build-it-yourself model for novice training of surgical skills in canine ovariohysterectomy. *J Vet Med Educ.* 2015;42(2):166–71.
32. Read EK, Vallevand A, Farrell RM. Evaluation of veterinary student surgical skills preparation for ovariohysterectomy using simulators: A pilot study. *J Vet Med Educ.* 2016;43(2):190-213.
33. Puri L, Das J, Pai M, Agrawal P, Fitzgerald JE, Kelley E, Kesler S, Mate K, Mohanan M. Enhancing quality of medical care in low income and middle income countries through simulation-based initiatives: recommendations of the Simnovate Global Health Domain Group. *BMJ Stel.* 2017;3(Suppl 1):S15–S22.
34. Catterall A, Baillie S, Packer E, Slamani D, Davies H. Workshops for veterinarians and technicians establishing clinical skills laboratories in Africa and the Middle East. *VetEd Symposium 2016.* Available from: <https://veted.files.wordpress.com/2016/07/veted-2016-guide-postconference.pdf> Accessed 28/08/2018
35. Singhal S, McCafferty L, Adkins B, Stearely S, Doty C. Use of banana peels as an alternative model for suturing education. *Ann Emerg Med.* 2013;62(5):S179.
36. Andreatta P, Marzano DA, Curran DS, Klotz JJ, Gamble CR, Reynolds RK. Low-hanging fruit: a clementine as a simulation model for advanced laparoscopy. *Sim Health.* 2014;9(4):234–40.
37. Grober ED, Hamstra SJ, Wanzel KR, Reznick RK, Matsumoto ED, Sidhu RS, Jarvi KA. The educational impact of bench model fidelity on the acquisition of technical skill: the use of clinically relevant outcome measures. *Ann Surg.* 2004;240(2):374–81.
38. Norman G, Dore K, Grierson L. The minimal relationship between simulation fidelity and transfer of learning. *Med Educ.* 2012;46(7):636–47.
39. Davis MH, Ponnampereuma GG, McAleer S, Dale VHM. The Objective Structured Clinical Examination (OSCE) as a determinant of veterinary clinical skills. *J Vet Med Educ.* 2006;33(4):578–87.
40. Schaper E, Ehlers J, Dilly M, Crowther E, Baillie S. Using YouTube to share teaching resources. *J Am Vet Med Assoc.* 2014;245(4):372-3.
41. Boursicot KAM, Roberts TE, Pell G. Using borderline methods to compare passing standards for OSCEs at graduation across three medical schools. *Med Educ.* 2007;41(11):1024-31.

42. McGaghie WC, Issenberg SB, Petrusa ER, Scalese RJ. A critical review of simulation-based medical education research: 2003–2009. *Med Educ.* 2010;44(1):50–63.
43. Universities Federation for Animal Welfare (UFAW) Annual Report 2017-2018
<https://www.ufaw.org.uk/downloads/ufaw-annual-report-ufaw-final-which-went-to-print.pdf> [Accessed 1st October 2018].
44. Langebæk R, Tanggaard L, Berendt M. Veterinary students' recollection methods for surgical procedures: A qualitative study. *J Vet Med Educ.* 2016a;43(1):64-70.
45. Langebæk R, Nielsen SS, Koch BC, Berendt M. Student preparation and the power of visual input in veterinary surgical education: An empirical study. *J Vet Med Educ.* 2016b;43(2):214-21.