e-Three-Dimensional-Touch Animation

Integrating a Bovine Rectal Palpation Simulator into an Undergraduate Veterinary Curriculum

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ABSTRACT

There are problems associated with teaching bovine rectal palpation to undergraduate veterinary students. The students need opportunities to examine enough cows to develop the required skills, but increasing student numbers and limitations on access to cows have made this more and more difficult to achieve. A virtual reality–based teaching tool, the Bovine Rectal Palpation Simulator, has been developed as a supplement to existing training methods. The student palpates computer-generated virtual models of the bovine reproductive tract while interacting with a haptic (touch feedback) device. During training sessions, the instructor follows the student's actions inside the virtual cow on the computer screen and gives instruction. A trial integration of the simulator into the fourth-year bovine reproduction course was undertaken at the University of Glasgow Veterinary School during the 2003/2004 academic year. Students were offered two training sessions, and feedback was gathered using questionnaires. In the first session, all students were taught a range of basic skills using a standardized teaching protocol. The second training session was customized to each student's learning needs and included practice in dealing with a range of on-farm scenarios. Student feedback indicated that the training had been useful for learning various aspects of bovine rectal palpation and provided information that helped in the further development of the simulator as a teaching tool.

INTRODUCTION

Bovine rectal palpation is a difficult procedure to learn, and students need opportunities to examine sufficient numbers of cows to develop the skills required to perform fertility examinations and to diagnose pregnancy. In the United Kingdom, the number of veterinary undergraduate students has increased in recent years while access to cows has become more limited.[1] The latter is due in part to animal welfare guidelines that restrict the number of examinations allowed per cow; also, in the current agricultural climate, farmers and veterinary surgeons are under increased time and financial pressures that may further reduce the number of cows students are able to examine. During training, as the student palpates the cow, the veterinary surgeon provides guidance. However, providing effective instruction can be difficult because the student's hand is not visible and because, at least to begin with, the student may be unable to describe the palpated structures accurately. Overall, ensuring that students have the opportunities and the training they need to develop adequate skills by graduation has become increasingly difficult.

A virtual reality-based teaching tool, the Bovine Rectal Palpation Simulator,[2] has been developed as a supplement to existing training with the aim of equipping students with skills that will enhance their learning and performance when examining cows. The simulator uses a force-feedback haptic device, the PHANToM (from SensAble Technologies),[a] which allows a user to interact with a computer-generated virtual environment through the sense of touch (see Figure 1).

Anatomical models have been created to represent the bovine reproductive tract—cervix, uterus, ovaries—and pregnancies, and these are positioned within the pelvis and caudal abdomen. The simulations were developed in an iterative design process with regular input and feedback from veterinary surgeons, which has resulted in the creation of a range of reasonably realistic models. The models have been combined to provide a range of scenarios for teaching students both the basic skills, including orienting within the pelvic area of the cow, and more advanced procedures, such as pregnancy diagnosis. During a training session (see Figure 2), the student places his or her middle finger in a thimble at the end of the PHANToM mechanical arm and palpates the reproductive tract, receiving touch feedback from the haptic device. The instructor provides direction while following the student's movements inside the virtual cow on the computer screen. A fiberglass model of the rear half of a cow has been built to cover the haptic device, as this provides a more realistic interaction with the virtual environment and the student is more immersed in the learning experience.

When introducing new teaching technologies, it is important to demonstrate that the skills acquired are at least as good as those developed using existing methods.[3] With regard to simulator-based training, various criteria have been identified that relate to issues of validation,[4] including creating a credible representation of the task being simulated and demonstrating that skills developed during simulator training transfer to the real task (i.e., the students are not just being trained to use a simulator). A validation of the bovine simulator as a teaching tool has been undertaken.[5] Simulator training was provided as a supplement to traditional training, anatomy lectures and practical sessions, that students receive in preparation for their first examination of a cow during clinical Extramural Studies (EMS) (work placement training). The performance of two groups of students was compared when examining cows for the first time, and the group whose training had been supplemented with the simulator located and identified the uterus significantly more frequently than the other group, who had received only the traditional training. This demonstrates the validity of the simulator as a teaching tool for one of the key components of bovine rectal palpation, finding the uterus in the cow.

Figure 1: The PHANToM force-feedback haptic device. The user places a finger in a thimble at the end of the mechanical arm and palpates virtual objects, in this case the bovine reproductive tract, depicted on the computer screen

Figure 2: A simulator training session. The student palpates the virtual reproductive tract, receiving touch feedback from the PHANToM haptic device positioned inside the fiberglass cow, while the instructor can follow progress on the computer screen and provide instructions

There is also a need to demonstrate the feasibility of integrating the simulator into a curriculum before recommending its widespread use. A trial integration of the bovine simulator into the curriculum at the University of Glasgow Veterinary School was undertaken during the 2003/2004 academic year. Teaching with the simulator was introduced in the fourth year (the first clinical year) as part of the bovine reproduction course, and students were offered two training sessions. This article presents the work carried out, beginning with an overview of the first

training session and the student feedback. The information gathered was then used to develop the teaching protocol further to help make more effective use of the simulator, both during the second training session and in the future.

TRAINING SESSION 1

Methods

The first training session was scheduled for the first term, and each student was allocated a 20-minute slot in the timetable. At the beginning of the session the instructor (Baillie) presented an overview of the simulator-based training environment and the student was asked to describe briefly his or her experience examining cows during EMS. All students were given the same standardized training and were instructed in the basic procedures for bovine rectal palpation and early pregnancy diagnosis. Initially, the student interacted with a relatively simple simulation while becoming familiar with the haptic device. At this introductory level the student was directed to combine movements in x, y, and z planes, learning to orient in three-dimensional space, and practiced palpating the basic landmarks of the pelvic area. Once familiar with the simple simulation, the student worked through a range of more complex virtual environments and learned to develop the skills required to find the uterus in different positions, to identify key anatomical structures, and to perform a pregnancy diagnosis (at the seven- to 10-week stage). The instructor identified each virtual object palpated by the student and described the characteristic properties the student needed to become familiar with in order to recognize the same structure in the cow. During this session, the student followed the instructor's directions while learning to develop an examination strategy but performed only limited exploration on his or her own.

Questionnaires were used to gather feedback from students. The first questionnaire was given to students immediately after the first session and included a section to gather information about the student's experience examining cows and learning bovine rectal palpation prior to the simulator training. The students were also asked to rate various aspects of the simulator training, responding to statements by qualifying their answer on a five-point Likert scale ranging from ''Strongly Agree'' to ''Strongly Disagree.'' Sections were included where students were given the opportunity to enter comments. A second questionnaire, using a similar format, was handed out after students had completed their next farm animal EMS to gather further feedback on the training.

Results

Of the 97 students in the fourth year, 94 attended the training session, and 69 returned the first questionnaire. The students who responded had a wide range of previous experience: 48% had examined only five cows or fewer (14, or 20%, had never examined a cow), while 10% had already examined more than 50 cows. Of those students who had examined cows, 87% had done so during EMS, 31% on farms at times other than EMS, and 5% at veterinary school, some having examined cows in more than one situation. The students' responses to statements about the simulator training session are shown in Table 1. The modal response was in the ''Strongly Agree'' or ''Agree'' category for the all of the statements. All students who completed the questionnaire considered simulator training to have been helpful in learning bovine rectal palpation. The feedback also indicated that the simulator had helped students to develop a search strategy and increased their knowledge of the relative position and the feel of key structures. Ninety-seven percent reported increased confidence to perform bovine rectal palpation, although for pregnancy diagnosis the categorization was more conservative (of the 88% reporting increased confidence, more than half selected the statement response category ''Agree'' rather than the ''Strongly Agree''). Guidance from the instructor was rated particularly helpful.

A high proportion of students (96%) entered comments in one or more of the allocated sections on the first questionnaire. Those who had previously examined cows entered a range of negative comments about their experiences, including the difficulties encountered: ''you are never sure that what you're feeling is actually what you think it is'' and ''I always feel the pressure of time''; although veterinary surgeons were willing to help, ''it's impossible for the vet to see'' and, therefore, getting useful guidance can be difficult. With regard to the simulator-based training,

Table 1: Student responses ($N = 69$), immediately after the first training session, to statements relating to aspects of the simulator training

	SA	A	N	D	SD
Simulator training					
was helpful for learning bovine rectal palpation	54	15			
provided a useful search strategy	57	12			
increased knowledge of relative position of key structures	46	23			
increased knowledge of the feel of key structures	32	34	3		
Guidance was helpful during haptic training	60	9			
Increased confidence to perform bovine rectal palpation	43	24	1	1	
Increased confidence to perform pregnancy diagnosis	25	36	7	1	

Response categories: Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D), Strongly Disagree (SD).

there were repeated comments along the lines of ''it was very helpful that the tutor knew where your hand was and could guide you'' and ''it was useful in establishing a method and strategy for performing rectals'' as well as ''building confidence'' and providing a ''relaxed learning environment.'' However, some reservations related to the differences between the virtual environment and the cow: there were ''no faeces and no contractions,'' the presence of which would have increased the realism of the whole experience.

The second questionnaire, distributed after the next farm animal EMS, was completed by 50 students. Their responses to statements about the effect of simulator training on various aspects of their performance in examining cows are shown in Table 2. The modal response for all categories was to ''Agree'' with the statements, except for confidence to perform pregnancy diagnosis, where the mode was in the ''Neutral'' category. Overall, although the responses were positive, the category selected was more conservative than immediately after the simulator training. The statements in the two questionnaires were not identical, but for similar question types in the first questionnaire a greater proportion of responses were in the ''Strongly Agree'' category. However, responses to the second questionnaire indicated that students still considered that simulator training had been helpful for learning bovine rectal palpation, had improved their abilities to orient in the cow and to find and identify the uterus, and had increased their confidence to perform bovine rectal palpation. The simulator training had been less useful for locating the ovaries and had a limited effect on confidence to diagnose pregnancy. Of those students returning the second questionnaire, 96% wanted to use the simulator again.

More than half the students (56%) entered comments on the second questionnaire. Recurring remarks from those who had never examined a cow before the first training session related to being unprepared for some aspects of the cow that were not included in the simulator: ''other structures ... were in the way'' and ''the real cow pushes your hand out''; some suggested that in future ''this should be explained to students.'' Some reported that dealing with these factors had hindered their performance and that the procedure had been more difficult than expected. The majority of students (86%) had not undertaken further EMS until between one and six months after the training session, and some comments related to having ''forgotten'' some of the training. A range of positive comments related to increased confidence ''in explaining where I might be to the vet'' and ''to have a go.'' Other benefits of the training were that ''I could approach the situation in a systematic way with a list of check points'' and that ''the haptic cow is good for identifying landmarks.'' Many students reported that they were still having difficulty locating the ovaries, and a few commented that ''if you were using two or more fingers'' the simulation would be better.

TRAINING SESSION 2

Methods

Before running the second training sessions, the project entered a further development phase. A focus group was held with eight students who had not examined cows before the first training session but had all been out on farms since. The students felt that they should have been better prepared for the difficulties they experienced when first examining a real cow. Certain procedures were identified as needing higher priority in future training sessions. Ovary palpation had been covered briefly in the first session, but the training provided had not equipped students with the required skills. Students felt that more time spent practicing pregnancy diagnosis would be beneficial and that the first training session had had a limited effect on their confidence to perform this procedure. Again, this area had been covered in the first session, but the simulations were limited to early stages of pregnancy and students had been under the instructor's direction rather than making a diagnosis based on what they palpated. The students suggested that having the opportunity to explore on their own with feedback on performance, rather than being directed by the instructor at all times, would be beneficial. They also expressed an interest in using the simulator to practice solving typical on-farm fertility cases. The instructor then undertook farm visits accompanied by four students who had examined cows both before and after the first training session. The aim was to investigate the performance and

Table 2: Student responses ($N = 50$), having undertaken farm animal EMS after simulator training, to statements relating to the effects of the simulator training on subsequent performance examining cows

	SA	A	N	D	SD
Simulator training					
was helpful for learning bovine rectal palpation	16	29	5		
improved your ability to orientate in the cow	15	33	1		1
improved your ability to find the uterus	9	35	4	2	
improved your ability to identify the uterus	9	30	9	2	
improved your ability to locate the ovaries	4	18	15	10	3
increased confidence to perform bovine rectal palpation	11	28	9	2	
increased confidence to perform pregnancy diagnosis	3	18	20	8	1

Response categories: Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D), Strongly Disagree (SD).

teaching of ovary palpation and the diagnosis of advanced pregnancies. On the basis of these findings, further simulations were created and tested, modifications were made to the teaching protocol, and a series of on-farm scenarios was written.

The second set of training sessions took place in the third term and were offered in free periods, as the bovine reproduction course had been completed. A form was distributed to students at the beginning of term that enabled them to select and prioritize the aspects of the procedure they wished to practice, including early and late pregnancy diagnosis, finding the uterus, finding ovaries, palpating normal and abnormal ovarian structures, and repeating the first training session. The session was then customized according to each student's learning needs. Part of the session was run in a problem-solving manner using on-farm scenarios. The instructor took the role of the farmer and explained why the cow had been selected for examination. The student palpated the simulation, took a history, made a diagnosis, and recommended a course of action or treatment. The case was then discussed further with the instructor. A range of simulations representative of typical visits to a dairy or a beef herd was available to students. After training, students were asked to complete a short questionnaire to provide feedback on the session.

Results

Fifty-four students attended the second training session, and 43 questionnaires were returned. The responses on the questionnaires indicated that students considered that the on-farm scenarios were a beneficial way of learning:

Definitely Beneficial	79%
Beneficial	21%
Neutral	0%
Not Beneficial	0%
Definitely Not Beneficial	0%

Comments relating to this section of the session were positive and included the remark that the scenarios ''made the whole learning experience real,'' ''helped you think in a clinical way ... and what the consequences of your decisions and actions would be,'' ''helped to put clinical knowledge and lecture info into 'palpable' context,'' and ''created the 'stress' that a new vet will feel.'' All students either strongly agreed or agreed that the training had increased their confidence to perform both bovine rectal palpation and pregnancy diagnosis, although once again with more reservation about the latter.

DISCUSSION

The simulator was successfully integrated into the curriculum, and the trial period provided an opportunity to test, further develop, and improve the teaching tool. After the training sessions, the student feedback was both positive and constructive, indicating that students valued the simulator training and had found the experience useful for learning a range of skills; many of their comments provided valuable information on areas requiring modification. Additionally, the simulator enabled the instructor to provide direction on techniques for bovine rectal palpation and to give feedback on performance.

The students were trained to develop and practice a range of skills during simulator sessions. Students learned to orient themselves in three-dimensional space and to develop a structured search strategy within the pelvic area and caudal abdomen. One of the primary learning objectives was to find and identify the uterus in different positions, as students need to master this fundamental skill before progressing on to performing fertility examinations and diagnosing pregnancy. The student feedback on the first training session was positive both immediately after the session and after the next EMS, although with slightly more reservations in the latter case. The simulator training had been helpful for learning the basic skills, although for more advanced procedures, such as ovary palpation and pregnancy diagnosis, the feedback highlighted the need for further investigation of teaching methods and for development of more simulations. Students reported that training had increased their confidence to perform the procedure, and, although confidence and competence are not necessarily correlated, students who feel more confident may be more prepared to make the most of opportunities to examine cows on farms.

There are several possible explanations for the more reserved feedback about the first simulator training in the second questionnaire, after the students had examined cows during EMS. The comments, particularly from those students who had never examined a cow prior to the training session, indicated that they had not been adequately prepared for the full reality of the rectal environment, as the simulator did not include any representation of the rectum, feces, or peristalsis. Incorporating these into the model would have been difficult, although the addition of a preserved specimen rectum could be considered. Additionally, the aim was to use the simulator to focus on learning a range of skills within the time available; this would have been more difficult to achieve if students had spent part of the session with, for example, the hand constricted by a peristaltic contraction. Another limitation of the simulator relates to the single point of contact provided by the PHANToM haptic device, in which the user interacts with the virtual environment using a thimble (see Figure 1). Previous experience in evaluating anatomical models with veterinary surgeons had indicated that using the middle rather than the index finger provides a better approximation for the hand and that palpation of structures is then reasonably realistic. However, examining ovaries involves manipulating the ovary between the fingers and thumb, which means that this procedure cannot be represented. Until devices that provide high-fidelity three-dimensional interaction for each digit and for the whole hand become available, simulating a full ovary examination, manipulation together with palpation, will continue to be limited.

The interval between training and the next EMS was in most cases several months, and this time lag may have contributed to the reduction in the perceived effect of the teaching, as some skills may have been forgotten during this period. In an ideal situation, the simulator training would be timetabled immediately prior to the real examinations, but there are practical barriers to organizing this for all students. Additionally, during simulator training, the instructor was

present throughout the session specifically to provide instruction and feedback, whereas in the on-farm situation, for practical reasons and because of the difficulties of providing instructions when the veterinary surgeon cannot see the student's hand inside the cow, the teaching can be both limited and variable.

The second training sessions were customized to each student's learning needs, which enabled individuals to focus on the areas that they considered most important. The on-farm scenarios included in these sessions were well received by students and rated as a valuable way of learning. The students had the opportunity to act as clinicians solving typical problems, including cases representing examples of common but difficult situations a new graduate will encounter. The simulator represents a safe environment: if the student makes a mistake, there are no consequences for the cow, the farmer, the new graduate, or the practice. In such cases, the instructor and student can then discuss alternative ways of dealing with the situation. The on-farm scenarios require the students to practice integration of knowledge: anatomy of reproductive, pelvic, and abdominal structures; physiology of the estrous cycle and pharmacology; selecting the drugs to treat the disease condition or manipulate reproduction. The second sessions were offered in the students' free time because of course restrictions, which proved more difficult to organize; in spite of a high proportion of students indicating that they would like to use the simulator again, the attendance rate was lower for the second session than for the first.

The validation study conducted previously showed that simulator training had a beneficial effect on skill development,[5] while current work has demonstrated that integrating the simulator into the curriculum was feasible. However, before a veterinary school makes a decision to use this technology, the resources required must be considered. Haptic devices are expensive, although cheaper versions are emerging over time. The teaching sessions involve one-on-one tuition, which is also costly in terms of the instructor's time and dedication. Therefore, there is a need to optimize simulator use with careful consideration of both the structure of the sessions and their timetabling within the curriculum. Student feedback indicated that customizing the training for the individual's learning needs would be an efficient way of using the simulator. Therefore, in the future novices would be instructed in basic procedures while further training, for more experienced students or in subsequent sessions, would involve selecting procedures that each student considered most relevant to his or her learning needs. Certain aspects of the procedure would be covered in handouts, including an explanation of the differences between the simulator and the real cow, with some instruction on how to deal with this, allowing the one-on-one sessions to focus on palpation of the virtual cow. All sessions would include an element of role-playing, using the on-farm scenarios to allow students to practice dealing with typical situations and making and thinking about the consequences of decisions. The basic sessions would be integrated into the curriculum timetable rather than taking place during free time, both for ease of planning and to facilitate attendance, while further training could be offered in a more flexible way, depending on demand. There would be a case for providing the basic training prior to the first real cow examination. All subsequent examinations would build on the skills developed with the simulator, and if novices were better prepared for this invasive procedure, there would be benefits for animal welfare.

CONCLUSION

The trial integration was successful both for providing training for bovine rectal palpation and for gathering feedback, which helped to improve the use of the simulator as a teaching tool. The simulator has certain limitations in representing some of the physical aspects of the real cow, but it does provide a useful supplement to traditional training methods. The instructor is able to have effective input into the learning process of a procedure that is otherwise, to some extent, self-taught. As opportunities to gain experience on farms have become increasingly limited in recent years, equipping students with at least the basic skills via the simulator will enable them to better use the cows they later examine as a learning resource.

Work continues on investigating aspects of teaching the procedure with the simulator and on improving the quality of the existing simulations and increasing their variety. The simulator has the potential to provide a versatile range of cases, and these could be used to help standardize basic training for all students, which can be difficult to achieve currently. More experienced students could be given the opportunity to access examples of pathological conditions and unusual cases. Simulations are also being developed for other species, with the potential that, in the long term, one device would deliver multi-species training for a range of palpation-based skills.

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NOTES

a The PHANToM Haptic Device, SensAble Technologies, <www.sensable.com>.

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