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Study of the learning process of veterinary students during simulator-assisted training of the surgical technique for treating a left-sided abomasal displacement in cattle

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The Clinical Skills Lab (CSL) at the University of Veterinary Medicine Hannover, Foundation (TiHo), Hannover, Germany trains students in clinical skills in supervised and unsupervised courses. In a safe learning environment, first day skills are learned, repeated, and reinforced on simulators. This increases the competence and selfefficacy of the students before transferring and applying the skills to live animals. The European Association of Establishments for Veterinary Education (EAEVE) lists the performance of aseptic procedures and the treatment of the most frequent diseases of common animal species as these first day skills. Abomasal displacement is one of the most common diseases in dairy cattle. Treatment is usually surgical and is an integral part of the daily work of bovine veterinarians. However, not all students have been able to learn this complex surgical technique as part of their veterinary studies practically.

Therefore, the aim of this study was to develop two simulators for learning the surgical technique of laparotomy in the right flank and omentopexy by Dirksen for left-sided abomasal displacement in cattle.

The simplified simulator is a transparent box containing the most important peritoneal cavity organs of cattle for performing the Dirksen surgical procedure. It enables visualization of the organs and their positional relationships to each other. Exploration and the Dirksen surgical technique can be performed on the simulator and with corresponding suture pads. The basic structure of the realistic simulator is a life-size, three-dimensional bovine model that incorporates nearly all of the organs of the peritoneal cavity. The model allows exploration and performance of the Dirksen surgical technique. A window on the left side of the model allows the surgical steps, which are performed on the live animal out of sight, to be demonstrated and checked by third parties. As part of this study, the simulators were tested by students in two study parts and evaluated with questionnaires regarding their suitability and future use in teaching. Furthermore, a questionnaire-based evaluation of the realistic

simulator was carried out by a total of 12 practicing veterinarians specialized in cattle medicine. In the first study part, the simulators were used in the clinical year (CY) of the Clinic for Cattle at the TiHo. In addition to evaluating the simulators, the aim was to compare blended learning and conventional face-to-face teaching. Blended learning is a combination of online and face-to-face teaching. Previous (veterinary) medical studies have shown that the learning success of students can be increased through blended learning. The transferability of these successes to complex surgical skills should be tested as part of the CY study.

A total of 21 students were randomly divided into two groups, whereby their level of experience was taken into account. A group lecture was the basis for the training. While one group participated in face-to-face training on a simplified simulator, the other group learned the surgical technique in a blended learning format with the help of videobased training. For the video-based online training, a video was created using the simplified simulator and interactively integrated into the "Moodle" learning platform. The skills acquired were then assessed in a practical test on a realistic simulator as an objective structured clinical examination (OSCE) in a blinded setting. The performance of students from different groups (face-to-face/video training and experienced/inexperienced) did not differ in the OSCE results. Both the majority of the face-to-face and video groups stated that the group-based training increased their anatomical and surgical understanding, motivation, and learning success. The results of the study indicate that blended learning can be a suitable alternative to conventional face-to-face teaching. The asynchronously provided teaching material should be as interactive as possible and clinically embedded. One limitation of this part of the study is the relatively small sample size. The study results can therefore not be generalized but should provide a basis for further work that will use the blended learning format.

In the second study part, the simulators were tested and evaluated by students in the 6th term at the TiHo in a supervised CSL course as part of an elective course (EC). After the two simulators were used separately in the CY study, they were used in combination in the EC. The simplified simulator was used to visualize the anatomy and for the first exploration under visual control. This was followed by exploration on the realistic simulator without vision, and afterwards the surgical technique was performed. The students' self-efficacy was analyzed in both study phases. In the CY study, selfefficacy was surveyed before the study, after the group-dependent training, and after the OSCE. In contrast, in the EC study, self-efficacy was determined before and after the EC. In each of these studies, self-rated self-efficacy increased significantly as a result of the study. Group membership (face-to-face/video training) had no effect on self-efficacy scores in the CY study. In addition to subjective self-efficacy, realistic selfefficacy was also assessed in the CY students: self-efficacy scores at the

time after the group-dependent training and before the OSCE, derived from the questionnaires, correlated with OSCE scores. Individual surgical steps in the OSCE were then compared to the corresponding self-efficacy items after the group-dependent training. The results show that the realistic self-assessment of skills varied within different surgical steps. For some surgical steps (e.g., identification of rumen and abomasum), over 90% of students assessed themselves correctly. For other surgical steps (e.g., repositioning the abomasum), only approximately two thirds of the participants rated themselves correctly. This discrepancy may be explained by the increased difficulty of the surgical steps involved.

The evaluation results show that both the simplified and the realistic simulator were well accepted by the students. The realistic simulator was rated better due to its lifesize and configuration. The realistic simulator was rated as (somewhat) realistic by all students and 11 of the 12 experts regarding its appearance and by at least 80% of the students with regard to its haptics. All experts stated that the realistic simulator was somewhat or fully suitable for the simulation. The evaluation also shows that the most important factors for students in training objects are realism, supervision, a stress-free learning environment, and animal welfare. Based on the evaluation results, the simulators have since been used in combination in CSL courses, elective courses, and in the clinical year at the Clinic for Cattle at the TiHo. For asynchronous preparation and post-processing, various teaching materials are available on the Moodle learning platform.

Evaluation of equine perineural anesthesia simulators with integrated success control and their suitability as instructional tools

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Perineural anesthesia is an important diagnostic method used by veterinarians when examining subacute to chronic lameness in horses. Skills to perfom these are defined as "Day One Competences" by the European Association of Establishments for Veterinary Education and should be mastered by every graduate. For time and logistical reasons, it is not realistic to allow every student to practice and repeat perineural anesthesia on a cadaver limb during their studies. For this reason, supplementary exercises on simulators had to be established in the Clinical Skills Lab (CSL) of the University of Veterinary Medicine Hannover, Foundation (TiHo). In this study, two simulators for perineural anesthesia were developed and evaluated that will be used as instructional tools in the CSL. Their suitability as an instructional tool was tested by means of an intervention study and evaluation by students and veterinarians.

The simulators represent the front limb of a warmblood horse from the hoof to just above the carpal joint and enable the following perineural anesthesia to be performed:

- Modified palmar digital nerve block: Ramus tori digitalis anesthesia
- Midpastern palmar digital nerve block
- Modified abaxial sesamoid nerve block
- Distal palmar metacarpal nerve block
- High four-point nerve block

They consist of a commercial bone model (Synbone AG, Zizers, Switzerland) and other artificial anatomical structures such as tendons and hoof cartilage, made of various silicones and epoxy resin. Simulator I has the form of a simplified anatomical model with a view of the relevant anatomical structures which enabling the landmarks and puncture sites to be located with visual support. An electrical circuit is integrated as success control. Students receive immediate feedback from the simulator in the form of an illuminated light when they hit the correct puncture site. Simulator II represents a more realistic model of an equine distal limb and includes a success control based on conductivity measurement. Feedback is

provided in the form of a diagram that can be viewed on a screen. If a puncture site is located correctly, the corresponding graph of the puncture site changes.

In an intervention study, the suitability of simulator I as an instructional tool was tested by comparing the practical skills and theoretical knowledge of students who had received an exercise either on simulator I and or on cadaver limbs. The study was conducted with 68 fifth-year students who completed their clinical rotation during the clinical year at the Clinic for Horses of the TiHo. The practical skills of 62 of the study participants were assessed in an examination in the form of an OSCE station. To determine theoretical knowledge, the participants completed theory tests before and after the exercise. Students who performed an exercise on Simulator I did not show significantly different results in the assessment of their practical skills and theoretical knowledge compared to students who exercised on the cadaver limb. Similarly, an exercise on simulator I influenced the students' self-efficacy to the same extent as an exercise on the cadaver limb. The study showed that the anatomical knowledge of the students was subjectively increased by the exercise on the cadaver limb as well as by the exercise on Simulator I. In addition to the intervention study an elective course was held in the CSL in the summer term of 2023 with 41 students from the sixth and eighth semesters, in which both developed simulators were used as instructional tools. Students' self-efficacy increased significantly after a theoretical introduction and practice of perineural anesthesia on simulator I. Subsequent practice on simulator II again increased selfefficacy significantly. The simulators were evaluated by seven veterinarians from the Department of Surgery and Orthopedics at the Clinic for Horses of the TiHo, 49 fifth-year students and 41 students from the sixth and eighth semesters. The results revealed deficits in the realism of the simulators. Nevertheless, the majority of all three survey groups rated both simulators as suitable for practicing perineural anesthesia. The study showed that the integrated success controls with immediate feedback offer added value compared to non-technically supported simulators and cadaver limbs. In addition, the success controls enable repeated punctures and checks of the punctures. In contrast to the cadaver limb, the simulators do not yet allow the identification of malposition of the injected fluid in synovial structures.

In summary, two suitable simulators for equine perineural anesthesia were developed in the study and their suitability as instructional tools was demonstrated. The simulators will be used as instructional tools in the CSL, supplementing the exercises on the cadaver limb in the Clinic for Horses. This will allow each student to practice and repeat perineural anesthesia several times during their studies. Simulators will be further optimized on the basis of the evaluation results.

Evaluation of digitalization strategies in university teaching during the pandemic in the summer semester 2020 at the University of Veterinary Medicine Hannover Foundation

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As a result of the COVID-19 pandemic in Germany in March 2020 and the resulting contact restrictions, the 2020 summer semester had to be held predominantly in digital form throughout Germany. Therefore, the semester at the University of Veterinary Medicine Hannover, Foundation (TiHo) had to be switched to a digital semester on an ad hoc basis. However, due to the declining number of infections in the summer months of 2020, a few courses could be held in person again at the end of the summer semester in small groups and under strict hygiene and distance regulations. Therefore this semester did not take place exclusively digitally.

This study aimed to investigate the implementation of the digital summer semester 2020 at the TiHo as well as the needs, wishes and requirements of students and lecturers with regard to long-term relevance and transferability of online teaching tools.

In order to identify initial experiences, needs and challenges on the part of students and teachers, a guided focus group discussion was conducted with nine students and another with eight teachers. The results were used to create an online questionnaire for students as well as one for lecturers, which was used to conduct a semester evaluation for both groups. Participation in the semester evaluation was voluntary for both students and lecturers and covered topics such as helpful assistance and difficulties at the beginning of the semester, technical requirements, implementation and use of the various digital teaching options, as well as areas for improvement and an outlook for future teaching. The final evaluation included 558 fully completed questionnaires from students and 103 fully completed questionnaires from lecturers.

The results of the study show that even before the COVID-19 pandemic, students frequently used digital teaching materials for their studies, such as teaching videos and CASUS cases, while lecturers used these more sporadically before the pandemicinduced switch to a digital semester. During the semester, there was a significant increase in the use of digital teaching

materials by lecturers, although this could be further encouraged and improved in some areas compared to student use. The biggest difficulty for lecturers was the digitization of practical content, and students also saw difficulties with implementation in this aspect. Teachers rated the time required to create digital courses as considerably higher compared to the preparation time for face-to-face courses. Students also stated that they needed more time to work on digital courses. There were several benefits of digital teaching, such as increased flexibility, the possibility of repetition and learning at one's own pace for students, as well as greater flexibility for teachers. Students and lecturers also noted a higher level of student participation and interaction in the courses. With regard to the technical equipment at the TiHo, both groups saw a need for improvement, but the lecturers were able to digitize their teaching with the available hardware. Students and lecturers both wished more future training for lecturers in online teaching and showed a clear interest in retaining digital, interactive courses in veterinary training. Deadlines, tasks and learning control questions or quizzes were seen as particularly helpful measures for the prompt processing of digital material.

In summary, it was shown that the implementation was rated as successful from both the students' and lecturers' point of view. Both groups see potential in e-learning offerings and would also like to see these for future teaching. Students particularly preferred the expansion of asynchronous courses, while lecturers saw the most potential in the blended learning format. Digital courses can be seen as valuable additions to veterinary training, which could demonstrate many advantages for students and lecturers.

Parameter Analysis and Investigation on Quality Management of Electronic Examinations at the University of Veterinary Medicine Hannover

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The most commonly used and arguably most important assessments are summative examinations at the end of a teaching and learning phase. Apart from their profound impact on the course of training and professional development, summative assessments should ensure that candidates possess the necessary competencies to practice their profession. Consequently, there are high requirements to maintain the quality of these examinations regarding quality criteria of objectivity, reliability and validity. Written, electronic examinations (e-examinations) utilizing multiple-choice questions were established at the University of Veterinary Medicine Hannover (TiHo), as they are considered particularly suitable for the medical field. This form of assessment gained high acceptance among both lecturers and students and is expected to be of high quality in terms of the aforementioned criteria. Electronic examinations were introduced to focus on the possible improvement in quality as well as the potential for expansion through new questions formats and, as a side effect, an increase in the efficiency of the process. By now, e-exams have been established for the majority of examination subjects at the TiHo.

In this context, a comprehensive evaluation of the e-examinations at TiHo was carried out. The aim of this work was to evaluate the status quo of electronic examinations at the TiHo through a systematic statistical analysis. Furthermore, the goal was to identify parameters that could facilitate a rapid assessment of examination quality in the postreview process, as well as parameters whose adjustment could contribute to enhancing the quality and further development of the examinations. Additionally, the feasibility of the online open-book examination format at the TiHo should be evaluated. For this purpose, the log data of selected examinations and the characteristic values from tests conducted either in person or online were analyzed. For the analysis of the electronic examinations, datasets from 327 examinations with an average of 248 participants each were evaluated in the form of raw data for statistical item analysis, spanning from 2008 to 2023. The analysis of the log data was carried out on the basis of five in-person exams and two online examinations.

Regarding the evaluation of the feasibility of online open-book examinations, data from three online assessments from each of two subject areas was available. The results illustrate that the majority of electronic examinations at the TiHo meet the recommended quality standards for summative assessments and that an increase in quality can be achieved through the fixed implementation of quality assurance measures, such as blueprints and item review procedures. For a quick evaluation of examinations and items by examination coordinators in the post-review phase, parameters such as reliability – calculated using Cronbach's alpha coefficient – along with difficulty index and discrimination index according to classical test theory, prove suitable. Parameters or measures for the further development of examinations include the use of an adequate number of items in examinations, a well-considered selection of item formats, as well as a thoughtful reuse of old questions and training programs for all individuals involved in the examination process. Adjustments to the examination system implemented in this context have already demonstrated a positive effect on the quality of examinations.

Furthermore, the format of online open-book examinations proved to be a suitable format for conducting formative tests, while their implementation for summative examinations is being approached cautiously due to advancements in the field of artificial intelligence. The comprehensive evaluation of electronic examinations at the TiHo, conducted for the first time through this study, emphasizes the importance of quality assurance measures for the examination procedures and the constant evaluation of summative examinations at educational institutions.

At the TiHo, quality assurance measures are continuously carried out with regard to eexaminations and expanded based on the results of this work - with a particular focus on the post-review process. Additionally, the online open-book examination format will be used in formative assessment.

Exploration and Evaluation of the Implementation of an Interprofessional Communication Training in Veterinary Education

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The care of animals in veterinary practice involves an increasingly diverse amount of different professions and specialists. Effective and high-quality healthcare for animals can only be achieved through efficient and targeted teamwork. In human healthcare professions, it has been recognized since several years that communication skills should be taught as part of education and training and that learning such non-technical competencies in an interprofessional environment can be beneficial. Similarly, there is a high demand for this in veterinary medicine, although the research in this area remains substantial and communication has not yet been integrated into the state curriculum for veterinary students.

This study aims to conduct and evaluate an interprofessional course for veterinary students and veterinary assistant apprentices for the first time. To achieve this, a blended learning course was developed in 2022 and offered to students and trainees as an elective course during the winter semester. This format was chosen to allow partially asynchronous learning for the two professions, which face organizational challenges for synchronous events due to their differing daily schedules. In addition to an interactive asynchronous online course, an online seminar, communication coaching and simulation training with professional actors were conducted. The content ranged from communication basics to teamwork and conflict resolution to resilience and stress management, each embedded in the online course through video material as worst-case and best-practice format. 13 apprentices and 18 students enrolled in the course. A pre- and post-test assessed knowledge, readiness for interprofessional learning and self-assessment of communication skills before and after the course. Additionally, an extensive evaluation of the entire intervention was conducted after the course.

There was a 65.59 % increase in knowledge, measured by the number of correct answers. Self-assessment of communication skills improved in some areas, particularly regarding preparedness for entry into the profession, with higher responses in the post-test. Furthermore, participants report improved understanding of roles within the other

professional group in the post-test. The Readiness for Interprofessional Learning Scale was used to measure readiness for interprofessional education and some increase was observed after completing the course. The evaluation of the course indicates that the learning concept for delivering the content is well-suited, with the simulation training with actors receiving the most positive feedback. Various scenarios were designed to address typical conflicts in veterinary practice and were conducted with two participants and an actor playing different roles. Subsequently, the role-plays were reflected upon using 360-degree feedback. In addition to conducting the course, individual interviews were performed with veterinarians and veterinary assistants from various veterinary practices and clinics.

The aim of these interviews was to gather personal experience and expectations regarding teamwork, interprofessional communication, understanding of roles and responsibilities, as well as sources of errors and causes of conflicts. These collected insights were intended to help critically assess the content of the course and the selection of scenarios and potentially generate new content tailored to practical topics. One of the most important findings from these interviews was that interprofessional communication holds a high to very high importance in veterinary practice. Furthermore, almost all respondents expressed a desire for more frequent team meetings, often preferring them to be interprofessional rather than separated by professions or departments to facilitate communication and coordination. These statements could also be relevant for practice or clinic managers to better consider the needs of their staff.

Further research based on this study arises from its limitations. The small sample size may not be sufficiently informative, so further course iterations with a higher number of evaluable datasets may lead to more definitive results. Additionally, it is important to assess the long-term effect of the intervention, which our research did not provide. This would require further test weeks or months after course completion to capture a long-term effect on knowledge, readiness, and self-assessment. Due to the small sample size, the asymmetric distribution of professions and the partly nominal data that cannot be numerically coded, only conditional statistical tests could be applied. The tests used may not show significant differences due to the sample size, which would likely be more apparent with higher participant numbers. Overall, this study aims to address an existing research gap in veterinary interprofessional communication education and provide initial indications for the establishment of similar events for other institutions.

Evaluation of hybrid teaching in two terms during the COVID-19 pandemic at the University of Veterinary Medicine Hannover

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In consequence of the COVID-19 pandemic, teaching at German universities had to be digitalized to a large extend in the spring of 2020. After a predominantly summer term in 2020, the University of Veterinary Medicine Hannover (TiHo) conducted the following two terms, the winter semester 2020/21 and the summer semester 2021, as hybrid semesters. The university defines this as a mixture of digital teaching and faceto-face events, with the focus on digital teaching during these semesters. In the context of this work, the implementation and acceptance of the hybrid semesters as well as the sustainability and transferability of hybrid teaching was examined. For this purpose, two voluntary surveys were conducted, one with lecturers and one with students of the TiHo. The surveys covered technical aspects such as equipment and platforms, as well as assessment of various aspects of hybrid teaching and learning by lecturers and students and the impact of the hybrid semesters on teaching and learning. In the student survey, 492 questionnaires were included in the analysis. The number of fully completed questionnaires in the evaluation of the lecturer survey was 87. In addition, the methods of teaching used in the courses of the veterinary medicine program before the start of the COVID-19 pandemic in the summer semester 2019, in the predominantly digitally conducted summer semester 2020, and in the hybrid summer semester 2021 were analyzed and compared. Furthermore, from 14 selected exams and the theoretical part of the three clinical exams, the exam results of the hybrid semesters were compared with the results before the COVID-19 pandemic and subsequent change in teaching. In the current thesis, it could be shown that both students and lecturers were predominantly positive regarding the implementation of the hybrid semesters. The hypothesis that hybrid teaching has advantages over pure face-to-face teaching, and should be considered in future veterinary teaching, was confirmed by the present work. Advantages such as the increased flexibility in time and place as well as the Summary 107 broadening of the range of activities made possible by digital elements can be maintained by teaching concepts with digital components such as blended learning or hybrid events with lecture recordings. At the same time, disadvantages of predominantly digital teaching, such as the lack of contact between students and lecturers, can be compensated with such concepts. The

expansion of the portfolio of digital formats used during the hybrid semesters provides the basis to implement such projects in the future. Teachers and students have a positive attitude toward offers with digital components for the future. No negative consequences of hybrid teaching on students' examination performance could be derived from the examination results of the hybrid semesters. Although the results of a large proportion of the exams differ significantly from the results of the last exams before the start of the pandemic, the examination marks were both better and worse than before the pandemic. In summary, the implementation of the hybrid semesters has been largely successful. The university finds itself well positioned to deal with similar situations. In addition, aspects or portions of hybrid teaching represent a useful extension and improvement of future veterinary teaching.

Investigation of electronic objective structured clinical examinations (eOSCEs) in the Clinical Skills Lab of the University of Veterinary Medicine Hannover, Foundation

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In the Clinical Skills Lab (CSL) of the University of Veterinary Medicine Hannover Foundation (TiHo), OSCEs (objective structured clinical examination) were implemented from 2014 as part of a teaching intervention (skills lab training) for students in the practical year of the various animal species clinics. Since 2018, TiHo has been the first veterinary training institution in Germany to conduct the OSCE in an electronic form as an eOSCE (electronic objective structured clinical examination).

In the current thesis, four studies have been carried out. An investigation was performed to analyze satisfaction and benefits regarding the eOSCE format as part of feedback in the training of clinical-practical skills for students of the practical year (PJ). Furthermore, an evaluation about the acceptance of an eOSCE as a potential summative examination format in the context of a state examination was performed. In the second study, examiners, test initiators and employees of the respective clinics involved in the review process of the items were asked about their satisfaction and opinion on the benefits of the eOSCE. In addition, the non-electronic OSCE and the eOSCEs were compared. As a third subproject, statistical parameters of the eOSCEs and their items were recorded within the framework of quality assurance and with the aim of evaluating the examinations and eOSCE checklists to detect possible deficits in the field of eOSCEs, teaching and practical competences of students. In the last study, the development of the students' self-appraisal in the course of the skills lab training was collected and compared with their competences and skills in the eOSCE.

For the evaluation of the students' satisfaction with the eOSCE, 175 data sets could be evaluated. The evaluation of the satisfaction of the examiners with the eOSCE provided 27 evaluable data sets. Fifteen eOSCEs from 4 clinics and 170 associated data sets were evaluated for item analysis. The study on the development of self-efficacy provided 175 evaluable data sets at the time of measurement before the skills lab training, 172 data sets after the training and 170 evaluable data sets after the eOSCE.

The first study shows that students accept the eOSCE well as feedback tool, but have diverging opinions regarding the use of the eOSCE as a summative examination format in the state examination. The examiners were also generally satisfied with the examination format. However, this study revealed problems during the technical implementation of the eOSCE on the day of the exam and during exam preparation, which needs to be improved in the future.

The evaluation of the test quality revealed that the desired Cronbachs-alpha value of 0.8 is not achieved for eOSCEs. For the implementation of the eOSCE format for summative examinations, the number of examination stations for eOSCEs should be elevated. The difficulty of the checklists of the stations for checking basic skills was not high enough for summative assessment, but is an indication that students are confident in the tested basic skills. This formative exam is a useful feedback instrument.

As expected, the students' self-efficacy as measured in the last study was low before the skills lab training and increased after the training. Even after the eOSCE, an increase in self-efficacy could be demonstrated in all students, with the exception of the students of the Clinic for Horses. Self-assessment and objective performance were only partially consistent; these findings can be used to set clinic-specific priorities in practical training.

Finally, the eOSCE is a feedback tool that has been well perceived by both students and lecturers at TiHo. The results will be used to make adjustments to the implementation and design of the exam as a basis for the potential use of eOSCEs in summative state examinations.

Investigations on self-regulated learning in the study entry phase of veterinary medicine at the University of Veterinary Medicine Hannover

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The aim of this research was to identify the needs of first-year students with regard to their study entry phase at the University of Veterinary Medicine Hannover, Foundation and with consideration of the heterogeneity of this group, in order to adapt the range of support and teaching offers, to expand them if necessary and thus to ensure a smooth transition from school to university. In addition, the curriculum was reviewed for possible hurdles as well as the already existing support offers - the elective courses "Learning to Learn" and "Learning Consultation" - were assessed for their sustainability and possible need for optimization.

To answer these research questions, a total of five surveys, each addressed to different groups, were conducted: In two surveys of the first semester (matriculation 2021), in which participants were first asked to evaluate prospectively and later retrospectively their perceptions, expectations and experiences of the study entry phase, a connected sample of 50 data sets was obtained. For the „Learning to Learn“ pretest and posttest, 105 linked data sets were analyzed, and for the evaluation, 114 completed questionnaires were analyzed. For the small group course "Learning Consultation", 17 complete evaluations were collected.

In accordance with the expectations and the results from other study programs and potentiated by the peculiarities of the veterinary medicine curriculum, students see themselves challenged primarily by the mass of content to be learned, the pressure to perform in academic education, and learning-related requirements from the spectrum of self-regulation. The University of Veterinary Medicine Hannover thus already offers support in the right areas with the existing Learning Skills Interventions as elective courses. Based on the evaluation of these classes, it could be shown that they provide sustainable relief in the perception of the participants and highlights their extraordinary relevance - especially of the acquisition of self-regulated learning skills in the study entry phase - in studies of veterinary medicine.

The timing of the study was in the midst of the COVID-19 pandemic, so social challenges are also a factor in the cohorts surveyed. Furthermore, the seemingly non-professional basic

subjects with a lot of space in the first semester timetable as well as a lack of clinical-practical content discourage first-year students. Differences between students with different prerequisites regarding special needs could not be found.

Interesting findings are also that future veterinarians identify themselves early on with the desired profession, which leads to a remarkably high goal commitment and that a change of the desired field of activity within the profession of veterinary medicine is already apparent in the first semester.

In summary, it can be stated that the study entry phase of veterinary medicine at the University of Veterinary Medicine Hannover, Foundation presents the students with great and potentially overwhelming challenges, which can, however, usually be overcome. Since the perception of the study entry phase is of uttermost importance for the attitude towards the intended profession, students should be supported during this timeframe in the best possible way. General study ability can and should be effectively increased through support in the area of self-regulation.

Development of veterinary telemedicine in Germany

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In the current thesis the use of telemedical approaches in the context of veterinary medicine are described. Veterinary medicine provides a highly complex environment, and is subject to an increasing digitalization effort, as also described for human medicine. The aim of this thesis was to investigate the degree of implementation of different digital approaches in the context of German veterinary medicine.

A comprehensive literature review, which should address the necessary framework conditions of these digitization efforts and potential hurdles, such as legal or infrastructural aspects, informs the empirical research conducted in the context of this dissertation. Using a quantitative research approach, the perspective of German veterinarians was surveyed using Limesurvey. Results of the survey imply, that digital approaches are already being used, also induced by the COVID-19 crisis, but that the lack of clear legal framework conditions represents a significant hurdle for further implementation. These results were derived based on answers of 169 veterinarians who voluntarily participated by means of an online questionnaire.

This survey serves as a basis for the critical discussion of the findings and the comparison to the existing state of research regarding telemedicine. Existing methodological limitations are critically examined and described in the context of available literature. This critical approach forms the basis for the derivation of practice-oriented recommendations, which should guide the future of digitization in the field of veterinary medicine and the handling of telemedicine accordingly.

Specifically, these are the following recommendations:

1. Creation of a transparent and well-defined legal basis and building a clear differentiation between teleconsultation, teletreatment and telediagnosis;
2. Supporting the selection and transformation of previous analog processes into digital or digital/telemedicine-supported processes;
3. Creation of awareness regarding telemedicine, its possibilities and its advantages;
4. Expanding available guidelines regarding telemedicine;
5. Creation of billing regulations for veterinarians.

At the same time, it seems reasonable to formulate additional concrete questions in future surveys, since ignorance about veterinary telemedicine per se may have an influence on the answers. Likewise, animal owners must be included in surveys on telemedicine, in order to be able to fulfill the concrete wishes and ideas.

Telemedicine comprises only a small part of the veterinary service, namely the provision of medical information when doctor and patient are physically distant, and the exchange of medical information across distances. In view of the general digitalization of many processes in medicine, telemedicine should be considered as an essential, but not the only part of this development.

Functioning, effective telemedical services can only be used adequately and result-oriented in a digital and professional environment. Corresponding tools are already available on the market and are constantly being further developed.

Integration into existing software systems is an essential necessity. At the same time, however, the willingness of veterinarians and their clients to use these tools must be promoted and strengthened.

Investigation of transfer thinking of students of veterinary medicine in the context of astructured simulation-based training

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Combining skills is an important mental ability of veterinarians in their everyday work. The repertoire of their own skills must be recombined for each patient. This is not only demanded by veterinarians hiring assistants coming directly from the University, but also by the European Association of Establishments for Veterinary Education (EAEVE) regarding their first-day skills. To be able to master combining skills immediately after their license to practice, veterinarians must learn these relevant skills during their studies. However, in universities most skills are taught separately. The aim of this study was to create and evaluate teaching stations that offer students the opportunity to learn how to combine skills and which are based on existing teaching stations.

Based on already existing and evaluated individual stations of the Clinical Skills Lab (CSL), four simulations were created in which the students can combine several skills. These were offered as a compulsory elective by the name of "Management of emergency situations in dogs" in fall semester 2020/2021 and spring semester 2021 for a total of 32 students in the 7th and 6th/8 semester. Each of these simulations included a complete treatment with clinical examination, history, diagnostics and treatment. The elective course initially included an introductory course with a lecture. Afterwards the students were divided into two groups: Group I (experimental group) and Group II (control group). The experimental group completed three simulations, called combined stations in the CSL, the control group went through ten regular individual stations. After that, both groups completed the final scenario representing an unfamiliar combined station. The students completed the final scenario individually, with an unknown simulator and a time limit of 50 minutes. A veterinarian of the CSL evaluated the students' performance using an OSCE checklist.

The ten individual stations were divided into the combined stations in such a way that no single station was included twice. Thus, all students could only practice each skill once and on the same simulators. During the elective course, the students' self-efficacy expectations

were queried at three points in time: after the introductory course, after the last exercise and after the final scenario. The questionnaires included some demographic and 20 self-efficacy questions. In the second and third questionnaires, the students were able to fill in five additional questions about whether the compulsory electives changed their skills. In the questionnaires a Likert scale was used. Completing all questionnaires was voluntary and not linked to successful participation in the elective course. An OSCE checklist was developed for the final scenario to be able to draw a comparison between objective and self-assessment. After the final scenario, the students filled out a worksheet. This contained several questions about the compulsory elective and was provided as a second objective assessment. The questionnaires, the checklist and the worksheet were coded with a code to be able to relate them to one another. In addition, the students were able to fill out an anonymous feedback questionnaire to evaluate the elective course after the final scenario.

This study resulted in 29 usable pairs of questionnaires. The item "No answer" was not marked in any of the questionnaires, so it was not included in the statistical analysis. As expected, the self-efficacy assessments of the students were low at the beginning and increased during the compulsory elective. The assessments of both groups in the second questionnaire are almost the same. On average, the combined station students considered themselves as good after the final scenario as in the second questionnaire. On the other hand, the self-efficacy of the individual stations students increased in the third questionnaire. In the objective review, the students in the combined stations perform significantly better. The more previous experience the students had, the better they performed. When comparing the objective review with the self-assessments, it was noticeable that the assessments of the combined station students are consistently more correct. This also explains the drop in the self-assessment of the students in the individual stations after the final scenario in the third questionnaire. The students from the combined stations also showed better results when working on the worksheet, but without significant difference. The feedback questionnaire was completed by all participants and shows that they were satisfied with the compulsory elective. There were only minor comments on optimizing the organization of the elective course. They consistently praised the good atmosphere in the groups. Both groups agreed that the selected scenarios are relevant to practice and that linking the individual stations to an overall scenario makes sense. Finally, this type of teaching module seems to offer a more incremental and real assessment of one's skills and should continue to be offered and expanded.

Studies on "Progress Test Veterinary Medicine" at the University of Veterinary Medicine Hannover, Foundation

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In 2013, The Competence Centre for E-Learning, Didactics and Educational Research in Veterinary Medicine (KELDAT) implemented a “Progress Test Veterinary Medicine” (PTT) at all German-speaking veterinary educational institutions as part of the KELDAT project. The aim of the PTT was to provide a feedback tool for students of veterinary medicine about their spontaneously retrievable knowledge level and growth of knowledge during their studies as well as their strengths, weaknesses and knowledge level compared to students of the same semester. The test is carried out voluntarily without any grading (formative test).

Within the scope of this thesis, two studies were conducted. In the first study students' acceptance and evaluation of the PTT were investigated. In addition, the availability of progress tests at veterinary educational institutions in Europe was determined. The second study aimed to comprehensively evaluate the PTT performed annually at the University of Veterinary Medicine Hannover, Foundation (TiHo) since 2013. The aim was to determine how participation in the PTT develops over the years, whether and how there is an increase in knowledge, and whether the students' knowledge is sustainably anchored. At the same time, this study should investigate whether strengths, weaknesses or opportunities for improvement of the curriculum can be identified and to what extent the PTT can be used as an evaluation tool for teaching.

For the evaluation of students' acceptance of the PTT, 450 data sets were analyzed. The survey on the distribution of progress tests at European veterinary educational institutions provided 14 complete data sets. For the first detailed evaluation of all PTTs, 2975 data sets from 1474 students were analyzed.

According to the first study of this thesis, it is assumed that progress tests in veterinary medicine have only been implemented twice in Europe so far – the PTT of the German-speaking countries and progress testing at the University of Utrecht, the Netherlands –, so that they can be considered as pioneers in this field in Europe. Furthermore, the first part of this thesis illustrates that the PTT was recognized by the students and accepted as a feedback tool, especially for comparing their own results with the respective semester, but also for identifying their own strengths and weaknesses.

The detailed evaluations of PTT carried out at the TiHo clarified that students increase their knowledge in the course of their studies and that their knowledge is anchored in the long term. Thus, the expectations of the PTT were fulfilled. In particular, subjects that are repeatedly taken up in different lectures and thus taught and deepened in an interdisciplinary manner lead to a sustainable acquisition of knowledge. In the future, however, more attention should be paid to student-centered and practice-oriented teaching in order to support and encourage students in their learning process.

The PTT will continue to be used at the TiHo in order to offer students a longitudinal feedback tool as well as to have another instrument for curriculum evaluation available at the same time.

Interprofessional needs assessment of communication skills and evaluation of the use of actors or actresses in communication skills training in veterinary medicine

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Within the framework of the present work, which was carried out at the Centre for E-Learning, Didactics and Educational Research of the University of Veterinary Medicine Hannover, Foundation (TiHo), a survey was conducted to determine the current interprofessional state of knowledge regarding communication skills in veterinary medicine. Furthermore, the use of actors in communication skills training in the Clinical Skills Lab (CSL) was evaluated. The aim of the survey was to determine the interprofessional relevance of communication skills in veterinary medicine. Furthermore, participants` self-assessment regarding their own communication skills and their interest in communication teaching as well as in interprofessional training concepts was to be determined. Another aim of the study was to evaluate the use of actors in communication skills training in veterinary medicine. In doing so, any advantages or disadvantages of this teaching method were to be elicited both subjectively and objectively. In order to record the interprofessional state of knowledge regarding communication skills, a survey was created using LimeSurvey® and made available for response in the period from 11 May 2020 to 21 July 2020. The survey was aimed at veterinary students, trainees for veterinary assistants including vet nurses and animal keeper trainees throughout Germany. After an initial review, 467 questionnaires were used for evaluation. To determine the subjective perception of the use of actors in communication skills training, a questionnaire was prepared and answered by employees of the clinic for small animals after they had completed a communication skills training with actors. The objective assessment of the use of actors was carried out with the help of an electronic objective structured clinical examination (eOSCE) during the integrated week of the clinic for small animals at the CSL. The performance of different groups of students, who had trained their communication skills in advance with or without actors, was tested in performing an anamnesis interview and later compared with each other. Based on the results of the survey, a highly ranked relevance of communication skills and a strong interest in learning communication skills as well as in interprofessional training concepts can be noticed. Furthermore, important problems in veterinary education as well as in professional

communication in different challenging situations can be identified. The subjective perception of the use of actors is overall extremely positive. Above all, the authenticity achieved through the use of actors and the feedback rounds are decisive for this. Despite the positive subjective perception, no statistically relevant advantage or disadvantage of the use of actors or peers for training anamnesis interviews in communication skills training can be determined in the eOSCE. Both are accepted and validated teaching methods. Taking into account the discussed advantages and disadvantages of these teaching methods, the use of both groups of persons as simulated patients at different levels and with different content in veterinary education can be justified. The findings of the study enable a demand-oriented implementation of teaching communication skills and interprofessional training concepts in veterinary education. The interactive learning of communication skills within the framework of communication skills training offers an excellent opportunity for this purpose. With regard to the learning of structured and complete anamnesis interviews, the use of peers is excellently suitable, since fellow students mainly pay attention to content-related aspects when giving feedback and this more cost-effective teaching method simultaneously offers the possibility of a change of perspective. In this way, veterinary students can learn how to conduct a structured anamnesis interview at an early stage of their veterinary education and learn to understand the motives of the animal owners. At a later stage, veterinary students should also be given the opportunity to practise difficult conversation topics. The use of actors has proven to be very effective in this context, as they can portray strong emotions or challenging reactions in a particularly authentic way. In addition, the actors give particularly effective formative feedback, which refers to the inner perspective of the animal owners. Thus, this teaching method offers both advanced students and already graduated veterinarians an optimal opportunity to learn or improve how to deal with difficult situations regarding their communication skills. For this aim, the different challenging situations. In particular, the situations identified in the survey should be taken into account. In summary, the results of this study enable a well-founded insight into the current interprofessional state of knowledge regarding communication skills in veterinary medicine in Germany. In addition, the findings on the use of actors and peers in communication skills training provide valuable support for the optimal use of these two teaching methods. Thus, the findings have laid the basic foundation for further implementation of communication skills teaching at the TiHo.

Key feature cases as virtual patients in veterinary neurological education

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In order to provide students of veterinary medicine with the necessary day one competences, e-learning offers are increasingly used in addition to traditional teaching formats such as lectures or practicals. For example, virtual patients offer the possibility of case-based, computer-assisted learning in a safe environment. A concept developed in the 1980s to test clinical decision making is the key feature approach. Key feature questions consist of only three to five critical issues that are crucial for the case resolution.

The aim of this work is to investigate the key feature format for neurological virtual patients in terms of acceptance, success rate and processing time comparatively to the already existing longer learning cases. In addition, a new concept mapping tool, the clinical reasoning tool in CASUS®, should be tested for veterinary medicine.

Based on an already existing neurological curriculum, the learning objectives on neurological examination, neuroanatomical localization, and diseases of the peripheral and central nervous systems were defined. Then 38 key feature cases were created using the CASUS® learning and authoring system. In this process, material (videos, photographs, cross-sectional images, laboratory findings) from real patients of the small animal clinic was collected and processed. For each newly created case, a formal and didactic as well as a content review by specialists took place. In eight cases, students were able to use the new clinical reasoning tool and select terms for the fields of findings, tests, differential diagnoses, and therapy from a drop-down menu, link them together, and finally compare the resulting concept maps with those of the experts. These eight cases were contrasted with another eight cases without the clinical reasoning tool that involved a similar condition and questions. The new cases were offered in two elective courses in the winter term 2019/2020 (WP 2) and summer term 2020 (WP 3) in the blended learning format. After course completion, students evaluated the cases with a validated questionnaire via LimeSurvey. A Moodle course was set up in which additional materials, such as publications, further cross-sectional images and findings, or videos on the course of the disease, were linked. In addition to the communicative channels in CASUS® (feedback function and discussion function), students could exchange information with each other or with the lecturers in Moodle forums. For the

comparison to the longer patient cases, data from a previous course from the summer term 2019 (WP 1) with long cases was analyzed.

In the winter term 2019/2020, 83 students registered for the new course format with the short cases. In the follow-up course, 146 students took part, 61 of whom participated for the second time. In the courses with the long cases, 50 students participated. In WP 1, a total of 77% of casework was completed successfully (with more than 50% correct answers), while in WP 2 and WP 3 it was 73% each. The individual student success rates, based on all questions, were 60% in WP 1, and 64% in WP 2 and WP 3. While the processing time of a long case was on average 56 minutes, the participants needed on average 17 minutes to solve a key feature case. The success rate of the cases that could be processed with the clinical reasoning tool was on average 58%, while the cases to be compared were finished with an average of 60% correct answers. The time taken to complete a case using the clinical reasoning tool was 19 minutes, significantly longer than the time taken to solve the comparison cases (15 minutes). Of the 146 participants in WP 3, 65% to 89% (depending on the case) used the clinical reasoning tool. It was striking that most entries (n=902) were made for findings, whereas significantly fewer terms (n=198) were selected for treatment options.

The response rates to the three surveys were between 82% and 90%. In general, all courses were evaluated very well on the 6-point Likert scale. A good course organization, high authenticity of the cases, good learning effect and positive learning climate could be demonstrated. The knowledge gain compared to the processing time was evaluated as adequate in all courses. The relative value of agreeing answers was even higher in the key feature courses WP 2 (99%) and WP 3 (99%) than in WP 1 (94%) with the long cases.

The average school grades for the events were 2.4 (WP 1), 1.9 (WP 2) and 1.2 (WP 3) (1 being very good and 5 being very poor). The statements about the clinical reasoning tool were answered rather neutrally with mean scores between 2.8 and 4.2 on the 6-point Likert scale. The students tended to reject the statement that they were able to process the cases better with the tool (M=2.8). Technical usability, on the other hand, was rated rather positively (M=4.2).

In the free-text responses on positive and negative feedback, the flexibility of the format was praised first, followed by the authenticity of the cases and the promotion of clinical thinking. In the key feature WPs, the integration of multimedia elements and the conciseness of the cases were explicitly emphasized. Suggestions for improvement differed more clearly between the two course formats. For the short learning cases, many students wished more information and expert knowledge. The high level of difficulty was criticized, as well as the use of multiple learning platforms. Especially with regard to the clinical reasoning tool, it was

mentioned that the given terminology of the drop-down menu is not transferable to veterinary contexts.

In summary, a very high level of acceptance for the new course format was demonstrated. The high percentage of students who chose the course a second time underlines this statement, as do the results from the evaluations.

In the comparison of success rates, no significantly better result could be achieved for a particular course format. Nor did the use of the clinical reasoning tool contribute to higher success in the casework. However, the time required to solve a key feature case is much shorter than that required for a long case. Thus, one can teach a greater variety of neurological conditions in a shorter time with the same level of success. The results suggest that the course with longer cases was primarily taken by students specifically interested in neurology, whereas the title of the key feature courses "Neurology in a nutshell" appealed to a broader spectrum of students. The positive evaluation of all formats suggests that the different concepts are valid and that longer cases should continue to be used. Courses with a mixture of long and short cases would be conceivable. The clinical reasoning tool could be implemented technically without any problems and could contribute to a fundamentally better structuring. However, an expansion of the Medical Subject Headings (MeSH Terms) in the drop-down menu would be necessary for a higher acceptance. The free text responses provided many valuable points that will also contribute to the further development and improvement of the courses. Basically, the new virtual patient format could be established very well and can now serve as a validated prototype for further courses, also in other veterinary subjects.

Investigations on teaching methods of endoscopic examination of the upper respiratory tract in horses

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Endoscopy is becoming more and more important in veterinary medicine. In equine medicine it is frequently used and often represents an essential part of clinical diagnostics. For example, flexible video endoscopes are mainly used for endoscopy of the respiratory tract and the stomach. In order to perform an endoscopy and operate the equipment correctly, veterinary students should receive practical training during their studies. Endoscopy is part of the so-called "Day One Competencies." These Day One Competencies were created by the EAEVE to define skills which a veterinarian should be able to perform at the beginning of his or her career. Consequently, they represent a guideline for training of students.

To address first-day skills, this study examined how simulation-based small-group teaching affects the development of endoscopic skills. The purpose of this work was to develop a "low-fidelity" endoscopy simulator and implement it during small-group teaching sessions to analyze its benefits and compare it with those of another teaching format.

The "Low-fidelity" endoscopy simulator was designed to fit into a plastic box in which a wooden maze was built in and defined target points were integrated. After completion of the development phase, the so-called "Endoscopy Simulator I" was used during an endoscopy training course at the Summer School 2018 and 2019 and was subsequently evaluated by the participating students (n=23). The evaluation of the simulator in terms of size, functionality, and level of difficulty was consistently very positive, as far as the evaluation of the tutoring and the assessment of necessity is concerned. In addition, the simulator was tested and evaluated by eleven experienced veterinarians from three clinics of the TiHo. In this evaluation the simulator could convince and was rated as functional and supportive in developing handeye coordination and spatial orientation. A generally good acceptance and the desire to include more endoscopy training in the curriculum were derived from the opinions. Additionally, based on this feedback the simulator was slightly optimized structurally.

In winter semester 2019/2020 and summer semester 2020, the "Endoscopy Simulator I" was used in the training of students of the practical year in a cooperation of the CSL with the Clinic for Horses. For this purpose, the participating students were divided into two groups: one group received simulator-based small group instruction on the "Endoscopy Simulator I" and the second group received face-to-face teaching in terms of a video lecture with free access to the endoscope without getting support of the tutor (independent learning).

During the practical test, which took place seven days after the training, a simulator, which was also developed in-house, was used. The so-called "Endoscopy Simulator II", consisting of an endoscopic 3D-printed horse skull and an instrument box, was also evaluated by five experienced veterinarians of the equine clinic. The students of the practical year were asked to perform a structured endoscopic examination of the upper respiratory tract on the 3D-printed horse skull. It was evaluated whether the essential parts were correctly endoscoped and how long the successful students needed for the individual steps. In the instrument box, students should take a sample of secretion, perform an injection and remove a polyp. Again, it was evaluated whether the essential steps were performed correctly and how much time was needed. In the actual practical performance, students of the simulation-based small group instruction were more likely to succeed than students of the other group. In terms of the time required, students in the simulation-based small-group instruction were usually faster, but the differences did not prove to be significant. Only in the removal of the polyp with the polypectomy snare participants of the small-group instruction were significantly faster than those of the face-to-face teaching group. In the assessment by the assistants regarding precise instructions and gentle handling, both groups performed approximately equally well.

By conducting written tests before the training sessions as well as before the practical examination, it was also possible to draw conclusions about the development of theoretical knowledge and self-efficacy. In terms of theoretical knowledge, both groups showed a massive increase in knowledge in all subject areas. The students of the small-group-instruction were clearly able to compete with the other group, which was particularly evident in the topics of "Setting and handling of the endoscope" and "Electrosurgery". The participants of the small-group instruction also showed twice as much positive tendence in determination of self-efficacy expectations as the comparison group, especially in the proper operation of the endoscope, spatial orientation, and the structured examination procedure.

Results of this work confirmed the benefits of simulation-based endoscopy training. Therefore, both developed simulators are to be integrated into the course offer of the CSL in

the future. In this way, every student can be given the opportunity to familiarize himself or herself with the basics of endoscopy and to practice using the flexible video endoscope, as well as the other devices and instruments during the course of their studies, in order to create good conditions for training on live animals. In this manner, teaching at TiHo is to be further optimized and the approach of constantly reducing animal experiments in regard to the animal protection laws will be pursued. At the same time, the training opportunity will increase students' self-confidence during their studies. Consequently, as licensed veterinarians, they will be able to perform required procedures more routinely and act less stressed, which will also have a positive effect on animal welfare in their daily work.

Investigations on the development and implementation of a simulator for transrectal sonographic gynecological examination of cattle in veterinary medicine studies

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Ultrasound imaging represents an important diagnostic tool in bovine reproductive medicine, especially in cycle determination, pregnancy diagnosis, fetal sex determination and embryo transfer. Because of the versatile use of ultrasound as a medical diagnostic tool, the EAEVE (European Association of Establishments for Veterinary Education) requires veterinary graduates to be able to perform a simple imaging examination as part of their first-day competencies. However, the examination of bovine transrectal gynecologic sonography represents a highly complex skill that can only be adequately learned by repeated training. Students usually do not have the opportunity to perform this high number of repetitions on live animals during their studies.

The aim of the present research project was to create a simulator for transrectal sonographic gynecological examination of cattle with emphasis on cycle determination and to evaluate it with regard to its future use in veterinary education.

Based on the commercially available simulator Breed'n Betsy®, the "Ultrasonic Cow Simulator" for transrectal sonographic gynecological examination was developed from ultrasound conducting materials. The uterus, the ovaries with one corpus luteum or two follicles, the ligamentum latum uteri with Ateriae uterinae, the vesica urinaria and the rumen were simulated as realistically as possible both by palpation and sonography. The developed organs were placed in a basin of plexiglass which was filled with distilled water for better conductivity of the ultrasound. The distilled water was heated to body temperature to allow an even more realistic impression when examining the simulator. In creating the simulator, emphasis was placed on the durability of the replicated organs, as well as the ease of use of the simulator. The Ultrasonic Cow Simulator was evaluated by three groups of different levels of knowledge. The assessment of the simulator with regard to its palpatory and sonographic properties was carried out on a questionnaire basis. Students of the 2nd/3rd semester (experimental group 1) evaluated the palpatory properties of the simulator in comparison to the commercially available simulator Breed'n Betsy® during their agricultural internship at the Teaching and Research Farm of the University of Veterinary Medicine Hannover. Students

of the 9th/10th semester (experimental group 2) evaluated the simulator during their ten-week cycle at the Clinic for cattle of the University of Veterinary Medicine Hannover Foundation as part of their practical year. They evaluated the simulator regarding its palpatory and sonographic properties. In addition, data on the students' self-efficacy were collected and their ability to perform a transrectal sonographic examination was assessed in a performance check on live animals. For this purpose, part of the students received an introductory lecture on transrectal sonographic examination and a training on the Ultrasonic Cow Simulator, while the control group was provided only with the introductory lecture. The live animal review was randomized and blinded to animals in the bovine clinic. The cows were all examined in advance by experienced veterinarians and only animals that had similar uterine findings (SII S KII) and showed a corpus luteum or, if not a sufficient number of animals with corpus luteum, cows with well-detectable follicles were included in the study. Students received written instructions for the exam and had ten minutes to complete the examination. Experienced veterinarians from the Clinic for Cattle monitored the examination with a tablet. They evaluated the students´ performance using an objective-structured checklist. In a third study, veterinarians from different clinics of the University of Veterinary Medicine Hannover Foundation, (experimental group 3) as well as other practicing veterinarians evaluated the simulator with regard to its palpatory properties in comparison to the simulator Breed'n Betsy® as well as to its sonographic properties.

A total number of 266 persons participated in the present research project. Of these 190 of 2nd/3rd semester students (n = 190), 58 of 9th/10th semester students (n = 58), and 18 of veterinarians (n = 18) participated. Only evaluable answers were included in the calculation of the results. The answer "I don't know" was not included in the evaluation. The palpatory properties of the Ultrasonic Cow Simulator were rated as "good" by the three experimental groups (2nd/3rd semester: 94.74 %; 9th/10th semester: 73.33 %; veterinarians: 77.78 %). Compared to the Breed'n Betsy®, the Ultrasonic Cow Simulator was perceived as more realistic by the students of the 2nd/3rd semester with 94.21 % as well as 100 % of the veterinarians. 96,67 % of the 9th/10th semester students and 77.78 % of the veterinarians rated the sonographic image of the simulator as good. In the study with students of the 9th/10th semester, students of the training group performed similarly to the control group in the objective performance review on the live animal. Experienced students performed better than less experienced students. However, the performance of the students was basically far below the expected level. The assessment of self-efficacy at the beginning of the experiment was similar in both the training and control group. However, after completion of the experiment, the training group recorded significantly higher self-efficacy. In categories such as "I recognize the uterus and ovaries of a bovine on a transrectal acquired ultrasound image.", "I have the confidence to independently perform a TSU.", "I can collect findings on

the uterus during the independently performed TSU." and "I can collect findings on the ovaries during the independently performed TSU." even significant correlations ($p < 0.05$) were found.

Suggestions for improvement of the Ultrasonic Cow Simulator were the installation of the left kidney by all three experimental groups (frequencies: 2nd/3rd semester students: 55, 9th/10th semester students: 4, veterinarians: 8), and in the category "improved haptics", the simulation of feces (frequencies: 2nd/3rd semester students: 21, 9th/10th semester students: 3, veterinarians: 0). They criticized that the arm's range of motion in the pelvic cavity was not restricted which would have made palpation more difficult (frequencies: 2nd/3rd semester students: 23, 9th/10th semester students: 9, veterinarians: 4). All three experimental groups felt that simulator practice was useful before examination of living animals (2nd/3rd semester students: 99.47 %, 9th/10th semester students and veterinary students: 100 %). The 2nd/3rd semester and 9th/10th semester students rated the training on the Ultrasonic Cow Simulator as high and medium, respectively, in terms of their learning success. 90 % of the students of the 2nd/3rd semester, 92.05 % of the students of the 9th/10th semester and 94.44 % of the veterinarians would like to see more simulators in the field of bovine reproduction used in veterinary teaching in the future.

In summary, the design of the simulator was rated as good by all three experimental groups and the use of the Ultrasonic Cow Simulator in various training modules could be successfully integrated into the veterinary curriculum. A single training session with the Ultrasonic Cow Simulator is not sufficient to achieve objectively higher success in transrectal sonographic examination of cattle. However, the hypothesis that a high level of experience is required for this examination could be confirmed. Training with the Ultrasonic Cow Simulator positively influences self-efficacy. Whereby it could be proven that a positive assessment of self-efficacy does not necessarily mean that this must correspond to the objectively demonstrated performance. In conclusion, it can be said that the use of the Ultrasonic Cow Simulator represents an innovative alternative for learning and training of the transrectal sonographic examination of cattle for reasons of animal welfare as well as the limited number of possibilities to perform this examination on live animals.