Aus dem Institut für Veterinär-Epidemiologie und Biometrie
des Fachbereichs Veterinärmedizin
der Freien Universität Berlin

Evaluation of virtual patients in a blended learning delivery format for clinical interdisciplinary lectures in veterinary education

Inaugural-Dissertation
zur Erlangung des Grades einer
Doktorin der Veterinärmedizin
an der
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vorgelegt von
Lena Vogt
Tierärztin aus Geseke

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´To study the phenomenon of disease without books is to sail an uncharted sea, while to study books without patients is not to go to sea at all.´

William Osler, (1901)

Table of contents

List of figures/tables

Figures

Paper 1

Paper 2

Tables

List of abbreviations

BL	Blended learning
CBL	Case-based learning
CBEL	Case-based e-learning
DOC	Day One Competence
DOCs	Day One Competences
EAEVE	European Association of Establishments for Veterinary Education
ECCVT	European Coordination Committee on Veterinary Training
FUB	Freie Universität Berlin
ILs	Interdisciplinary lectures
IT	Interdisciplinary teaching
KCs	Key characteristics
TAppV	Verordnung zur Approbation von Tierärztinnen und Tierärzten (Licensing regulations for veterinary medicine)
VM-FUB	Faculty of Veterinary Medicine at Freie Universität Berlin
VP	Virtual patient
VPs	Virtual patients
VPH	Veterinary public health

Definitions

Didactic Design	The development of learning environments with a focus on using digital technology (Reinmann, 2013)
Interdisciplinary lectures (ILs)	A course at the Faculty of Veterinary Medicine at Freie Universität Berlin or German veterinary schools teaching interdisciplinary, case-based content that is relevant to veterinary practice in accordance with the veterinary medicine licensing regulations (TAppV, 2006).
Interdisciplinary teaching (IT)	The general concept related to the mediation of interdisciplinary content in education through multiple parties.
QuerVet (project)	QuerVet was initiated in 2016 as a collaborative project between the Faculty of Veterinary Medicine at Freie Universität Berlin and the Center für Digitale Systeme (CeDiS) over a period of four years. The focus was on the improvement of the ILs at the Faculty of Veterinary Medicine at Freie Universität Berlin through the development and implementation of interdisciplinary cases in clinical medicine and veterinary public health, in a blended learning delivery format.
Standardised Patients	are human actors trained to portray patients for communication skills (Kononowicz et al., 2015).
Virtual Patient	Within the scope of this thesis a VP is defined as ´a specific type of computer-based program that simulates real-life clinical scenarios; learners emulate the roles of health care providers to obtain a history, conduct a physical exam, and make diagnostic and therapeutic decisions´ (Association of American Medical Colleges, 2007). VPs introduce learners to unfolding and interactive patient case situations and tasks (Ellaway et al., 2015). Other types of simulation such as standardised patients, manikins and high-fidelity simulators are excluded from this definition (Cook & Triola, 2009). According to the adapted VP classification by Kononowicz et al. (2015) the VPs designed in the QuerVet project classify as interactive patient scenarios.

1. Introduction

Veterinary education is a great challenge not only because of the wide range of subjects it includes, but also because it involves the medical treatment of many different species. The demands and expectations towards veterinary care and its further specialisation are constantly increasing. Therefore, the thorough preparation of future professional veterinarians, through a solid education, with a focus on issues such as Day One Competences (DOCs) is an important requirement. The application of knowledge in practice-like situations, the interconnection of different subjects and their content, as well as the practicing of clinical reasoning and hands-on training, are key elements for this preparation. Naturally, the best way to practice is to actively participate in the clinical treatment of real patients. Unfortunately, during the clinical training in an animal hospital the surroundings are sometimes too fast-paced for students to understand all the interconnections of a case. In addition, there is often not enough time for in-depth supervision. Good supervision is necessary to guide students and provide feedback. Also, without supervision and in a stressful environment, the risk to students or patients of being injured is higher. Furthermore, during the clinical training in an animal hospital it is not always possible to make all relevant cases accessible to every student, in order to train all the necessary skills and to provide all the necessary clinical experience. Consequently, in veterinary education additional hands-on training and interdisciplinary and case-based courses are provided in addition to the students' participation in the clinical treatment of patients. Since 2013, following the German Animal Welfare legislation, veterinary hands-on training with animals is classified as animal experimentation, and the principles of the 3Rs (Replace, Reduce, Refine) must be applied. This presents a challenge for the hands-on training in veterinary education, and practical approaches must be found as a solution.

Interdisciplinary lectures (ILs) in veterinary education take one of these roles, as their objective is to make students familiar with specific cases relevant to veterinary practice in the field of clinical medicine and veterinary public health (VPH). ILs combine and interlink many different subjects and species through case-based learning (CBL) and offer extensive preparation for the students' future profession by combining basic science and applied science. The licensing regulations for veterinary medicine (TAppV) determine veterinary education in Germany, and paragraph §53 specifically relates to the ILs. Here, interdisciplinarity, a case-based approach and relevance to veterinary practice are marked as the three key characteristics (KCs) for the ILs. At the Faculty of Veterinary Medicine, Freie Universität Berlin (VM-FUB), the ILs are implemented as a mandatory course over three semesters in the clinical phase of the curriculum.

In 2007, the VM-FUB was evaluated by the European Association of Establishments for Veterinary Education (EAEVE), which coordinates the evaluation and accreditation of

European veterinary schools. While the VM-FUB received an overall positive assessment, one conclusion drawn from the suggestions was to revise the lecture format and organisation of the ILs. A student survey in 2014 also identified the need for improving the ILs. In consequence, the QuerVet project, which started in summer 2016, concentrated on the thorough revision of the ILs at VM-FUB. Due to the fact that the ILs at VM-FUB are determined as a non-practical course, an alternative to practical clinical cases and demonstrations was sought that enables the delivery of interdisciplinary case-based content. Given that, according to the TAppV, lectures can be partly transferred into interactive learning programs, virtual patients (VPs) in a blended learning (BL) delivery format were identified as a feasible solution to the above-mentioned problems. Through this approach as an alternative to practical clinical cases and demonstrations, VPs could simultaneously help to further implement the 3R principles into veterinary education. Within the scope of the QuerVet project, the focus of this thesis was therefore on the development, implementation and evaluation of VPs in a BL format for the clinical ILs.

There are a few studies analysing BL and VPs in veterinary education, but so far there have been no studies analysing VPs in veterinary ILs. Also, there are no studies concerning the realisation of learning objectives according to Bloom's taxonomy through VPs in veterinary education.

The aim of this work was to analyse the suitability of VPs in a BL delivery format for teaching ILs in veterinary education. For this, three areas were assessed: (i) the achievement of the associated learning objectives according to Bloom's taxonomy through the use of VPs, (ii) the implementation of the three KCs for ILs (interdisciplinarity, case-based approach, relevance to veterinary practice) compared to the previous lecture format and (iii) the acceptance of VPs for the clinical ILs in a BL delivery format. Additionally, it is discussed how VPs can contribute to the 3R principles with regard to the use of animals in veterinary education.

2. Literature review

2.1. Interdisciplinary teaching

In general, interdisciplinarity in academic education means the integration and joint contribution of different disciplines; the goal being to ´facilitate unity and synthesis in terms of knowledge´ (Holley, 2009). The objective of interdisciplinary teaching (IT) is for students to comprehend the relation between the different disciplines and to promote a broad view with an understanding of the greater processes (Newell & Green, 1982).

In health care education interdisciplinary working or teaching usually refers to the integration of the different professions such as medical care, nursing and psychology (Waddell et al., 2010; Evers et al., 2005; Harman et al., 1998). In veterinary education, IT means closely combining the content of different subjects such as anatomy, pathology and neurology (Koch et al., 2010). This is probably due to the fact that, in health care different professions work together and in veterinary care collaboration is still normally localised within the veterinary profession. Also, interdisciplinary collaboration should be distinguished from multidisciplinary collaboration, which refers to a team whose individual members operate independently of each other on a health care question, and a transdisciplinary team that closely works together with blurred professional boundaries, involving open communication focused on the patient's problem (Gordon et al., 2014; Hall & Weaver, 2001; Walker et al., 1998).

An interdisciplinary approach in teaching means that different content is combined, and through the cooperation of different disciplines the format of a traditional lecture, where one person is responsible for the organisation, content and presentation cannot be maintained as such (Hall & Weaver, 2001). Universities are organised around different disciplines each focussing on teaching and research in their specialised subjects, and IT creates the opportunity and challenge to transcend these institutional boundaries (Holley, 2009).

Furthermore, IT in general follows a similar didactic approach to an integrated curriculum or modular curriculum in medical education. An integrated or modular curriculum focusses on integrating basic and clinical subjects, learning spirals and longitudinal teaching approaches interlinking the different modules (Hitzblech et al., 2019; Brauer & Ferguson, 2015). Additionally, the defining of learning outcomes and the constructive alignment of ´teaching, learning and assessment based on the learning objectives defined for each teaching session´ plays an important role (Hitzblech et al., 2019). This integrative design can also help students accomplish learning objectives on all three domains (cognitive, psychomotor, affective) of Bloom's taxonomy of educational objectives through the transfer of knowledge, clinical abilities and professional attitudes (Brauer & Ferguson, 2015).

2.1.1. German requirements

In Germany, veterinary education is regulated by the licensing specifications for veterinary medicine which have contained requirements regarding ILs since 1999 (Baljer et al., 2004). According to paragraph §53 of these regulations, the objective of ILs is to introduce students to clinical medicine and veterinary public health (VPH) with practically-relevant content and tasks on the basis of knowledge that has already been acquired or is being currently taught (TAppV, 2006). The predetermined amount of IL lecture time is 196 hours which is stated in Annex 1 of the TAppV. In particular the subjects ´internal medicine, reproductive medicine, stock management, surgery with participation of pathological anatomy, clinical pharmacology, animal nutrition, animal breeding, animal husbandry, veterinary professional law, animal welfare and ethology, topographical anatomy, epidemiology, infectious diseases and animal disease control including possibilities for prevention of epizootic diseases are to be presented in an interdisciplinary approach´ (TAppV, 2006). With the aid of specific individual cases, the origin, diagnosis and therapy of diseases is to be covered. Options for painless killing of animals should be communicated with students. Also, special attention should be paid to the ´consequences of applying ionising radiation or radioactive materials, residue problems, environmental contaminants as well as food safety and hygiene (meat, diary) with a focus on the risk assessment, quality management and the marketability of food products from animal origin through all steps of production´ (TAppV, 2006). Furthermore, ´the possible effects of animal diseases and the consequences of their treatment on human health and the environment are to be considered´ (TAppV, 2006).

In summary, three core elements of the national requirements can be identified: (i) interdisciplinarity, (ii) a case-based approach and (iii) thematic relevance to veterinary practice, which should be implemented in the subjects of clinical medicine as well as the VPH. These elements are referred to as the three KCs of ILs.

Referring to paragraph §2 of the TAppV, it is expected that the ILs will be taught with the inclusion of several disciplines with a coordinated organisation of content (TAppV, 2006). Lammerding-Köppel et al. (2006) describe IT as team-teaching with the participation of lecturers from different disciplines (Lammerding-Köppel et al., 2006). ´In veterinary medicine interdisciplinarity is the collaboration of different disciplines that teach similar content often independently of each other´ (Koch et al., 2010).

Thematic relevance refers to cases that are both important and common in veterinary practice. ´Important´ can be interpreted as ´very rare´, but nonetheless the topic of the case is crucial as it ideally addresses the DOCs. Day One Competences are the abilities and skills a veterinary student should acquire during their studies, which they should be able to apply on the first day of their future profession (EAEVE & FVE, 2016).

Case-based learning simulates real-world situations, and students engage in problems that they will probably encounter later in their profession (Kim et al., 2006). Also, CBL is said to be superior to traditional teaching methods and can take place in a web-based learning environment (Kim et al., 2006). ´Case-based learning increases student self-confidence in clinical reasoning skills´ (Patterson, 2006). Generally, lectures are permitted to be partly transferred into interactive learning software which also allows CBL to take place in a web-based format (TAppV, 2006).

2.1.2. Interdisciplinary lectures at the VM-FUB

The ILs at VM-FUB occur in the clinical phase of the curriculum, and comprise a course over semesters 6,7 and 8 of the 11-semester curriculum. In the past, the delivery format was almost exclusively face-to-face as an in-class lecture. Each weekly lecture lasted for three hours in total which is equivalent to four teaching units.
Table 1 below was created on the basis of IL timetables from summer 2013 until winter 2016/17, just before the QuerVet project started. It describes the interdisciplinarity of the individual lectures while distinguishing between lectures that, through their content focus, are counted either solely as clinical medicine, VPH or both (for details regarding the specific timetables see Appendix).

Table 1: Analysis of the interdisciplinary lecture timetables divided into clinical, VPH and mixed topics from summer 2013 until winter 2016/17 at the VM-FUB

Semester	Content focus	Non-inter-disciplinary	2 subjects	3 subjects	4 subjects	5 subjects	Total
Summer 2013 – Winter 2016/17	Clinical	51	64	18	6	1	140
	VPH	16	11	7	3	-	37
	Both	-	10	-	-	-	10
Total		67	85	25	9	1	187

This table shows that the largest proportion of the overall content (45%) was delivered with two different subjects and the second largest proportion (36%) was not interdisciplinary at all. Accordingly, 19% of the lectures were conducted with three or more different subjects.
Within the considered semesters, between 50% and 86% of the ILs were filled exclusively with clinical content. Of this clinical content, the proportion of non-interdisciplinary content varied between 18%-71%. Furthermore, between 20%-67% of the clinical ILs were conducted with

two different subjects. Of the clinical ILs, 12,5% were supervised by colleagues from three different disciplines, 5% by four disciplines and 1% by five disciplines.
Overall, five slots were unoccupied over this period of time and 16 slots were filled with content that did not comply with the content specifications of the ILs which were therefore regarded as off-topic. The timetable of the 6th semester in summer 2013 was not included in this analysis due to the fact that half of the content was not accounted for. Referring to the study office of the VM-FUB (Birk, 2021) the ILs were not well accepted among the lecturers which serves as one possible explanation for the open slots.
It was not possible to retrospectively assess the case-based approach of each lecturer within the in-class lectures.
In the past, the ILs did not consist of a coherent overall course concept. The organisation of topics and adherence to the KCs (interdisciplinarity, case-based approach and thematic relevance for veterinary practice) were neither centrally managed nor monitored.
An internal faculty survey also showed that students were critical of the ILs and 54% of the participating students agreed that the ILs did not fulfil the aim of enhancing an intensive IT (Schunter, 2016). Based on free text responses concerning the overall curriculum, 18% of the VM-FUB students called for a closer relation to practice and 10% requested better coordination of the teaching content (Schunter, 2016).

2.1.3. EAEVE visit of the VM-FUB

The European Association of Establishments for Veterinary Medicine (EAEVE) is the official accreditation authority for veterinary schools within Europe and it was founded in 1988. Its mission is the evaluation, promotion and development of ´the quality and standard of veterinary medical establishments and their teaching within, but not limited to, the member states of the European Union (EU)´ (EAEVE, 2020). For the mutual recognition of degrees the assurance of a comparably high standard of education and training is of great importance (Directive 2005/36/EC, 2005; Directive 78/1028/EEC, 1978).
In general, the EAEVE supports the promotion of DOCs in veterinary education, which focus on the final outcome of this education and refer to the skills a veterinary student should have acquired by the first day of their profession (EAEVE & FVE, 2016). This conforms with the intention of the ILs to prepare students with relevant cases for that first day of employment and should be considered when creating the content of the cases.
The VM-FUB was first evaluated and accredited in 1997. In 2007 the faculty was evaluated again and received an overall positive assessment, however, among other things, the ILs were criticised (EAEVE, 2007). Consequently, the VM-FUB decided to improve the organisation and visibility of the ILs as well as their content and didactic approach.

2.2. Digital technology in medical education

2.2.1. E-learning / Blended learning

New developments in digital technologies provide educators and learners with constantly increasing access to learning resources (Ruiz et al., 2006). Already in 1998 it was pointed out, that digitalisation can increase learning experience in medical education (Chu & Chan, 1998). Lammerding-Köppel et al. (2006) suggest refining medical education towards active learning (referred to as the shift from teaching to learning) with a focus on practice-oriented and interdisciplinary as well as student-centred learning. As criteria of ´competence-oriented medicine didactic qualification measures´ they list, inter alia, the encouragement of using innovative methods which thereby promote new technologies (Lammerding-Köppel et al., 2006).

The European Coordination Committee on Veterinary Training (ECCVT) recently published a report on the impact of digital technologies and artificial intelligence in veterinary education and practice, and came to the conclusion that digital technology has the ability ´to improve the quality and efficiency of the learning and teaching processes´ (ECCVT, 2020). Accordingly, digital technologies can provide the opportunity to enhance clinical reasoning and decision making when equipped with approved tools. In 2002, Short (2002) stated that the use of information and communication technology will offer great opportunities to improve veterinary education. However, it was noted that the slower implementation of e-learning in veterinary education could be related to the ´smaller size of the profession, the reluctance to change traditional teaching practices and the limited investment in terms of finance and resource to develop new approaches´ (Short, 2002).

E-learning

E-learning refers to the support of teaching and learning with digital technology and electronic media. This can be in offline form through CDs or DVDs or online and thereby web-based (Kraft, 2003). Ruiz et al. (2006) refer to e-learning as the application of internet technologies in education which can also be named ´web-based learning, online learning, distributed learning, computer-assisted instruction, or internet-based learning´ (Ruiz et al., 2006).

One of the major advantages of e-learning is the flexibility it offers to access learning content independent of time and place, and the ability of the learner to work at his or her own pace (Boller et al., 2018; Roth et al., 2014; Börchers et al., 2010; Ehlers et al., 2010; Seitz & Dannenberg, 2006; Childs et al., 2005; Chu & Chan, 1998). Since the needs or preferences of individual learners differ (Singh, 2003), e-learning offers a solution through the individualisation of the learning process (ECCVT, 2020; Boller et al., 2018; Roth et al., 2014) while promoting different learning preferences and enabling unlimited repetition of digital content (ECCVT,

2020). Digital content includes images and videos through which traditional teaching can be complemented (Short, 2002). Additionally, digital content can be repurposed which helps save resources (Short, 2002). Online content can be exchanged and updated quickly (Ehlers et al., 2010; Chu & Chan, 1998), improves accessibility to learning material, and can help save financial resources (Ehlers et al., 2010; Rosenberg, 2001).

In digital technology the ECCVT sees an opportunity to improve veterinary education and the opportunity to share content with other institutions in order to save resources (ECCVT, 2020). E-learning enables interdisciplinary collaboration and the creation of standardised course content through international cooperation and teaching projects with the participation of multiple universities (ECCVT, 2020; Koch et al., 2010). Options for communication can be synchronous or asynchronous through chatrooms and video-calls, discussion forums or e-mail exchanges with instructors or tutors (Short, 2002).

Seitz & Dannenberg (2006) pointed out the opportunity to create case-based scenarios with e-learning which promotes the learner's ability to make decisions in a specific situation. The learner is the active part in this scenario with the support of the learning environment. While the case is embedded into an authentic context knowledge and experience is acquired effectively and learning objectives on different levels are delivered (Seitz & Dannenberg, 2006).

E-learning offers an opportunity to achieve learning objectives that traditional methods are not able to reach (Börchers et al., 2010) and through e-learning the coordination of learning outcomes can be simplified (ECCVT, 2020).

Besides all of these benefits, e-learning does also present some threats or disadvantages to education. The ECCVT sees risks in replacing hands-on training and learning of DOCs entirely with digital technologies, because of the possibility that these are taught insufficiently to students (ECCVT, 2020). This threat was also emphasised by Short, who pointed out that some content of the veterinary curriculum should be taught practically and should not be replaced entirely by e-learning (Short, 2002).

When implementing new technologies into the curriculum, organisational and financial barriers can occur. Also, the choice of an appropriate software tool and offering students the possibility to access the necessary hardware may be difficult (Childs et al., 2005). In 1998, Chu & Chan (1998) saw disadvantages in the limited portability of digital devices as well as the poor resolution of available hardware (Chu & Chan, 1998). Nowadays, high-end mobile devices offer a practical solution to this problem. Nonetheless, technical problems can still occur (Ehlers et al., 2010) and deteriorate the usability as well as complicate the learning process. Also, the disregard of the General Data Protection Regulation (GDPR) and ´ethical aspects of digital personal information may cause difficulties in digital education´ (ECCVT, 2020).

One major disadvantage for learners that occurs while learning with digital technologies is the isolation from other learners and the lack of face-to-face contact to the instructors or educators (Börchers et al., 2010).

Blended learning

The combination of e-learning with in-class lectures is called blended learning (BL) (Lehmann et al., 2015; Ruiz et al., 2006; Rovai & Jordan, 2004; Kraft, 2003; Singh, 2003). This approach mixes a variety of media types while promoting different learning delivery methods and has the ability to enhance application-learned behaviour (Singh, 2003).

Blended learning provides the benefits of online learning without losing the personal contact to the instructors or other students and is therefore on the one hand a more flexible learning environment and on the other hand a more solid didactic experience (Rovai & Jordan, 2004). Since e-learning should not replace traditional face-to-face teaching entirely (ECCVT, 2020; Little et al., 2018; Börchers et al., 2010), BL provides a solution to the above-mentioned problem and can be used to complement and enhance traditional teaching methods with e-learning (Little et al., 2018; Ruiz et al., 2006). Moreover, Rovai et al. (2004) even suggest that BL can create a more positive sense of community among students than either traditional or online delivery formats given that some students favour face-to-face discussions and others feel more confident working through online content on their own (Rovai & Jordan, 2004).

Flipped classroom

Flipped classroom also describes a mixture of face-to-face time with an online learning environment. However, in this case the distribution of activities is well defined. In the online environment students work on the provided material and acquire background knowledge so that in the subsequent in-class lecture the instructor can use the time to provide a more active and learner-centred experience since the students should already be familiar with the content (Boller et al., 2018; Moffett & Mill, 2014).

A multinational survey of faculty experience with the flipped classroom approach in 2019 showed that, while most participating veterinary teachers and administrators knew of this approach and had a positive attitude towards it, few actually used this approach extensively (Matthew et al., 2019). As pre-class activities participants named among others PowerPoint© (Microsoft, Redmond) with audio/lectures, video and websites or quizzes and CBL as well as group activities and work sheets (Matthew et al., 2019). The flipped classroom approach increased the learning efficiency for the participants especially through the enhancement of engaging and active learning and the increase of learning motivation.

E-learning and blended learning in medical and veterinary education

E-learning improves medical education (Means et al., 2009; Cook et al., 2008; Ruiz et al., 2006; Childs et al., 2005). However, it should be implemented as BL (Means et al., 2009; Ruiz et al., 2006; Childs et al., 2005). In a meta-analysis and review of e-leaning studies it was pointed out that besides the possibility to flexibly extend the learning time and collaborate during the online period, it was the blend of different elements in particular that created the learning advantages (Means et al., 2009). Also, BL improved students´ grades and reduced dropout rates (Garrison & Kanuka, 2011).

To be successful, e-learning should be integrated into the curriculum instead of being offered as a voluntary option in addition to mandatory lectures (Hege et al., 2007; Childs et al., 2005). In a systematic literature review in 2005 the authors conclude that e-learning should be realised with a tool that (i) is interactive and learner-centred, (ii) promotes different learning methods and provides feedback to learners and (iii) presents relevant content (Childs et al., 2005).

A study focused on teaching how to place a nasogastric tube in a horse compared computer-assisted learning with traditional face-to-face teaching in veterinary education. They observed that after studying with the e-learning material students showed more confidence and took less time to perform the requested procedure (Abutarbush et al., 2006). One highlighted benefit of this study is the possibility for students to review the learning materials as often as needed. In addition to a better performance on live animals and this allows for a reduction in the number of animals needed in veterinary education.

Publications describing the implementation of BL into the veterinary curriculum show that veterinary students rate BL very positively (Kelly et al., 2021; Boller et al., 2018; Little et al., 2018; Moffett & Mill, 2014; Ehlers et al., 2010). The surveyed students pointed out that the mix of face-to-face teaching and e-learning benefits the learning experience through the possibility of using the in-class lectures for hands-on training (Kelly et al., 2021; Little et al., 2018). One study states that thoroughly defined learning objectives help create a beneficial BL course (Little et al., 2018). A study analysing the implementation of a flipped classroom approach indicated that although students preferred this specific type of BL test results in the traditional teaching format were superior (Moffett & Mill, 2014). In contrast, Ehlers et al. (2010) reported that an elective BL course for teaching the examination of a dog‘s heart improved learning outcomes significantly (Ehlers et al., 2010).

In 2010, a survey analysing the acceptance of CBEL in veterinary education was conducted. Both students of all German speaking universities as well as practising veterinarians were asked and the results showed a high level of acceptance of innovative teaching methods such as e-learning. However, it was suggested not to replace traditional face-to-face teaching

entirely and to implement e-learning as a complementary element in teaching (Börchers et al., 2010).

One study analysed the acceptance of an interdisciplinary case-based BL course delivered to veterinary students (Koch et al., 2010). In this pilot project two veterinary universities collaboratively created an interdisciplinary course that was implemented as an elective BL course with three cases concerning neuroimmunology. The learning and authoring system CASUS® (Instruct gGmbH, München) was used, combined with a virtual classroom and in-class lectures over the course of three weeks. In a survey the acceptance of the course concept as well as the subjective learning outcome was analysed. Results showed a good acceptance rate by students and it was pointed out that the course enhanced the application of newly acquired knowledge. The project, however, was offered only to a small number of students and in a limited period of time (Koch et al., 2010).

2.2.2. Virtual patients

The term VP has been used very heterogeneously in publications in the field of medical education, which may lead to misunderstandings (Kononowicz et al., 2015). According to the literature review from 2015 the most commonly used definition of a VP in medical education is ´interactive patient scenarios´ (Kononowicz et al., 2015). The Association of American Medical Colleges however defines VPs as ´a specific type of computer-based program that simulates real-life clinical scenarios; learners emulate the roles of health care providers to obtain a history, conduct a physical exam, and make diagnostic and therapeutic decisions´ (Association of American Medical Colleges, 2007). At the same time, Ellaway et al. (2015) define a VP as a software tool that introduces learners to unfolding and interactive patient case situations and tasks (Ellaway et al., 2015).

Hence, Kononowicz et al. (2015) implemented a classification to help clarify the term of VPs in medical education and facilitate the exchange of research in this field (Kononowicz et al., 2015). This adapted classification consists of seven labels and then lists the predominant competency and technology followed by a short description (Table 2).

Table 2: Adapted virtual patient classification (Kononowicz et al. 2015)

Class label	Predominant competency	Predominant technology	Short description
Case Presentation	Knowledge	Multimedia systems	Interactive multimedia presentation of a patient case to teach primarily basic medical knowledge
Interactive Patient Scenario	Clinical reasoning	Multimedia systems	Interactive multimedia presentation of a patient case to teach mainly clinical reasoning skills (e.g. VPs created for the eVIP project)
VP Game	Clinical reasoning or Team training	Virtual worlds	Virtual worlds to simulate high risk scenarios and team training situations (e.g. Second Life VPs)
High Fidelity Software Simulation	Procedure or basic clinical skills	Dynamic simulation or mixed reality	Real-time simulation of human physiology to teach mainly procedures or skills such as surgical simulations. Non-standard devices (e.g. haptic technology) can be included
Human Standardised Patient	Patient communication skills	Multimedia systems	Video-recorded actors who role-play a patient to train patient communication skills
High Fidelity Manikin	Procedural and basic clinical skills, / Team training	Manikins or Part Task Trainers	Manikins with realistic anatomy to train complex procedures such as endoscopy
Virtual Standardised Patient	Patient communication skills	Conversational characters	A virtual representation of a human being using artificial intelligence technologies and natural language processing to train communication skills

Other authors also state that VPs are counted as case-based training (Zadow et al., 2013) as well as case simulations (Cook & Triola, 2009; Dhein, 2005), but it should be pointed out that not every CBEL or simulation can be counted as VP. Cook and Triola (2009) took a more critical approach and excluded cases that did not ´unfold in response to the learners input´

(Cook & Triola, 2009). Furthermore, other types of simulation like standardised patients, manikins and high-fidelity simulators are excluded from the definition of a VP (Cook & Triola, 2009; Huang et al., 2007). This view differs from the adapted VP classification system by Kononowicz et al. (2015).

Purpose of virtual patients in medical education

Virtual patients have been used to transfer a variety of skills or competencies (Cook & Triola, 2009). One of the most commonly mentioned strength of VPs is the facilitation of the development of clinical reasoning skills (Kononowicz et al., 2015; Consorti et al., 2012; Cook et al., 2010; Cook & Triola, 2009; Round et al., 2009; R. B. Friedman et al., 1978). ´Clinical reasoning is the application of knowledge to collect and integrate information from various sources to arrive at a diagnosis and management plan´ (Cook & Triola, 2009). Virtual patients offer students the opportunity to rehearse making clinical decisions (Round et al., 2009) and induce learning experiences through practice-like situations (Ellaway et al., 2015). The learner has the opportunity to interrogate the VP and request information on examinations or laboratory tests. The VP subsequently provides the learner with the required data and in the end a diagnosis and treatment plan needs to be made (Cook & Triola, 2009).

On the one hand, VPs can be used to teach a compilation of relevant cases despite patient availability and therefore guarantee students contact with very important or rare cases that every student should have worked on as a DOC (Huang et al., 2007; R. B. Friedman et al., 1978). On the other hand, VPs are able to demonstrate the long-lasting care of a chronically sick patient in a timespan of hours instead of years to simulate the monitoring and adjustment of therapy (Huang et al., 2007). Virtual patients are also used to teach basic science (Kleinsorgen et al., 2017) or to present a meaningful connection between basic science and applied science (Bogert et al., 2016) as well as communication skills in medical education (Bearman et al., 2001).

In the education of many different health professions VPs have been used to enable students to work through a clinical case on a computer (Trace et al., 2012), to increase the efficiency in clinician teaching (Round et al., 2009) and to facilitate individualised learning, offering learners more control over the content (Ruiz et al., 2006).

Virtual patient designs

As already mentioned above, there are different types of VPs described in literature (Kononowicz et al., 2015). Depending on the type of VP, different competencies such as knowledge and clinical reasoning skills or communication skills are conveyed and also different technology for the VP presentation is chosen (Kononowicz et al., 2015).

It is important to address the desired learning outcomes and critically analyse the efficiency of these goals rather than to blindly implement available and highly advanced technology (Kneebone & Baillie, 2008). With regard to specific learning outcomes, different formats of VPs are available: (i) a pedagogic format with a clear case structure and guidance for the collection of clinical information, (ii) a problem solving format to enhance clinical reasoning and decision making and (iii) a high fidelity format that provides a most realistic experience without feedback or guidance (C. P. Friedman et al., 1991). Pedagogic or guided formats of VPs should be presented to students without clinical experience and promote knowledge building, whereas high-fidelity and open structured VPs are for experienced learners giving them the opportunity for higher cognitive performance (Thistlethwaite et al., 2012; Cook & Triola, 2009; C. P. Friedman et al., 1991). According to Bloom's taxonomy, learning objectives within the cognitive domain can be classified into six main categories that successively build upon each other: (i) knowledge, (ii) comprehension, (iii) application, (iv) analysis, (v) synthesis and (vi) evaluation (Bloom et al., 1956). Unfortunately, often only the lower levels such as knowledge and memory development are found in education (Crowe et al., 2008). This subject is further discussed in the chapter 2.3.

In detail, regarding the specific set-up, which depends on the super ordinated type or format, VPs can be designed with different types of case progression referred to as free navigation, linear or branching case progression (Cook et al., 2010; Huang et al., 2007). Some VPs offer learners a guided case scenario while others request the learner to make their own diagnostic and therapeutic decisions (Ellaway et al., 2015). Virtual patient cases are mostly text-based with additional audio and video material of real patients (Zadow et al., 2013; Dhein, 2005). The method of interviewing the VP varies between free text and a predefined menu of questions (Cook et al., 2010). The patients' outcome can range from recovery to death, depending on the students choices (Balogh, 2014). Cook and Triola (2009) assume that the ideal design of a VP differs depending on the training level of the learner (Cook & Triola, 2009). The VP can be designed to be presented to different audiences such as ´students, resident trainees, faculty or allied health professionals´ (Huang et al., 2007).

Cook et al. (2010) identified features such as feedback, the range of task difficulty and the integration of multiple learning strategies as effective for a simulation format. The implementation of different learning strategies includes the provision of worked examples, the offering of hints, the opportunity for group discussion, feedback and the request of a full differential diagnosis list (Cook et al., 2010). In particular, the adaptive and interactive nature of a case forms an effective simulation and enables individualised learning (Cook et al., 2010). Work on a VP can occur with learner collaboration in a group or alone (Cook et al., 2010). Access to a case can be limited to one time or offered continuously (Huang et al., 2007).

Communication between student and lecturer can take place in small group lessons or lectures, or via a learning platform (Huwendiek et al., 2009).

The majority of VPs are created by a team of clinicians, lecturers and technologists (Round et al., 2009). Also, there are a few examples where students develop and experts/lecturers finalise the VPs (Duckwitz et al., 2021; Trace et al., 2012). A peer-review system can be used to choose suitable VPs for curriculum integration (Huang et al., 2007). Regarding case-based teaching methods, Kim et al. (2006) gave a conceptual framework for developing teaching cases. According to their framework, case-based teaching should be (i) relevant (level of learner, goals and objectives, setting of case narrative), (ii) realistic (authenticity, distractors, gradual disclosure of content), (iii) engaging (rich content, multiple perspectives, branching of content); (iv) challenging (difficulty, unusual cases, case structure, multiple cases), and (v) instructional (building upon prior knowledge, assessment, feedback, and teaching aids) (Kim et al., 2006).

There are also different strategies for curriculum implementation of CBEL (Hege et al., 2007). Virtual patients can be presented as optional additional learning material to students (Kleinsorgen et al., 2018) or integrated into the curriculum as mandatory elements (Cook & Triola, 2009; Huwendiek et al., 2009; Hege et al., 2007). For best efficiency VPs should be integrated into the curriculum (Issenberg et al., 2005) and linked to other instructional activities since VPs are merely one element in the education of skilled health professions (Cook & Triola, 2009). Also, students should be made familiar with new teaching methods early in the curriculum as it leads to better acceptance (Börchers et al., 2010). Blended learning is seen as an important principle in developing the curriculum and integrating VPs into the curriculum (Lehmann et al., 2015; Huwendiek et al., 2009).

Benefits of virtual patients

Through the individualised and self-directed nature of learning with VPs, students are more independent and learning takes place in a less stressful environment (Cook et al., 2010). The student has more control over the content and the pace of learning (Conrad et al., 2007). There is the freedom to make mistakes (Kneebone & Baillie, 2008; Dhein, 2005) as VPs help avoiding risks for learners (Ellaway et al., 2015) or to the patients welfare (Ellaway et al., 2015; Kneebone & Baillie, 2008; Dhein, 2005). The VP learning environment is dependable and safe and exercises can be repeated as often as needed (Round et al., 2009). Also, it is a standardised learning experience (Ellaway et al., 2015).

In contrast to paper-based cases, VPs offer more interactivity with the inclusion of visual and auditory media (Dhein, 2005) and thereby provide a more extensive learning experience (Trace et al., 2012). The opportunity of giving immediate feedback to the student helps to point

out possible deficiencies in their knowledge (Byron et al., 2014; Bryce et al., 1998; R. B. Friedman et al., 1978).

In general, VPs support the process of learning (Cook & Triola, 2009). They make it possible to connect basic science with clinical problems (Dhein, 2005) and at the same time help to increase the motivation to learn basic science (Kleinsorgen et al., 2017).

Educators on the one hand, benefit from VPs through the possibility of sharing resources (Byron et al., 2014; Smothers et al., 2008; Huang et al., 2007; Dhein, 2005) which can help minimise costs and capabilities (Byron et al., 2014; Conrad et al., 2007). Furthermore, VPs can be converted or repurposed to fit into other disciplines and can easily be updated when the state of science changes. To students, on the other hand, VPs offer a greater variety and range of cases as well as better accessibility to them (Byron et al., 2014) since it is not controlled by clinical settings (Kneebone & Baillie, 2008).

Disadvantages of virtual patients

Like online learning itself (Börchers et al., 2010), there are concerns that, because personal face-to-face feedback is missing, VPs can isolate learners (Bearman, 2003).

Also, Cook and Triola (2009) pointed out that ´affective skills (warmth, empathy and other non-verbal skills) still require practice and assessment using live human beings´ (Cook & Triola, 2009). However, Balogh (2014) stated that under specific circumstances and with a fitting learning environment emotions and sympathy can arise and learners can relate to the simulation or VP as well as the outcome of the scenario (Balogh, 2014).

Virtual patients mostly demand superior and complex programming and also take significant time to create (Huang et al., 2007; Dhein, 2005). At the same time, they are cost-intensive (Huang et al., 2007) and require intensive staff resources (Bearman, 2003). The type of VP has a great influence on the costs; for example, a VP created with an authoring tool with little technical effort is far more affordable than a high-fidelity VP that takes a lot of time and expensive technology to be created (Kononowicz et al., 2015).

There is also the potential risk that although the VP provides an accurate image of a clinical setting or case it may not be educationally valuable (Trace et al., 2012). The use of the VP would consequently be ineffective if it does not enable education (Cook & Triola, 2009). Another risk not to be underestimated is that costly and labour-intensive VPs are only used for a short period of time and not used continuously (Trace et al., 2012).

Results in medical and veterinary education

The implementation of VPs in medical education has intensified over the past decades (Berman et al., 2016; Lehmann et al., 2015; Huwendiek et al., 2009; Huang et al., 2007). The first VP was established at the University of Illinois and used for educating nurses (Bitzer,

1966). Since then, VPs have been used in various designs and forms (Kononowicz et al., 2015; Zadow et al., 2013; C. P. Friedman et al., 1991) for many different fields (Lehmann et al., 2015; Leung et al., 2015; Menendez et al., 2015; Leung et al., 2011; Bearman et al., 2001). Overall, the teaching efficiency and students' attitudes towards VPs in these studies was very positive. However, in veterinary medical education the process of integrating VPs has been slower (Majernik et al., 2017; Trace et al., 2012). Examples to be quoted are the virtual vet clinic (Dhein, 2005), the virtual equine farm (Nassar, 2011) and VPs used in teaching veterinary basic science (Kleinsorgen et al., 2018). Most of the VPs integrated in veterinary education revolve around small animal science (Bogert et al., 2016; Balogh, 2014; Byron et al., 2014; Dhein, 2005).

There are several other publications describing CBEL (Sawras et al., 2020; Börchers et al., 2010; Allenspach et al., 2008; Vandeweerd et al., 2007) as well as computer-assisted learning (Little et al., 2018; Abutarbush et al., 2006; Ehlers et al., 2003; Wilson & Sneed, 2001) and simulations (Keegan et al., 2009) in veterinary education. However, using the above-mentioned definitions these are not directly counted as VP.

Studies in veterinary education generally point out that students have a positive mindset towards VPs and find VPs a worthwhile (Dhein, 2005) and useful learning tool (Trace et al., 2012; Vandeweerd et al., 2007). Students were very satisfied with interactive elements and feedback within a VP (Bogert et al., 2016; Dhein, 2005) and also more motivated and engaged through the use of VPs (Byron et al., 2014). According to Kleinsorgen et al. (2017) VPs ´encourage active learning and the development of higher order thinking skills´ (Kleinsorgen et al., 2017).

Results of studies analysing the use of VPs in basic science in veterinary education show that VPs can help connect basic science and clinical scenarios (Kleinsorgen et al., 2017; Nassar, 2011).

There are many tools used for the implementation of VPs. In German veterinary education the multimedia learning and authoring system CASUS® is used by some faculties for CBL or implementation of VPs (Kleinsorgen et al., 2018; Kleinsorgen et al., 2017; Ehlers, 2009; Ehlers et al., 2003). Other tools that have come into use are the e-learning platform Articulate Storyline 2® (Articulate Global, Inc., New York, NY, USA) for VPs (Sawras et al., 2020) or the open source software and e-learning authoring tool courselab (WebSoft Ltd., Russia) (Ehlers et al., 2010).

Concerning the management of financial and staff resources, some educators implemented VPs precisely to save resources (Byron et al., 2014; Conrad et al., 2007), while others had to terminate the project due to the massive investment of hours by the educators (Dhein, 2005). In order to save valuable resources many projects in veterinary and medical education advise

(Kleinsorgen et al., 2018; Kneebone & Baillie, 2008; Vandeweerd et al., 2007) and support (Smothers et al., 2008) the sharing of VPs between training institutions.

Virtual patients in blended learning delivery formats

One study compared face-to-face group teaching with VPs in a BL delivery format for medical students. Focus group discussions showed that students liked both methods but requested an increased implementation of BL with VPs (Huwendiek et al., 2008). Also, students pointed out that working with VPs was a more active learning experience than in the group teaching setting. Group teaching was described as less specific and more dependent on the tutor or group, which influenced the learning outcomes, while the BL with VPs showed consistently high learning outcomes (Huwendiek et al., 2008). Another study by Lehmann et al. (2013) analysed VPs in a BL approach for the preparation of laboratory skills training. The study found that this resulted in more effective teaching time and better preparedness of the students, who showed a high acceptance of this format (Lehmann et al., 2013).

Sawras et al. (2020) describe an interactive CBEL course that was successfully implemented in a BL approach for veterinary students in their second year. The perceived utility and usability, perceived effectiveness, clinical confidence and impact of students learning preferences on a CBEL tool were analysed. This example suggests that BL is the ideal delivery method for CBL (Sawras et al., 2020). Feedback from students in this study indicated that CBEL helps students connect content from diverse lectures and subject areas, and facilitates the achievement of the learning objectives – knowledge, synthesis and evaluation – while very effectively ´teaching a methodical approach to a clinical case´ (Sawras et al., 2020).

2.3. Bloom's taxonomy for educational objectives

Bloom was a pedagogic psychologist. He classified educational objectives into three categories: ´the cognitive, the affective and the psychomotor domain´ (Bloom et al., 1956). The cognitive domain includes educational objectives such as knowledge acquisition up to the ´development of intellectual abilities and skills´ (Bloom et al., 1956). In contrast to this, there are the affective and psychomotor domains. The former refers to ´interests, attitudes and, values´ and the latter to ´manipulative and motor-skills´ (Bloom et al., 1956). This thesis exclusively refers to the cognitive domain for educational objectives and consists of six different taxonomy categories: (i) knowledge, (ii) comprehension, (iii) application, (iv) analysis, (v) synthesis and (vi) evaluation.

Categories of cognitive domain of Bloom's taxonomy for educational objectives

The individual categories of cognitive educational objectives are arranged in relation to their complexity and degree of abstraction, and successively build upon each other. Also, apart from the ´application´ category, all categories contain subcategories (Bloom, 1956). In this work, only the main categories are included as they are of relevance to the present thesis and student surveys.

The first category of Bloom's taxonomy refers to the ´acquisition of knowledge or information´, which involves the ´knowledge of specifics´ as well as the more complex ´knowledge of theories and structures´ (Bloom, 1956). Some of the sample verbs to describe learning objectives in this category are: ´to list´, ´to name´ and ´to define´ (Huitt, 2011).

In contrast to the first category the following categories refer to ´intellectual skills and abilities´ (Bloom et al., 1956).

Comprehension, the second category, consists of processes such as translation, interpretation and extrapolation. The focus is on the ´meaning and intent of the material´, and presumably, most tasks in educational institutions fall within this category (Bloom et al., 1956). ´To explain´, ´to describe´ and ´to summarise´ are some of the associated sample verbs (Huitt, 2011).

The third category deals with application, thus with the practise of abstraction in special or concrete circumstances for problem solving. The abstraction relates to ´general ideas, rules of procedures, or generalized methods´ (Bloom et al., 1956). Application differs from comprehension insofar as the student, when confronted with solving a new and unknown problem, has to ´apply the appropriate abstraction´ (Bloom et al., 1956). When referring to application related sample verbs include ´to demonstrate´, ´to apply´ and ´to construct´ (Huitt, 2011).

The fourth category, analysis, refers to the identification of individual elements of a communication as well as the recognition of its relations and the underlying structures (Bloom,

1956). In this category the listed sample words include ´to categorise´, ´to separate´ and ´to compare´ (Huitt, 2011).

In Bloom's taxonomy the fifth category, synthesis, refers to working with elements and parts to form either a whole, a pattern or a structure. According to Bloom et al. (1956) this also involves reconstruction and recombination and normally operates within a ´theoretical and methodological framework´ (Bloom, 1956). In contrast to the previous categories in which the work deals more with separate parts, synthesis refers to a more holistic task (Bloom et al., 1956). Some of the sample verbs to describe this category in detail are ´to create´, ´to hypothesise´ and ´to develop´ (Huitt, 2011).

The sixth, and therefore highest and most complex, category is called evaluation. This refers to judging about the value of for example ´ideas, works, solutions, methods, material´, while resorting to ´criteria as well as standards´ (Bloom et al., 1956). According to Bloom et al. (1956) evaluation belongs to the highest category because it builds on each previous category as well as on the combination of these (Bloom et al., 1956). Huitt (2011) lists ´to judge´, ´to recommend´ and ´to justify´ as some sample verbs in this last category (Huitt, 2011).

Application of Bloom's taxonomy

Bloom et al. (1956) described the taxonomy as a basic guidance for teachers, educators and researchers who concern themselves with questions about curricula and student evaluations. It should enable better discussions about problems and facilitate the comparison of curricula with learning outcomes (Pring, 1971; Bloom et al., 1956).

In analysing curricular goals and exams, the application of Bloom's taxonomy often shows that learning objectives are mainly located within the first level, knowledge, and important learning objectives from higher levels are neglected (Crowe et al., 2008). An analysis of the curriculum itself with the aid of the taxonomy helps educators to better understand the curriculum (Krathwohl, 2002).

Bloom's taxonomy in the context of current learning theories

Critical views of learning taxonomies point out that they tend to be shaped by the learning theories of their time, which are mainly behaviourism or cognitivism. They are therefore one-sided and because of this not as precisely applicable (Reinmann, 2013). Furthermore, a taxonomy might limit teaching content by only including applicable content, and a taxonomy itself is not beneficial for building up the content of a lecture, which is the actual issue for teaching and learning. A taxonomy however, can help to organise and classify the learning objectives of the lectures. In fact, learning objectives themselves are the starting point for creating lectures and planning technology based teaching and learning (Reinmann, 2013).

Since learning is a very complex process and needs to be viewed from many different perspectives, it appears to be impossible that one learning theory would suffice as justification for and explanation of all learning methods. Therefore, it is not a drawback that there are several theories about the process of learning – it is in fact important to be proficient in the different learning theories (Reinmann, 2013). Learning theories are no replacement for didactical actions, but they do have significant influence on decisions related to teaching and learning processes, therefore indirectly on the didactic design (Reinmann, 2013).

It is generally accepted that three major learning theories exist: (i) behaviourism, (ii) cognitivism and (iii) constructivism (Reinmann, 2013).

The behaviouristic learning theory is teacher-centred and applies to practical competencies in particular, helping to identify the corresponding learning objectives (Badyal & Singh, 2017; Torre et al., 2006). It was formed chiefly through animal experiments and dominated psychology until the middle of the 20th century (Reinmann, 2013). In medical education behaviourism finds its application especially in the training of clinical skills and in CBL (Torre et al., 2006). The desired skills are learned through feedback, corrections and rewards by the teacher, and typically it starts with a demonstration of skills by the teacher, followed by imitation by the students (Badyal & Singh, 2017).

From the 1980s on cognitivism, which considers learning as a mental process, became of significance (Reinmann, 2013). In cognitive learning theory the learner themselves and their internal cognitive structure is the focus, and ´the learner uses cognitive tools, such as insight, information processing, perceptions, and memory, to facilitate learning by assigning meaning to events´ (Torre et al., 2006). The cognitive learning theory promotes self-directed learning, and the teacher has a more supportive and organisational role (Badyal & Singh, 2017; Torre et al., 2006).

The first constructivist concepts were developed by Dewey, Piaget and others starting in the 1920s. Constructivism sees the learner in an active role when building knowledge through context and experience (Badyal & Singh, 2017; Bada, 2015). In this learning theory the emphasis is not only on the memorising of facts, but on an authentic and engaging learning environment as well as the understanding and transfer of principles (Bada, 2015; Garde et al., 2007). The teachers role is to guide the student, to encourage critical reflection and help the learning process (Badyal & Singh, 2017; Torre et al., 2006). In medical education constructivism finds its application for example in courses that integrate basic and clinical science and ´apply this knowledge to clinical cases´ (Badyal & Singh, 2017).

A movement from behaviourism and cognitivism towards a constructivist learning theory has taken place, and the current focus in education is on an approach that puts the learner in the centre and creates an interactive and authentic learning environment around this learner (Garde et al., 2007). Digital technology has fostered this shift in education and e-learning in

particular has created new possibilities (Tam, 2000). Garde et al. (2007) stated that constructivism and e-learning are a ´valuable means for modern teaching and learning environments´ and that impactful learning environments can be created through e-learning which cover all levels of Bloom's taxonomy (Garde et al., 2007). They give examples of learning objectives in all categories of Bloom's taxonomy which are implemented in their CBEL (Table 3).

Table 3: Examples of learning objectives for case-based e-learning on all levels of Bloom's taxonomy adapted from Garde et al. (2007)

Level	Category	Example
1	Knowledge	Answer knowledge questions added by the case author.
2	Comprehension	Interpret single lab test results (e.g., a value is extremely high).
3	Application	Conduct efficient physical examination; conduct efficient medical history taking.
4	Analysis	Analyse lab results and draw conclusions; analyse physical examination and draw conclusions.
5	Synthesis	Analyse lab results and analyse physical examination and draw conclusions, e.g., diagnosis and prognosis.
6	Evaluation	Evaluate your own behaviour when comparing it with the case expert's ´solution´; assess value of external medical knowledge found.

Particularly in medical education, it is necessary to teach and learn on all levels of Bloom's taxonomy (Garde et al., 2007). E-learning that includes multimedia and interactive elements can contribute to the achievement of all levels (Knolmayer & Montandon, 2003). Furthermore, CBL provides the ideal setting to reach more than one level of Bloom's taxonomy, and cases can be adapted so that individual levels or groups of levels can be focussed variably (Garde et al., 2007). Nevertheless, they emphasise that besides the e-learning tool, the surrounding setting and quality of the cases are of importance for effective implementation (Garde et al., 2007).

The definition of learning objectives has an important scope of application in the field of constructive alignment. Constructive alignment is a constructivist approach to teaching that was defined by the pedagogic psychologist John Biggs (Biggs & Tang, 2011). It promotes the idea that in education elements like learning objectives or ´intended learning outcomes,

teaching/learning activities, assessment tasks and their grading´ are all coordinated and complement each other (Biggs & Tang, 2011).

2.4. Animal welfare in educational training

When planning and executing animal experiments, the number of animals needed, as well as the distress and harm caused to the animals must be reduced to an absolute minimum. If possible, the animal experiment should be replaced with alternative methods. These principles are called the principles of the 3Rs (Replace, Reduce, Refine) by Russel and Burch (Russel & Burch, 1959) and should be applied to all animal experiments (Directive 2010/63/EU, 2010; TierSchG, 2006). In 2013, the German animal welfare act was revised and as a result any hands-on training and further education using animals is classified as animal experimentation (TierSchG, 2006). Therefore, special animal welfare approval must be requested and the 3R principles must be applied in educational training using animals. Besides the legal foundations calling for the implementation of 3R, veterinary students themselves feel uncomfortable about harming animals for educational purposes and demand alternatives to animal experiments in veterinary education (Martinsen & Jukes, 2005). Nonetheless, practical training with animals is not only of relevance to the training of veterinary students for their future profession as practising veterinarians but also to the preparation of researchers in the field of scientific research (Thöne-Reineke et al., 2018).

In veterinary education the TAppV und EAEVE define specific DOCs and demand practical training with animals (EAEVE & FVE, 2016; TAppV, 2006). But because the hands-on training with animals classifies as animal experimentation, the 3R principles must be applied (Directive 2010/63/EU, 2010; TierSchG, 2006). This presents a challenge for educators in veterinary education. According to Knight (2007) the harmful use of animals in teaching includes invasive procedures, significantly stressful practices, any method resulting in the death of the animal and the dissection of animals killed only for this intention (Knight, 2007). Surgery and physiology are said to be the subjects with the largest number of cases of animal harm in veterinary training (Knight, 2007). In the past, many educational institutions rejected alternatives to the use of animals in education for many reasons such as the upholding of tradition, insufficient resources or doubts regarding the efficiency of possible alternatives (Knight, 2007). However, a total replacement of all animal use in veterinary educational training would result in a severe reduction of educational quality, and to be able to serve the 3R principles education must include training using animals (Thöne-Reineke et al., 2018).

Methods considered for 3R implementation and alternatives to animal use in educational training are, on the one hand, physical items such as ethically-sourced or advanced-synthetic cadavers, models, training manikins, 3-D printed materials and simulators and, on the other

hand, digital technologies such as instructional videos, computer software, simulations and virtual reality (Vemulapalli et al., 2017; Jukes & Martinsen, 2006; Jukes & Chiuia, 2003). Some of these have not only been proven as equal replacement methods but as improvements compared to teaching methods using animals (Knight, 2007; Martinsen & Jukes, 2005). In laboratory animal science training a study regarding alternatives to animal use showed a positive attitude of educators towards the use of simulators but also highlighted the demands for better and more authentic models (Humpenöder et al., 2021).

Knight (2007) pointed out some additional benefits of the use of these alternatives, which include a better understanding of complex contexts, a less stressful learning environment, a better usage of resources and the ´integration of clinical perspective and ethics early in the curriculum´; also the exposure of students to potentially toxic chemicals in laboratories or anatomy dissection would be omitted (Knight, 2007).

Nonetheless, it is still necessary to combine such alternatives with non-harmful hands-on training with animals or animal patients (Martinsen & Jukes, 2005). Furthermore, it is important that the alternative approaches and their efficiency are validated (Pereira et al., 2017).

Regarding digital technologies as alternatives to animal use and the possibility of implementing the 3R principles in veterinary education, the report of the ECCVT expert working group stated that digital technologies may be useful and can help ´increase sustainability and efficiency of used resources at many levels, and enhance animal welfare by improving the quality of the training of veterinarians who will take care of the animals´ (ECCVT, 2020). Nonetheless, it is underlined that practical hands-on training is elementary and exceedingly important for veterinary training and for achieving all the necessary DOCs. Therefore, digital technologies should only be used as a complementary addition and not as full replacement (ECCVT, 2020; Sawras et al., 2020; Börchers et al., 2010).

A study comparing e-learning instruction with a traditional instruction course using live demonstration of skills for veterinary training found out that students' test results concerning knowledge gain was higher with the e-learning module. Even more importantly, the performance of the corresponding hands-on skills regarding the students' speed and confidence was also better in the e-learning group (Abutarbush et al., 2006). The authors conclude that e-learning can be a valuable alternative tool for the preparation of students prior to the hands-on training itself (Abutarbush et al., 2006).

When implementing CBEL in education the advantage is the preparation of students and their introduction to specific procedures through different learning methods prior to the hands-on training (Ehlers et al., 2003). Also, Sawras et al. (2020) pointed out that ´CBEL may be an effective method of creating a bridge between lecture and live animal practice´ (Sawras et al., 2020).

Furthermore, e-learning in general as well as CBEL offers students a safer and less stressful learning environment (Sawras et al., 2020; Cook et al., 2010) in which mistakes can be made without harm to the animal (Ellaway et al., 2015; Kneebone & Baillie, 2008; Dhein, 2005). Students are able to capture relations between clinical processes, exercise the application of acquired knowledge in a safe and standardised environment and ´understand the necessary steps and decisions required when treating a live animal´ (Sawras et al., 2020). Subsequently, they may feel more secure when practicing in the corresponding hands-on training with animals afterwards (Keegan et al., 2009).

Although VPs can be included in digital alternatives to animal use in veterinary education, VPs are rarely mentioned in the context of 3Rs in veterinary education. There are studies mentioning VPs in relation to virtual reality programs for the training of hands-on skills as alternatives to animal use in medical education (Pereira et al., 2017; Jukes & Martinsen, 2006) but this classification differs from the definitions of a VP (see chapter 3.2.2.).

Moreover, the question arises of how best to implement VPs to serve the 3R principles in the training of veterinary students. The review by Pereira et al. (2017) suggests the general procedure of using models and digital alternatives first, then to let students study ethically-sourced cadavers and finally include them in the treatment of animal patients under close supervision which could present a starting point to that question (Pereira et al., 2017).

3. Aims and objectives of this thesis

In summary, it can be said that ILs in German veterinary education are supposed to present interdisciplinary and case-based content in the field of clinical medicine and VPH with relevance to veterinary practice. Prior to this work, ILs at VM-FUB did not fulfil these requirements and with regard to the final report of the EAEVE it was reasoned to revise the ILs. Furthermore, an internal student survey showed that students themselves were not satisfied with the ILs, and acknowledges the need for improvement.

The analyses and results of VPs implemented in veterinary and medical education are promising and show that students are motivated using VPs. VPs in a BL delivery format could offer a feasible solution to the aforementioned deficiencies and help integrate interdisciplinary case-based content into the ILs. However, in general there is limited knowledge about the potential for VPs to promote veterinary IT or the implementation of VPs in a BL delivery format in veterinary education. Also, the promotion of the learning objectives according to Bloom's taxonomy in the context of VPs has not yet been investigated.

Within the QuerVet project the objective was to (i) create sustainable, interactive VPs that have an interdisciplinary character and are relevant to veterinary practice, (ii) integrate the VPs in a modular BL format into the curriculum as part of the mandatory clinical ILs and (iii) to analyse their suitability for teaching ILs in veterinary education.

This thesis explicitly addresses the hypotheses that (i) through VPs in a BL delivery format students are able to reach learning objectives that are referred to in categories 1-3 of Bloom's taxonomy, (ii) VPs in a BL delivery format are able to implement the three KCs of ILs (interdisciplinarity, case-based approach, relevance to veterinary practice) better than the previous traditional face-to-face format in the ILs, and that (iii) VPs are accepted by students for the delivery of clinical interdisciplinary content in a BL delivery format.

4. Publications

4.1. Teaching small animal reproduction via virtual patients

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Authors contribution

LV designed the study and developed the evaluation concept; planned and submitted the animal welfare request for the animal experiments. LV carried out the study, developed and created the described clinical cases/VPs; analysed, interpreted and presented the data and drafted the manuscript.

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SUPPLEMENT ARTICLE

Reproduction in Domestic Animals WILEY

Teaching small animal reproduction via virtual patients

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Abstract

Virtual patients have become an interesting alternative in medical education. Due to increasing demands regarding theoretical and clinical teaching and to improve an interdisciplinary approach, a new blended learning concept including virtual patients was developed and implemented in the veterinary curriculum of the Freie Universität Berlin. In the presented project, three virtual patients from the field of canine reproduction were developed. They focus on pregnancy diagnosis with suspected luteal insufficiency, pyometra and benign prostatic hyperplasia, respectively. The results of an evaluation by veterinary students of the 7th semester showed a high acceptance of virtual patients in a blended learning reproduction module in the interdisciplinary lectures. Students especially preferred videos, such as video lectures, hands-on videos and animations as well as a glossary for background information, to successfully and autonomously work on a virtual case. The content covered by the new modules that were developed in the context of this project is part of a spiral curriculum; they will be revised and enhanced during the clinical year.

KEYWORDS

dogs/cats, general reproduction, interdisciplinary research, online learning, simulation training, veterinary education

1 | INTRODUCTION

The project QuerVet focuses on improving the interdisciplinary lectures offered to veterinary students at the Faculty of Veterinary Medicine, Freie Universität Berlin, by presenting relevant virtual patients and cases in veterinary public health (VPH).

In the German regulations of licensing to veterinary medicine (TAppV, 2006), the curriculum time available for interdisciplinary lectures is 196 hr; most of it in study semesters 6–8.

These interdisciplinary lectures are supposed to offer case-based content that is relevant in veterinary practice. The listed clinical subjects, for example, should address health problems related to internal medicine, surgery and reproductive medicine with consideration of pathology, animal nutrition and anatomy. The clinical focus should lie on identifying the origin, diagnosis and therapy of diseases through specific cases (TAppV, 2006).

Until 2016, the interdisciplinary lectures offered at our faculty did not follow a coherent course concept. Lecture slots were assigned to the different institutions and lecturers, and the selection of topics was heterogeneous. Most lectures were given as an in-class lecture with a duration of three hours, and less than half of the topics were presented in an interdisciplinary or case-based structure. In a

survey in 2014, over 50% of the interviewed students evaluated the interdisciplinary lectures as not efficient for teaching interdisciplinary topics (Schunter, 2016).

Education of veterinary students must include practical clinical training on live animals. For this, students have to be prepared through a learning cascade starting with demonstration of certain practical procedures, repetition of those procedures under supervision and the refinement of the procedure. Since the use of animals in education is classified as an animal experiment according to the European Directive 2010/63/EU on the protection of animals used for scientific purposes (Directive, 2010/63/EU, 2010) and this has been implemented into the German Animal welfare act in 2013 (German Animal Welfare Act, 2006), it has to be applied for authorization to the competent authorities. Everyone using animals for educational purposes is obligated to implement the 3R principles, which means to replace animal use by alternative teaching methods wherever possible (Replace). If animal use is unavoidable, the number of animals has to be reduced to the minimum requisite (Reduce) and techniques should be used which pose the minimal burden to the animal (Refine).

Virtual patients are 'interactive computer simulations of real-life clinical scenarios for the purpose of medical training, education, or assessment' (Ellaway, Candler, Greene, & Valerie, 2006). It has been shown that the interactive format of virtual patients enhances diagnostic and clinical reasoning skills of veterinary students (Kleinsorgen et al., 2018) and that virtual patients make students feel better prepared for real patients with similar clinical symptoms (Lehmann et al., 2015). The combination of virtual patients with face-to-face teaching is important for their successful integration, which is called 'blended learning' (Lehmann et al., 2015). More benefits of virtual patients are avoiding risks for patients and learners, standardizing learning experiences and mediating learning experiences using practice-like situations (Ellaway, Topps, Lee, & Armson, 2015).

Virtual patients, therefore, could offer a feasible solution to the problems of interdisciplinary education as well as help to further refine and reduce animal experiments in practical veterinary education.

However, to this extend virtual patients have not yet been systematically integrated in veterinary education for teaching interdisciplinary lectures in a mandatory blended learning format in Germany.

Our aim was to develop and implement an interdisciplinary course with virtual cases starting with a small animal reproduction module consisting of three virtual patients. They were implemented in a blended learning concept, adapted to the existing curriculum and addressed topics relevant in veterinary practice. The evaluation of this reproduction module by students focussed on the acceptance of virtual patients. For this context, we examined the didactic use of media and the usability and the self-assessed learning outcome. Also, we analysed the assessment of the blended learning concept in an overview of the complete semester with several modules.

2 | MATERIALS AND METHODS

2.1 | Design

2.1.1 | First step—Choice of Topics and learning objectives

Relevant clinical topics for the virtual patients were identified in a survey sent to veterinarians working at Freie Universität Berlin and other veterinary clinics or practices in Germany. From this list, topics were chosen in consultation with the clinical lecturers at our faculty for the blended learning approach. According to the specifications for interdisciplinary lectures (TAppV, 2006), we created a general case structure and then aligned it to real scenarios with specific diagnoses. We defined learning objectives for each case and made them available to the students at the beginning of the case. The learning objectives were categorized according to Bloom's Taxonomy for learning objects for systematic classification of the process of learning (Bloom, 1976). In addition, for each specific topic, we created individual modules containing different virtual patients or cases.

2.1.2 | Second step—Curriculum and implementation

The curriculum was analysed for the most appropriate time to implement the specific topics, so that the students are able to work on each module while having enough prior knowledge. This analysis was a first step to establish a learning spiral, that is that specific information will be refreshed and enhanced during the curriculum. Furthermore, the relevant prior knowledge necessary to understand and work on the case was listed at the beginning of each case. For the implementation of the modules within this blended learning approach, free slots were provided in the timetable for students to work on the online cases. However, they could also use other times during the respective time periods, generating a high flexibility in time and place. Students had usually one week to work on each case. To increase autonomous and active learning in the online phase, the students received virtual patients with necessary background information and if needed the opportunity to get support for technical- or content-related problems. To enable face-to-face discussions on a higher level during the in-class lecture, we scheduled one 90-min lecture after the completion of the reproduction module with three online cases.

2.1.3 | Third Step—Learning platform and case structure

We used the learning platform tet.folio, an online web application developed at Freie Universität Berlin, Department of Physics, Physics education unit (Haase, Kirstein, & Nordmeier, 2016). It was created with

an emphasis on customized interactive content. Students work page by page through the online course-book. Answers, notes and other activities are always saved individually. The platform was integrated into the learning management system Blackboard (Washington DC, USA) used at the Freie Universität Berlin. This had the advantage that students had a familiar platform to access the modules, that tet.folio activities were automatically transferred into the Blackboard grade centre and that users only needed to login once (single-sign-on).

Within the case structure, realistic scenarios of decision-making and assessing clinical findings were simulated. In addition, feedback tools were implemented to provide the students with visual and textual feedback depending on the correctness of the given answer or decision. For each virtual patient, a glossary with relevant background information including hands-on videos and animations regarding the patient and its diagnosis was created and selectively linked to the suitable position within the case. Also, students had the opportunity to use a virtual notepad to keep their notes about the patient at hand all the time. After completion of the case, students were given access to download and print a modified glossary.

2.1.4 | Fourth step—Material and media

Whenever possible, already existing material such as radiographs, ultrasound images or videos of patients and their symptoms was used to build realistic virtual patients.

In addition, educational videos including videos showing practical procedures (hands-on videos) or short lectures as well as animations were created to give the students more insight into or understanding of specific topics regarding the patient.

Interactive elements such as an abdominal ultrasound examination and a swab-sample taking were created in a close cooperation with the Department of Physics. For the interactive element of the abdominal ultrasound, for example, the movable picture of an ultrasound probe was linked to the playback of a sagittal abdominal ultrasound of a bitch using a specific html5 programming routine. The students were asked to move the probe with the mouse cursor to control the video which would move accordingly to the student's mouse cursor motion (Figure 1).

2.1.5 | Fifth step—Realization

For the clinical part, one pilot case concerning small animal reproduction and a related in-class lecture for further discussion were implemented. In a short introduction prior to the implemented case, the concept and web application were explained, and students had the opportunity to log in with our assistance and ask further questions.

The following year, two additional cases were added to this reproduction module. After completion and implementation of this reproduction module, students worked on three virtual patients in a three-week online period and finished the module with an interactive in-class lecture for discussing questions and problems (Figure 2).

2.1.6 | Ethic votum and animals in research

An ethics proposal for the evaluation by the students was submitted with the application number EA4/125/18 and approved by the Ethics Committee of the Charité at Campus Benjamin Franklin.

All animal-patient-related examinations, procedures and handling protocols used in the respective modules were approved by the local competent authorities, which is in Berlin the Regional Office for Health and Social Affairs (LAGeSo, L 0001/17). All applicable national and institutional guidelines for the use and care of animals used in education were respected. Experimental procedures were assessed as minor discomfort experienced by the animals, and therefore the severity was categorized as mild.

2.2 | Evaluation

For the pilot case, we chose a more complex survey, which, in addition, concentrated on the didactic use of media and the case-related usability. Both we examined immediately after completion of the online case. For the didactic use of media, the usefulness of provided functionalities (description of learning outcome, textual feedback, visual feedback, notepad, mail button for support, introductory tutorial) and material such as the video lecture, hands-on videos, animations, interactive element (swab-sample taking/abdominal ultrasound) and the glossary were examined (Appendix S1). The survey of the usability focused on availability of necessary information, comprehensibility of texts, structure of texts, availability of important content for processing of tasks, association of the case with clear tasks and objectives and the level of difficulty of the exercises (Appendix S2). The case-related usability was also evaluated in the following semesters 2017/18 and 2018/19.

Moreover, with a focus on the overall concept, we asked the students in a paper-based survey about the self-assessed learning outcome of the reproduction module in the three categories knowledge, comprehension and application (Appendix S3) and the blended learning concept (Appendix S4). These two surveys were conducted in the semesters 2017/18 and 2018/19. The survey of the self-assessed learning outcome in the first three categories is already implemented in the quality assurance at the Faculty of Veterinary Medicine, Freie Universität Berlin. This survey questionnaire was adjusted to the new reproduction module with a total of 26 specific statements in the three categories.

The survey of the blended learning concept consisted of five statements regarding the explanation of the overall concept, preference of face-to-face teaching over online teaching for the learned topics, preference of blended learning, wish for expansion of the concept to other lectures and the meaningful combination of contents of online cases with face-to-face lecture in the modules of the semester. Here a veterinary public health module was integrated into the winter semester besides the reproduction module and examined equally.

An overview of the conducted surveys can be seen in Figure 3.

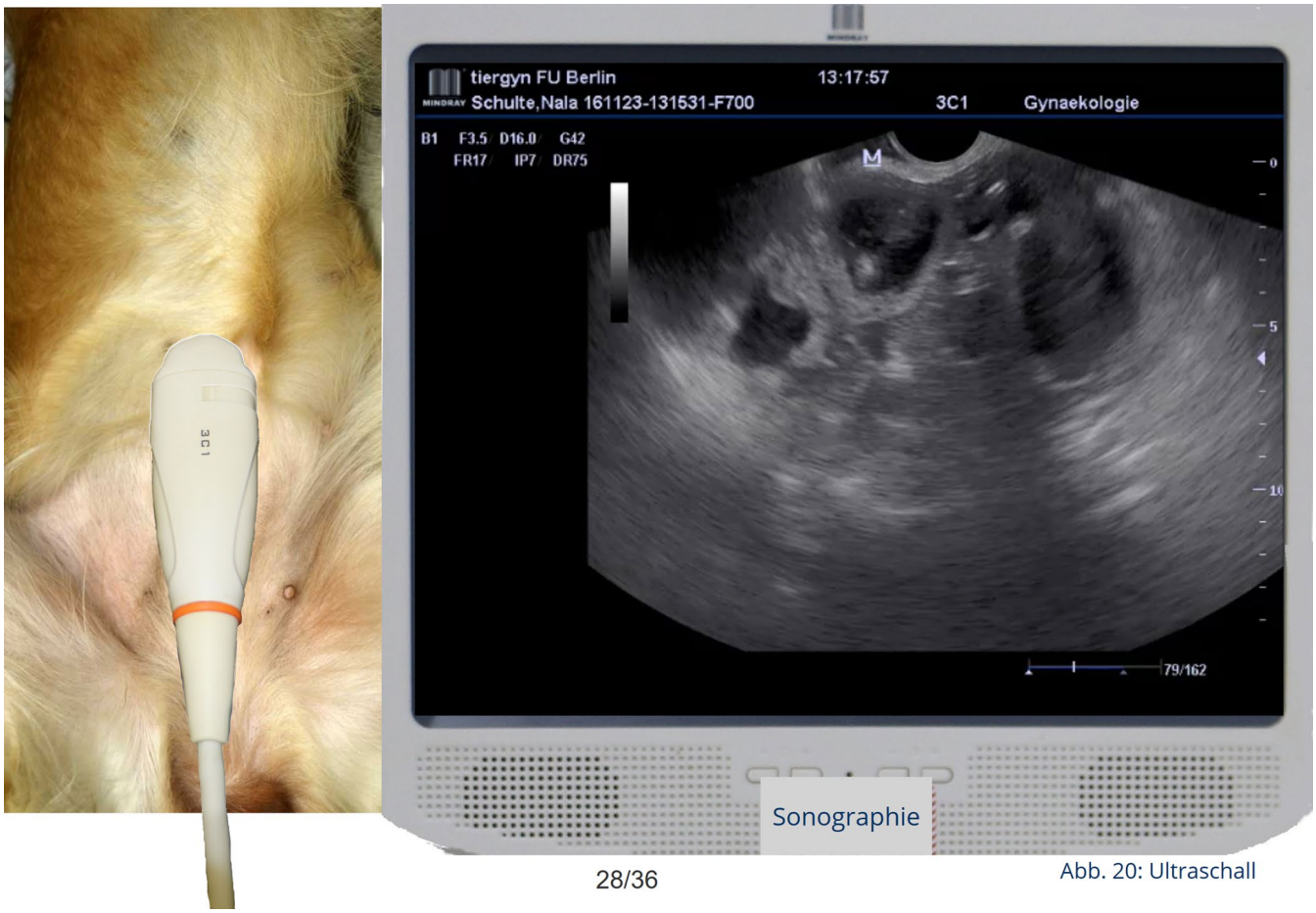

FIGURE 1 Screenshot of an interactive element in the pilot case. By moving the probe up and down with the mouse cursor the ultrasound-video on the right moves accordingly. Students were asked to analyse the ultrasound findings and determine if the bitch is pregnant

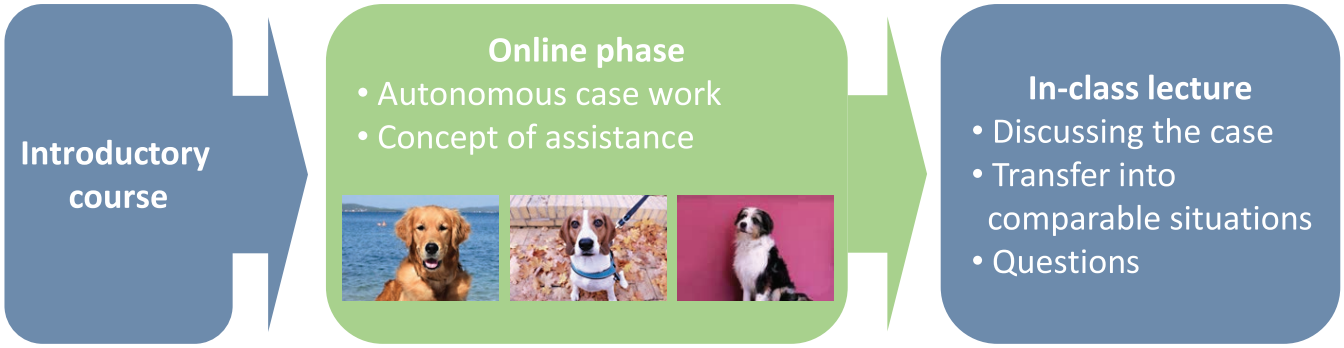

FIGURE 2 Chart showing the blended learning concept of the reproduction module with an introductory course, an online phase for working autonomously on the three virtual patients and an in-class lecture for further questions

In cooperation with the Center for Digital Systems at Freie Universität Berlin, we developed survey tools. This survey included questions and statements to which students were asked to indicate their level of agreement on a response scale consisting of items of the Likert type. The surveys were carried out with Unizensus 5.4.14 (Blubbsoft GmbH). Unizensus is the central evaluation software of the Freie Universität Berlin for teaching and course evaluations.

The results of the surveys were analysed and used for improvement of the following cases.

All surveys were anonymous and voluntary.

After having conducted the pilot case, newly developed e-learning cases were continuously evaluated with both paper-based and online surveys depending on the phase within the modules, but the size of the surveys was reduced.

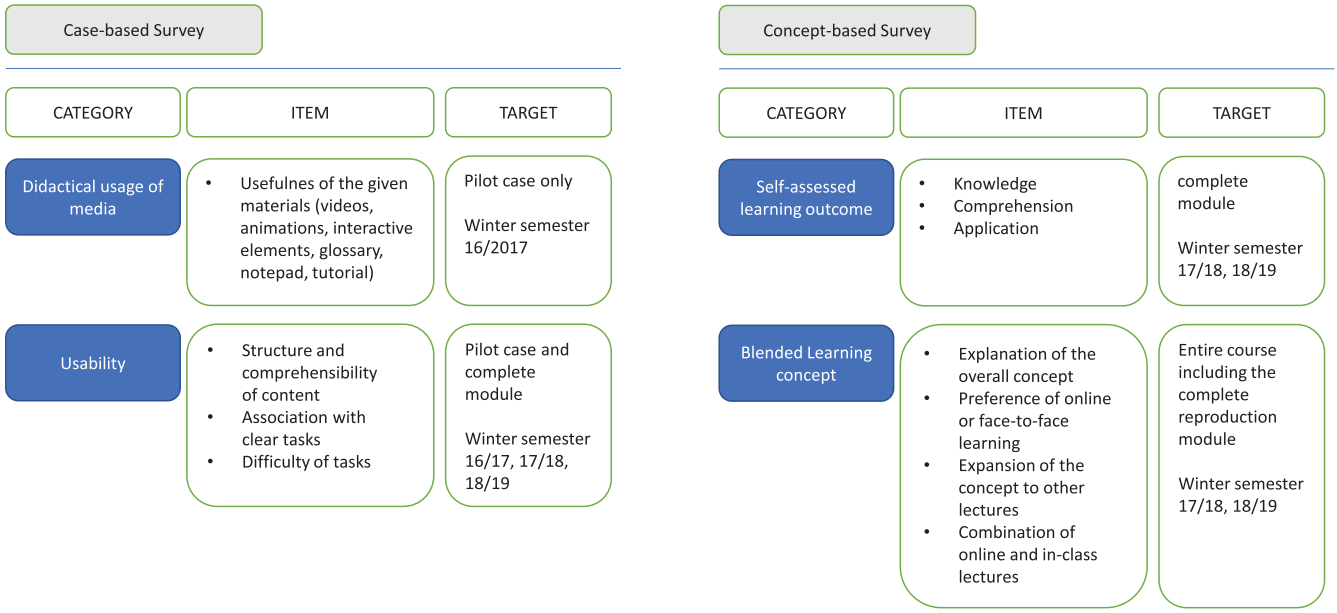

FIGURE 3 Concept of case-based and concept-based surveys, showing items and targets of each survey

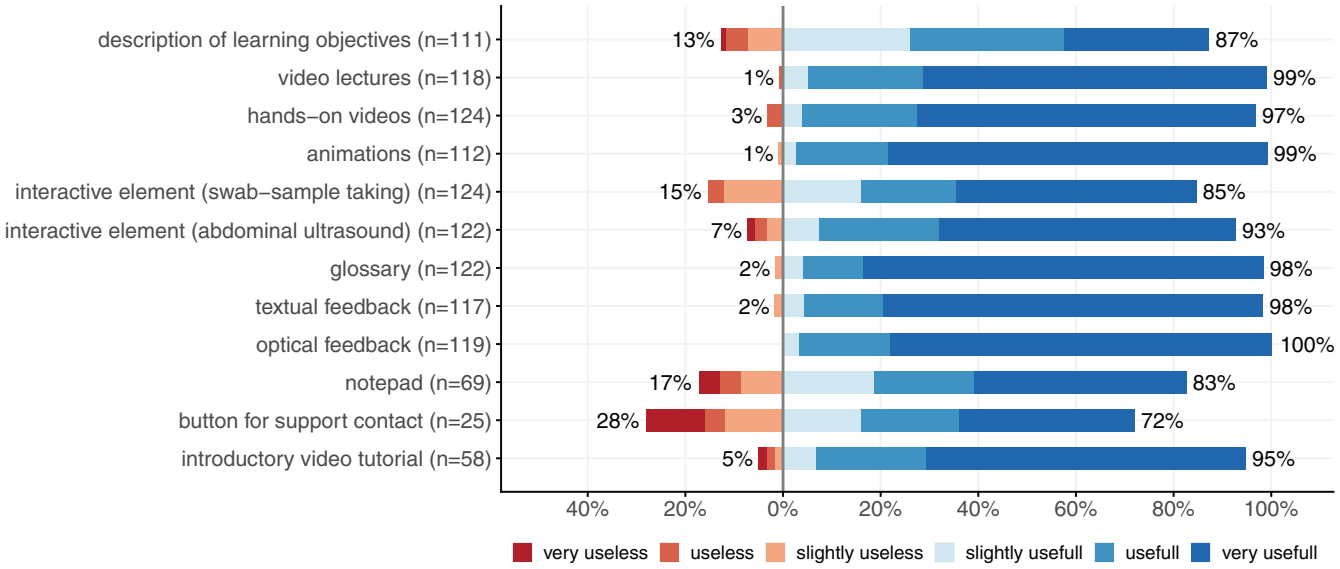

FIGURE 4 Diverging stacked bar charts showing results of didactic use of media of the pilot case in the winter semester 2016/2017 (n = 156) in a response-scale consisting of items of the Likert type (1 = very useless to 6 = very useful). The negative and positive proportions of 12 items are included. The question was: 'Did you find the following functions and materials of the online case helpful'? See Table S1 for exact numbers

2.3 | Statistics

Responses to Likert-type questions were expressed as overall, positive and negative proportions per item. The internal reliability was calculated with Cronbach's α coefficients, and a value greater than 0.60 for all scales was valued for a good reliability (McKinley, Manku-Scott, Hastings, French, & Baker, 1997). The binominal 95% confidence intervals were calculated after Wilson (Agresti & Coull, 1998). All answer proportions were considered significantly different from values outside their confidence intervals. For all statistical calculations and the creation of related figures, we used the software R version 3.6.0 (R Foundation for Statistical Computing) using the package sjPlot version 2.7.2 (Lüdecke, 2018).

3 | RESULTS

The compilation of the first virtual patient started in July 2016 as a pilot case and was first released and extensively evaluated with students of

the 7th semester in February 2017. The assignment was an ovulation timing and pregnancy diagnosis with suspected luteal insufficiency.

The two additional virtual patients addressed pyometra and benign prostatic hyperplasia and were added to the module of reproduction in February 2018.

3.1 | Case-based survey

3.1.1 | Didactic use of media

For the survey of the pilot case, students of the 7th semester in the winter semester 2016/2017 (n = 156) answered questions regarding the didactic use of media on a response scale consisting of items of the Likert type (1 = very useless to 6 = very useful).

Significantly more than 90% of the students found the following media type useful: video lectures (99% [95%–100%]), hands-on videos (97% [93%–100%]), animations (99% [95%–100%]) glossary (98% [94%–100%]), textual feedback (98% [93%–100%]) and the visual feedback (100% [96%–100%]). The lowest usefulness was reported for the support contact button with a percentage of negative answers of 28% (Figure 4).

3.1.2 | Usability

Usability was analysed for the pilot case, respectively, the entire module in the winter semesters 2016/2017, 2017/2018 and 2018/2019. The survey consisted of five items focussing on comprehensibility, structure, availability of necessary information and the presence of clear tasks and aims with a response-scale consisting of items of the Likert type (1 = strongly disagree to 6 = strongly agree). The total number of students in the three semesters was 479.

Significantly more than 90% of the students agreed on a high usability in all five items. Most of the students chose strongly agree. The internal reliability of the scale usability with five items was also high with Cronbach's alpha at α = .87 (Figure 5). The level of difficulty of the implemented exercises was also evaluated with a response scale consisting of items of the Likert type (1 = far too easy to 5 = far too difficult). On this scale, more than 88% of the students agreed on exactly the right degree of difficulty.

3.2 | Concept-based survey

3.2.1 | Self-assessed learning outcome

The survey of the self-assessed learning outcome consisted of 26 statements and was examined in the 7th semester with the complete reproduction module in the winter semesters 2017/2018 and 2018/2019 (n = 323). With respect to the 26 specific statements on three categories of Bloom's Taxonomy for learning objects, most of the students agreed on reaching a high level of the self-assessed learning outcome in each category with the new reproduction module. The individual questions can be found in the Appendix S3.

The highest learning outcome, with a 95% proportion of positive responses, was recorded in the 'Knowledge' category. The categories 'understanding' and 'application' had a percentage of positive responses of over 80%. To analyse the reliability, Cronbach's alpha was calculated for all three categories of the self-assessed learning outcome and it exceeded α = .81 for all three aspects (Figure 6).

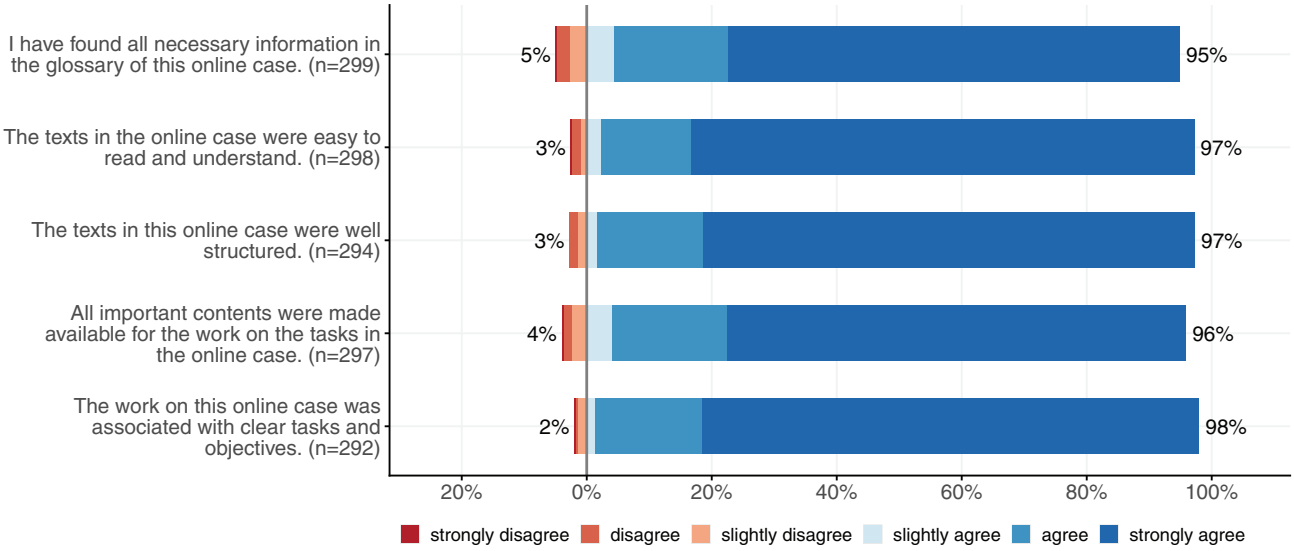

FIGURE 5 Diverging stacked bar charts showing results of the case-related usability in the pilot case in the winter semester 2016/2017 and for the complete reproduction module in the winter semesters 2017/2018 and 2018/2019, demonstrating the negative and positive proportions of five items (n = 479). See Table S2 for exact numbers

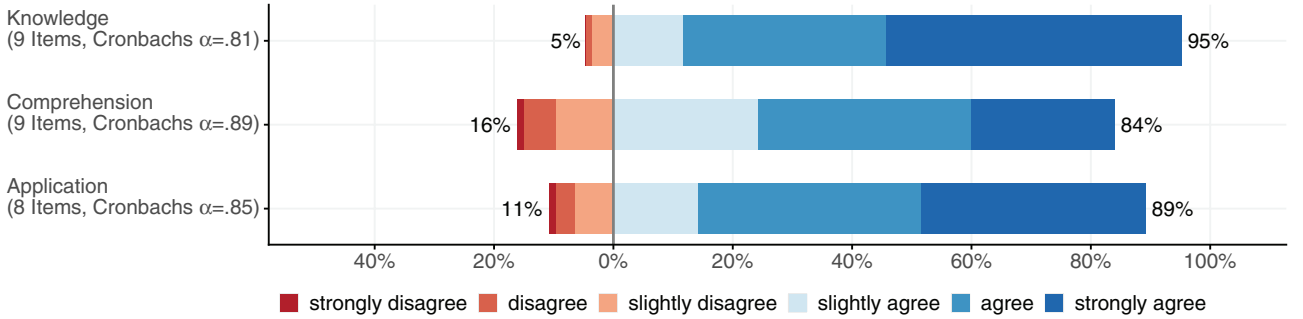

FIGURE 6 Diverging stacked bar charts showing results of self-assessed learning outcome in the categories knowledge, comprehension, application in semesters 2017/2018 and 2018/2019 in the reproduction module (n = 323). For the questions of each category see Appendix S3

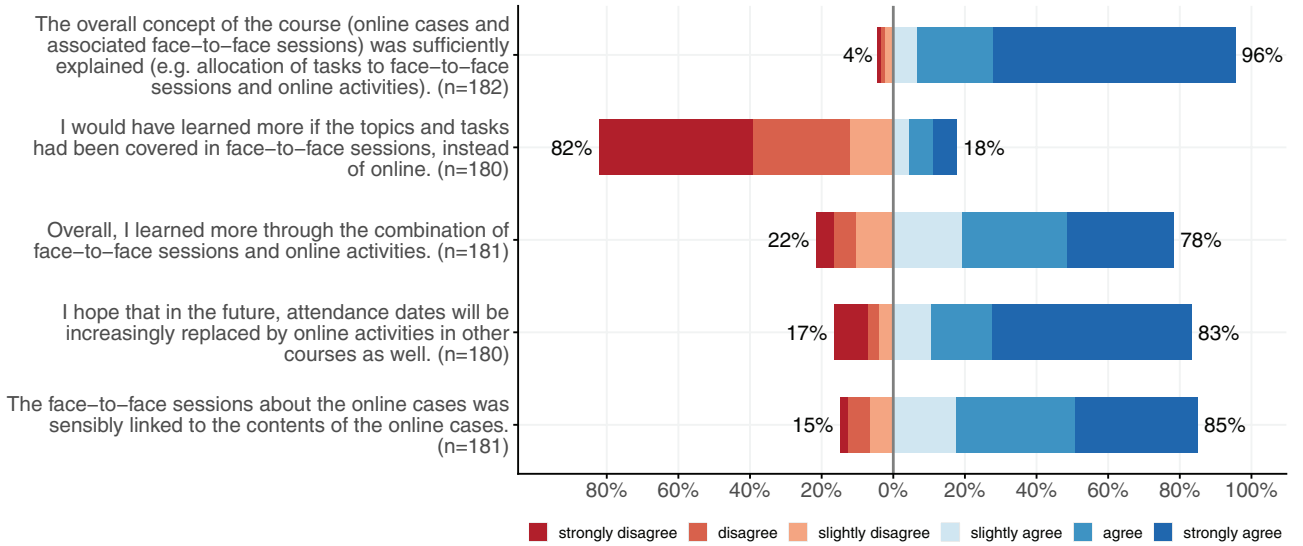

FIGURE 7 Diverging stacked bar charts showing results of blended learning concept consisting of five items in semesters 2017/2018 and 2018/2019 (n = 323). See Table S4 for exact numbers

3.2.2 | Blended learning concept

The survey of the blended learning concept consisted of five items and was examined in the 7th semester with several modules in the winter semesters 2017/2018 and 2018/2019 (n = 323). Results showed that significantly more than 70% of students were satisfied with the new concept and its implementation, preferred the blended learning over in-class lectures and hoped for expansion of the concept. The second statement holds an opposite significance as to revise the student's awareness. A blended learning subscale was not calculated, as the items covered many different dimensions (Figure 7).

4 | DISCUSSION

The interdisciplinary lectures at the Freie Universität Berlin in 2014 were evaluated as being suboptimal and have not been based on a coherent course concept. Apart from that, the requirements for clinical veterinary training in general regarding animal welfare have changed.

Therefore, the task was not only to successfully create a consistent course concept that fulfilled the teaching requirements but also to implement virtual patients in a blended learning format.

For this reason, an extensive course concept was developed. In addition, we assessed the acceptance of this format by students and evaluated whether virtual patients were suitable for teaching interdisciplinary lectures in a mandatory blended learning format.

According to the evaluation results, students found video lectures, hands-on videos, animations and the glossary very useful, which showed that students appreciate this kind of supporting media for virtual patients. The videos and glossary not only give background information to a patient, but also support understanding contexts and applying knowledge to relevant situations. The lowest number of votes and lowest rating concerning usefulness was given to the button for support. The lowest rating can presumably be explained by the fact, that the button was not needed or used very often. This can also be the reason for the few votes as well. Students

sometimes contacted the project team directly via E-Mail for mainly technical related problems.

The usability of the three cases was graded as very high concerning the comprehensibility, structure, availability of necessary information, the presence of clear tasks and aims and the difficulty of the exercises. In this context, the usability of case-based learning modules is essential for a good acceptance of virtual patients in education.

When students were asked to assess their learning outcome (Figure 6), the first category (knowledge) of Bloom's Taxonomy received the highest agreements. Knowledge means remembering facts and is considered being the lowest category. It may be concluded that the presented teaching concepts mainly focus on knowledge acquisition. However, also the second (comprehension) and even the third category (application) received agreements of more than 80%. These categories are regarded as relatively high concerning the level of understanding and application. It was our aim to enhance autonomous and active learning on higher levels with this format of education. Although there were higher categories of learning integrated in the cases, we only evaluated the first three categories. A survey of higher dimensions such as analysis, synthesis and evaluation in Bloom's Taxonomy is difficult for students to answer objectively. Also, students already know this kind of survey of the first three categories from other surveys implemented at the department of veterinary medicine at Freie Universität Berlin. As there were no examinations scheduled in the interdisciplinary lectures, the self-assessed learning outcome offered a practicable alternative for an overview of the students learning success.

In terms of a spiral curriculum, the information learned in this project will be revised and enhanced during the clinical year. In future studies, it should be assessed if teaching on virtual patients will support the learning outcome of real-life clinical patients learning.

The blended learning concept received a high acceptance and over 80% of the students support an extension of the concept to other courses. This concept was implemented to give students more flexibility as well as face-to-face discussions on a higher level.

Results show that teaching reproduction with virtual patients is well accepted by students for interdisciplinary lectures in the 7th semester. Students especially preferred videos such as lectures, hands-on videos and animations as well as a glossary for background information to successfully and autonomously work on a virtual case. The assessment of the self-assessed learning outcome provided positive results in each of the three categories. This shows that the students confirm to have learned the relevant content of knowledge for each case of the implemented reproduction module, which could be interpreted as an effect of the good acceptance of this format. However, these results reflect subjective ratings and further objective assessment should be considered.

Based on these positive results concerning the implementation of virtual patients in a blended learning concept, the combination of virtual patients with simulators in skills laboratories and the possibilities of refining and reducing animal experiments in veterinary education thereby are of future interest.

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CONFLICT OF INTEREST

None of the authors have any conflict of interest to declare.

AUTHOR CONTRIBUTIONS

MD, LV, VD, CH, SB designed the study. LV and MLW planned and submitted the request for the animal experiments. LV, VD, CH, PH, SA and SH carried out the study. LV, AB, SA and MLW drafted the paper. LV and AB analysed the data. All authors discussed the results and contributed to the final manuscript.

DATA AVAILABILITY STATEMENT

For privacy reasons, the raw data cannot be shared.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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4.2. Students' acceptance of case-based blended learning in mandatory interdisciplinary lectures for clinical medicine and veterinary public health

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Authors contribution

LV created the study design, and developed and created the described clinical cases/VPs. LV collected, analysed, interpreted and presented the data concerning the national and international requirements for ILs as well as the case-based learning for the clinical ILs and the acceptance of this format. LV developed the evaluation concept, and planned and submitted the animal welfare request. LV wrote the manuscript.

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RESEARCH ARTICLE

Students' acceptance of case-based blended learning in mandatory interdisciplinary lectures for clinical medicine and veterinary public health

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Abstract

Background: In German veterinary education interdisciplinary lectures (ILs) are an important and mandatory part of the curriculum as their merging character builds a useful preparation for the future profession as a veterinarian. These lectures should enable students to work on practically-relevant and interdisciplinary cases, which should ideally be defined jointly by lecturers from different disciplines.

Methods: In order to give students the opportunity to work on these cases and at the same time have contact with their lecturers and fellow students, the Faculty of Veterinary Medicine, Freie Universität Berlin, has converted its former in-class ILs (face-to-face delivery format) into a blended learning format. The mandatory lectures comprise 196 curricular hours and are delivered over the course of three semesters within the veterinary curriculum. The new concept was developed over a period of three academic years and extensively evaluated (old-new-comparison) with regard to its acceptance and compliance with national requirements for interdisciplinary teaching.

Results: A total of 306 students were asked to evaluate different aspects of the newly implemented format. Overall, more than 79% of the students attending the newly implemented blended learning format responded positively, and the evaluation showed a significant improvement of learning motivation and acceptance when compared to the traditional teaching format.

Conclusion: The results indicated that blended learning is a suitable option for teaching mandatory ILs in clinical medicine and veterinary public health.

KEYWORDS
blended learning, case-based learning, interdisciplinary lectures, veterinary curriculum

INTRODUCTION

Interdisciplinary teaching in veterinary education is typically characterised by the collaboration of lecturers from different subjects such as pharmacology, internal medicine and animal welfare, which, in the veterinary curriculum, are often taught independently.[1] Similar to integrated curricula that promote the merging of basic and clinical science,[2] the intention of interdisciplinary teaching is to interlink knowledge acquired in various core subjects. Not only the comprehension of the interaction of different subjects and their mechanism, but also the application of this linked knowledge to real-life cases is essential since this represents a preliminary stage of subsequent interdisciplinary thinking and collaboration in real-life situations.

In Germany, the veterinary education is specified by the regulations of licensing to veterinary medicine.[3] They include specific requirements for practically relevant and case-based interdisciplinary lectures (ILs). For this, 196 curricular hours are allocated for an integration of clinical disciplines as well as veterinary public health issues (VPH).[3] Additionally, the European Association of Establishments for Veterinary Education (EAEVE) recommends Day One Competences which should be considered when developing ILs. At the Faculty of Veterinary Medicine of Freie Universität Berlin (VM-FUB), ILs were mostly offered as traditional face-to-face lectures (180 min) in third and fourth year (of a five-year curriculum). The analysis of the previous ILs indicated that the emphasis was on clinical topics with only a small number of VPH topics, less than half of the lectures were interdisciplinary and

only about 10 % followed a case-based approach. Content was not coordinated between lecturers and therefore partly duplicated. Also, a student survey conducted in 2014 highlighted a low student satisfaction with the ILs presentation and choice of topics.[4]

In consequence, additional evidence was assembled how to best improve ILs to be better accepted by students, and whether a transfer in a new delivery format could be useful to address both national and international requirements for interdisciplinary teaching. The aim of the new course concept was that students are able to actively solve the interdisciplinary cases required by the TappV and at the same time, in-person contact with fellow students and lecturers should be maintained. In order to meet all requirements, the course was changed to a Blended Learning (BL) format. Rovai and Jordan stated that BL is a flexible course design where online elements can be offered without completely losing face-to-face contacts; thus making it a robust educational tool.[5] In veterinary education, BL has been successfully integrated and well accepted by students,[6–10] and a survey in 2010 already pointed out a good acceptance of case-based e-learning.[11] However, there is only one study analysing the acceptance of an interdisciplinary case-based BL course in veterinary education.[1] This collaborative pilot project 'Neuroimmunology' created an elective course for students with promising evaluation results, but was only conducted with a small number of students over three weeks and with three cases.

One specific requirement of ILs is training based on real life cases. This can be very well addressed by case-based learning (CBL) which can be well combined with the BL format.[12] CBL 'is [a] learning and teaching approach that aims to prepare students for clinical practice, through the use of authentic clinical cases'.[13]

Furthermore, these authors state that CBL supports 'the transfer of learning from theory into clinical application' and may take place in small face-to-face groups or likewise online which 'can work well providing attention is paid to the online learning environment'.[13]

Unfortunately, up to now there is only limited literature on best-practice examples of how to prepare or teach ILs and whether new delivery formats such as BL or CBL can be successfully implemented in interdisciplinary clinical and VPH teaching.

The aim of our study was to analyse if it is possible to transfer an entire mandatory interdisciplinary course of 196 h over three semesters into a BL course by creating and implementing virtual clinical patients and online cases in VPH and whether there is a better acceptance of the new BL format in comparison to the old lecture-based format. Special attention was paid to the acceptance of the mandatory BL delivery format by students and the applicability of this concept to the two interdisciplinary veterinary fields of clinical medicine and VPH.

MATERIALS AND METHODS

Conceptual design

Alongside the wide range of demanded topics in clinical medicine and VPH and the high number of lecture hours the following elements were identified from the national requirements (TAppV) to be the key characteristics (KCs) of the overall course under consideration: interdisciplinarity, a case-based approach and thematic relevance for veterinary practice.

To implement the predefined wide range of interdisciplinary topics such as internal medicine, animal reproduction, food safety and outbreak investigations as well as to enhance the CBL, BL was chosen as the appropriate teaching format. Furthermore, BL offers the students the flexibility in time and place to individually work on a case on the one hand and offers the necessary support to complete the presented tasks on the other hand. The integrated virtual cases provide an opportunity for each single student to deal with the presented problem individually and at the same time to take part in an interactive process according to the respective capacities or time budget.

Blended learning

The BL format was constructed to offer a coherent interdisciplinary case-based content over three semesters (6, 7 and 8) for a cohort of approximately 170 veterinary students per semester. At the beginning of the 6th semester students were introduced to the course concept and the online learning environment. Cases with similar topics were arranged in combined modules, with an average number of three online cases and one subsequent in-class lecture per module. At all times students were able to contact the responsible lecturers or technical support. During the in-class (face-to-face) lectures, the focus was set on providing a forum for questions and case discussions. In some modules, additional cases or problems were offered and jointly worked through. Lecturers were encouraged to use an interactive format with emphasis on discussions and to include activating elements such as voting tools during the in-class lecture to increase students' participation.

This BL format differs from the known flipped classroom model as not only the background information but also the application of the acquired knowledge takes place online and at home prior to the in-class activity.

Selection of tool/online learning environment

As online learning environment, the web-based authoring and learning tool tet.folio was chosen (Appendix S1). It is a web application developed at FUB, Department of Physics, Physics Education Unit.[14] With the emphasis to develop customised interactive content, students can work page by page through the online course-book. All individual activities like answers or notes are automatically saved by the system.[15] Tet.folio was already used on a smaller scale at the VM-FUB, and it is still under active development. Therefore, it was possible to integrate project specific requirements.

To offer a singular platform already familiar to the students and to facilitate access by using the already existing user account, it was decided to link tet.folio with the FUB learning management system Blackboard (Washington DC, USA). A simple landing page gives access to the content in tet.folio for predefined student groups, and the student activities in tet.folio were fed back into the user administration and grade centre of Blackboard.

Case-based approach

National and international requirements for case topics

For identification of suitable topics for the proposed case-based approach, the project team was guided by national and international requirements. The TAppV gave broader thematic guidelines such as the field of internal medicine, reproduction and animal nutrition for companion and farm animals as well as epizootic disease control, epidemiology and food hygiene in VPH.[3] International requirements for teaching content are specified by the EAEVE, which are more detailed but also focused on Day One Competences that a veterinary student should have at the end of their veterinary training.[16] As the national specifications for content were defined very broadly, and the ILs can be seen as one of the major steps in preparing for real life situations, it was decided to use the EAEVE Day One Competences as supplementary guidelines (See Appendix S2).

Curriculum analysis for implementation of topics

The final case topics were identified with the input of internal and external experts in the field of veterinary clinical medicine and VPH. For development of two pilot online cases, two topics considered as relevant and suitable by the project team were selected.

For the implementation of the two pilot cases and for each following case, an overview of all topics taught in the clinical semesters 5–11 at VM-FUB was compiled in order to ensure that each case is sufficiently aligned with previously taught subjects and existing knowledge.

This led to a distribution of the different cases over the three semesters of interest (6-8) and division into different thematic modules (Appendix S3).

Case structure

Based on a conceptual framework for developing teaching cases, these should be relevant, realistic, engaging, challenging and instructional.[17] With the objective to meet these core attributes, two different case structures had been developed since real VPH cases have a distinctly different workflow when compared to the virtual patients in the clinical context of this project.

The VPH cases cover various fields such as food hygiene, epidemiology and animal welfare. Based on the predefined structure, each VPH case was embedded in a mock story that continued throughout the case. After presenting the specific problem, students were asked to take specific roles in the process of solving the case such as the official veterinarian or epidemiologist. Based on the role, various tasks had to be performed that required previously acquired knowledge, and the student was encouraged to work the case from every interdisciplinary angle necessary to solve the problem. Therefore, interactive elements and exercises such as taking food samples, running and interpreting laboratory tests, performing animal welfare visits and much more were integrated into the cases. To supplement the story, the cases were enriched with animations, pictures, audio and video sequences as well as a glossary that provided relevant background information.

The virtual patients follow the pattern of a clinical patient with the sequential steps of the assessment of medical history, clinical examination, diagnostics, differential diagnosis and a treatment plan. In addition to already existing teaching material, supporting pictures, videos, animations and interactive elements were created for and implemented in the cases. Each case was enriched with different tasks of clinical decision-making, and a glossary with background information was provided.[15] The entire structure was designed to create realistic scenarios to optimise the student learning experience. To achieve this, the case descriptions were rich on multimedia elements and interactive tasks.

Less experienced learners require more structured cases to prevent a cognitive overload.[18] Also, students prefer well-structured approaches in CBL rather than open cases.[13] To match case complexity with the learning progress of the students over time, less challenging cases were planned for the 6th semester, and the complexity increased progressively in semesters 7 and 8. In parallel, the structure of and guidance through the cases were reduced with increasing semester.

Evaluation process

The concept of evaluation had two main focuses: (i) to assess the implementation of the national requirements (KCs: interdisciplinarity, the case-based approach and thematic relevance to veterinary practice) into the new course concept in comparison to the previous course concept; (ii) to analyse the acceptance of the newly implemented BL format by students. This was achieved by comparing the learning motivation and subjective knowledge gain of students in the new concept with that of the traditional teaching format and assessing the students' evaluation of general aspects of the BL format and the online case presentation.

In order to achieve these evaluation goals, four paper-based evaluations as well as 26 case-focussed online evaluations were conducted, in which the students from 6th to 8th semester were asked to assess the above-mentioned items.[19]

The survey of the implementation of the national requirements (KCs) was conducted together with the survey concerning learning motivation and the subjective knowledge gain. These questionnaires compared the previous ILs and its traditional course to the new course concept. The two paper-based surveys ('previous survey' and 'survey new') were conducted in summer semester 2017 with the students of the 6th semester. The first survey ('previous survey') was answered in mid-semester (summer 2017) until which students had only been exposed to the traditional format of ILs with mandatory in-class lectures (180 min). The second survey ('survey new') had to be completed at the end of the semester, after the students had a half semester of the new ILs arranged in a BL format.

For the evaluation of the KCs, students had to answer seven items: two items related to interdisciplinarity, three items on the case-based approach and two items on thematic relevance to veterinary practice. Furthermore, they had to answer five items related to learning motivation and subjective knowledge gain. These 12 items were presented in the same question-

naire, and for each item a six-point Likert-type scale ranging from 1 ('strongly disagree') to 6 ('strongly agree') was used.

Questions related to general BL aspects were only asked in the end-of-semester ('survey new'). All items regarding the general BL format were evaluated on the same six-point Likert-type scale. To verify that the questions were read properly, the score direction of one of the items was reversed.

The survey of the online cases focused on their usability and case structure and was conducted online at the end of each online case. It was answered by students from summer semester 2017 to winter semester 2018/2019. These series of surveys consisted of five items with the above mentioned six-point Likert-type scale and one item regarding 'the difficulty of the cases' with a five-point Likert-type scale ranging from 1 ('far too easy') to 5 ('far too difficult'). Additionally, two free-text answers were included in which students were asked to highlight what they liked and disliked most.

The evaluation was conducted with a total of 306 students. A cohort of 157 students from semester 6 to semester 8 was followed up between the summer semesters 2017 to 2018, and another cohort of 149 students in semesters 6 and 7 was asked in summer semester 2018 and winter semester 2018/2019.

Results from a detailed evaluation of the two pilot cases have been presented elsewhere.[15,20]

Qualitative feedback from lecturers

After implementing the first five cases in a BL format in summer 2017, an e-mail was sent to the participating lecturers ($n = 11$) to ask them for their opinion on the implemented BL delivery format in the ILs, the usability of the tool tet.folio and the overall impression of the project itself.

Ethics vote and animal-patient-related experiments

The ethics proposal and animal-patient-related experiments are the same as published earlier.[15] Using animals for educational purposes is classified as an animal experiment.[21,22] The animal-patient-related examinations, procedures and handling protocols were approved by the legal authorities (LAGeSo, L 0001/17).[15] The ethics proposal for the evaluation by the students was approved by the Ethics Committee of the Charité at Campus Benjamin Franklin (application number EA4/125/18).

Statistical analysis

Data analysis was performed with R version 3.6.0 (The R Foundation for Statistical Computing, Vienna, Austria). The R package sjPlot[23] was used for plotting diverging stake bars according to the recommendations of plotting Likert scales by Robbins and Heiberger.[24] The surveys were implemented in the course evaluation tool Unizensus 5.4.14 ebfu (Blubbsoft GmbH, Berlin, Germany) which is routinely used for teaching evaluation at FUB. To assess the reliability of the used Likert-type scales Cronbach's alpha was calculated with $\alpha > 0.6$ indicating good reliability.[25]

Answers to the KCs (interdisciplinarity, case-based approach and practical relevance) as well as the learning motivation and subjective knowledge gain were dichotomised into agreeing and disagreeing with the stated fact (Likert scale agreement ≥ 4) to evaluate the difference between the previous and the new concept. To calculate the relative acceptance ratio (RAR), a Poisson regression with a binary outcome was used. The RAR describes the factor by which the percentage of students agreeing with the stated facts increased. Additionally, 95% confidence intervals (CI) and p-values were reported. A p-value ≤ 0.05 was considered significant. For the overall agreement to items in the same category, a mixed model was used with a random effect for student to take the repeated measurement of the student opinion into account. The mixed regression model was calculated using the R package lme4 and visualized using the package forestplot.[26]

To explore the diminishing returns of the BL modules regarding the learning motivation and subjective knowledge gain as well as the KCs, a two generalised additive linear models were fitted using the R package mgcv.[27] To model the average Likert-type score depending on the number of completed BL modules, the Likert-type score of all items in the key components and the learning motivation as the outcome were used. The number of completed BL modules was modelled using a restricted cubic spline, and a random effect for student was added for the previously stated reason.

RESULTS

Comparison of the previous and new concept

The first evaluation of the previous course concept of ILs took place in the mid.-semester (summer 2017) with students of the 6th semester, and 109 of 157 (69.4%) students took part in this survey. The first scale regarding the KCs of ILs consists of seven items with $\alpha = 0.9$. When combining all seven items, 37.9% of all students answered the items positively (score 4 'slightly agree' to score 6 'strongly agree') whereas 62.1% gave it a negative evaluation (score 1 'strongly disagree' to score 3 'slightly disagree'). The five items of the scale for learning motivation and subjective knowledge gain had an $\alpha = 0.92$. Most students (79.0%) evaluated the learning motivation and knowledge gain of the old lecture format negatively, while only 21% gave it a positive evaluation (Figure 1).

At the end of the 6th semester (summer 2017), 60 of 157 students (38.2%) evaluated the new course concept. Here the KC score had again a good reliability with $\alpha = 0.82$, and more than 98% evaluated them positively. Cronbach's alpha of the learning motivation and subjective knowledge gain was $\alpha = 0.81$, and again more than 98% of students gave a positive evaluation.

All items were rated significantly better in the new course concept ($p < 0.001$) with the share of students evaluating the KCs positively more than doubling (RAR 2.60 [95% CI 2.24–3.03]). The learning motivation and subjective knowledge gain were evaluated positively by a proportion of students more than four times as large (4.77 [3.85–5.96]). Especially the items 'I now know what I would have to do on similar topics as those discussed' and 'My understanding of the practical veterinary work has developed through the previous courses of

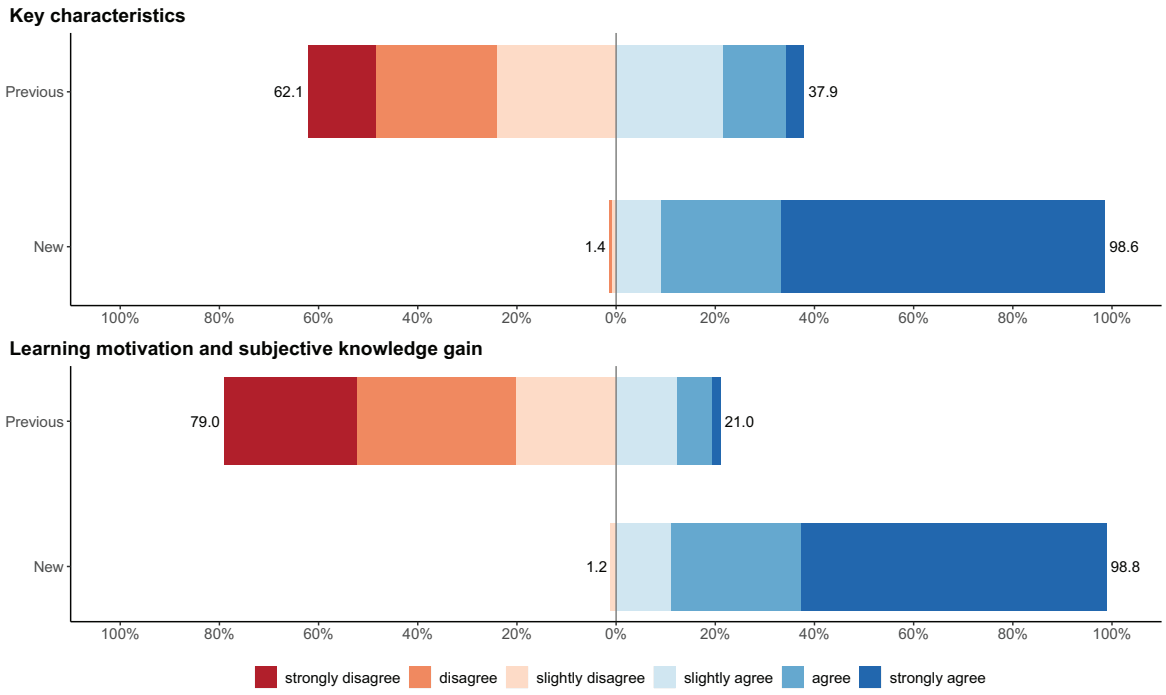

FIGURE 1 Summary of key characteristics (seven items) and learning motivation and knowledge gain (five items) of previous and new course concept of interdisciplinary lectures at the Faculty of Veterinary Medicine at Freie Universität Berlin, in summer semester 2017. Evaluated by students of 6th semester on a six-point Likert-type scale from 1 ('strongly disagree') to 6 ('strongly agree'). Represented by a diverging bar chart with a zero line; on the right side the positive answers are shown in blue and on the left side the negative answers are shown in red

the ILs' has been strongly improved in the new course concept with RAR of 4.86 (3.03–8.10) and 6.00 (3.62–10.45) (Figure 2).

The blended learning format

The BL format of the new concept of ILs was evaluated from summer semester 2017 to summer semester 2018 following the same cohort of 157 students in 6th semester to 144 students in 8th semester. Over the sequence of three semesters, 445 students were registered in the above-mentioned semesters (each student on average three times), and 216 (48.5%) completed their surveys on the last course day of the respective semester. The BL format was consistently rated well (Figure 3). The highest proportion of positive responses (>83%) in almost all items was seen in students of the 6th semester (first year of ILs). The same cohort in subsequent semesters 7th and 8th also rated them very positively (>79%). In the reversely coded item 'I would have learned more in face-to-face lectures', students evaluated negatively with >77% negative answers in all three semesters. In summary, all items in all three semesters were evaluated consistently positively by >79% of the students.

Case-based evaluation

To assess whether there is a difference between the usability and the case structure of the clinical and VPH online cases, a short evaluation after every online case took place. During the period from summer semester 2017 to winter semester 2018/2019, in total 26 online cases (12 VPH/14 clinical) were offered to the students from 6th to 8th semester during ILs. From the two different cohorts 601 students were registered for the courses in this time. In total, 1983 surveys were completed during these semesters of which 1022 were related to clinical case modules and 943 VPH cases. For 18 surveys that categorisation was missing. A total of 3846 surveys were offered to students during this period. Thus, a response rate of 51.5% was reached.

Results for the five items related to usability and case-based structure were combined and presented for the clinical and the VPH cases. In both categories, more than 96% of students answered each of the five items positively.

Diminishing returns of the new concept

Diminishing returns were estimated from 516 surveys in the years 2017–2019. The surveys were conducted with students from 6th to 8th semester at the end of the respective semester. Students had worked on between two and seven BL modules up to the point of the survey.

The mean of all items in the previous course concept regarding the KCs without any exposure to BL modules was 3.06. The arithmetic mean of all items after two BL modules (after 6th semester in 2017 and 2018) was 5.41 (95% CI 5.36–5.46) and slightly dropped to 4.99 (4.90–5.08) after seven BL modules (after 8th semester 2018) (Figure 4). Despite the decrease by 0.42 Likert points after seven modules, the BL concept was still rated 1.93 Likert points higher than the traditional course concept (Figure 4).

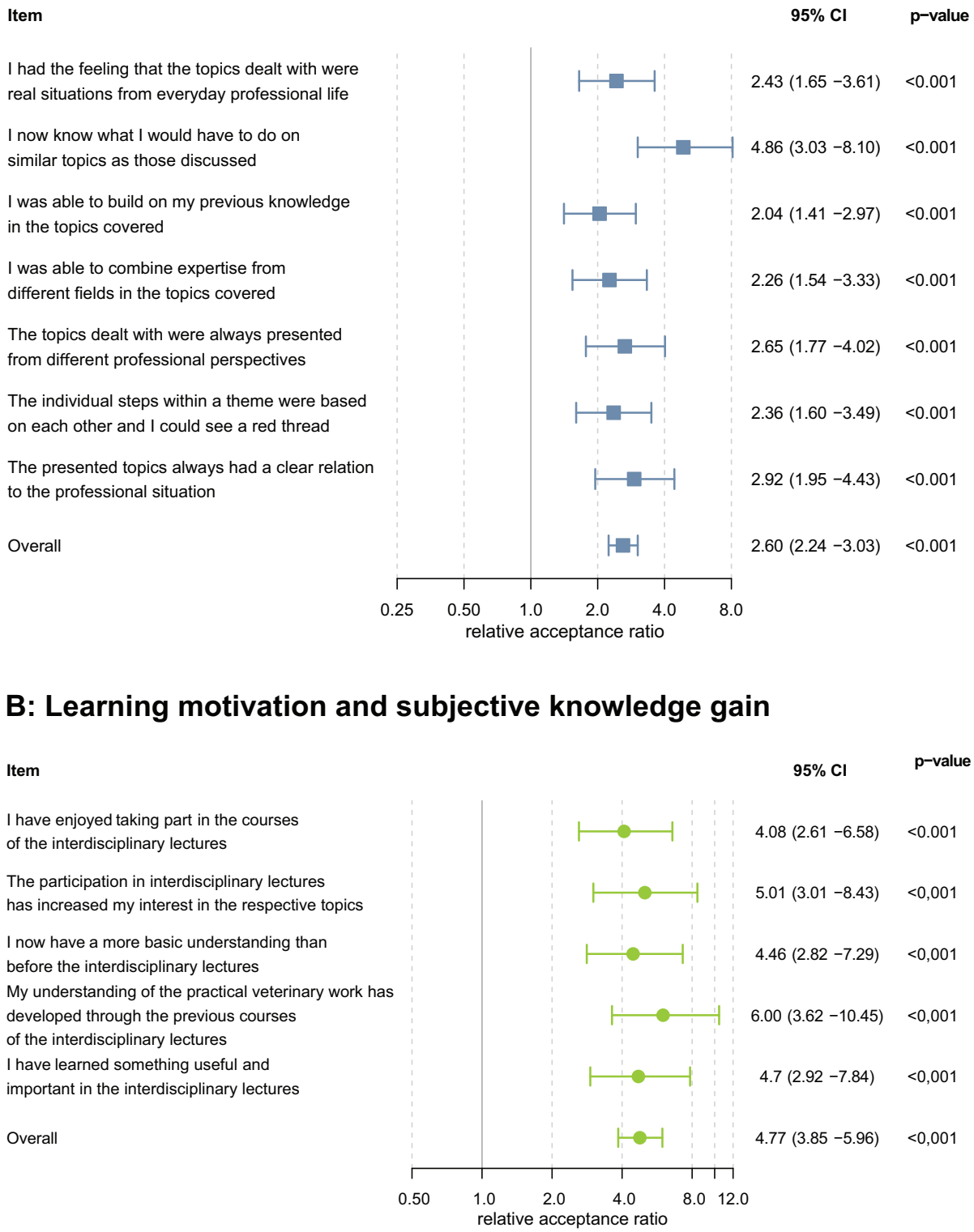

FIGURE 2 Forest plot of the key characteristics of IL (a) and learning motivation and subjective knowledge gain (b) at Faculty of Veterinary Medicine, Freie Universität Berlin. Relative acceptance ratio was measured with Poisson regression

The learning motivation and subjective knowledge gain was rated with a mean of 2.47 in the previous course concept. After two BL modules, the average score was 5.34 (5.28–5.40) and after seven modules 4.85 (4.73–4.96). In total, the learning motivation and subjective knowledge gain decreased by 0.49 Likert-points over the seven BL modules but still was 2.38 Likert-points higher (after seven BL modules) when compared to the previous IL course concept.

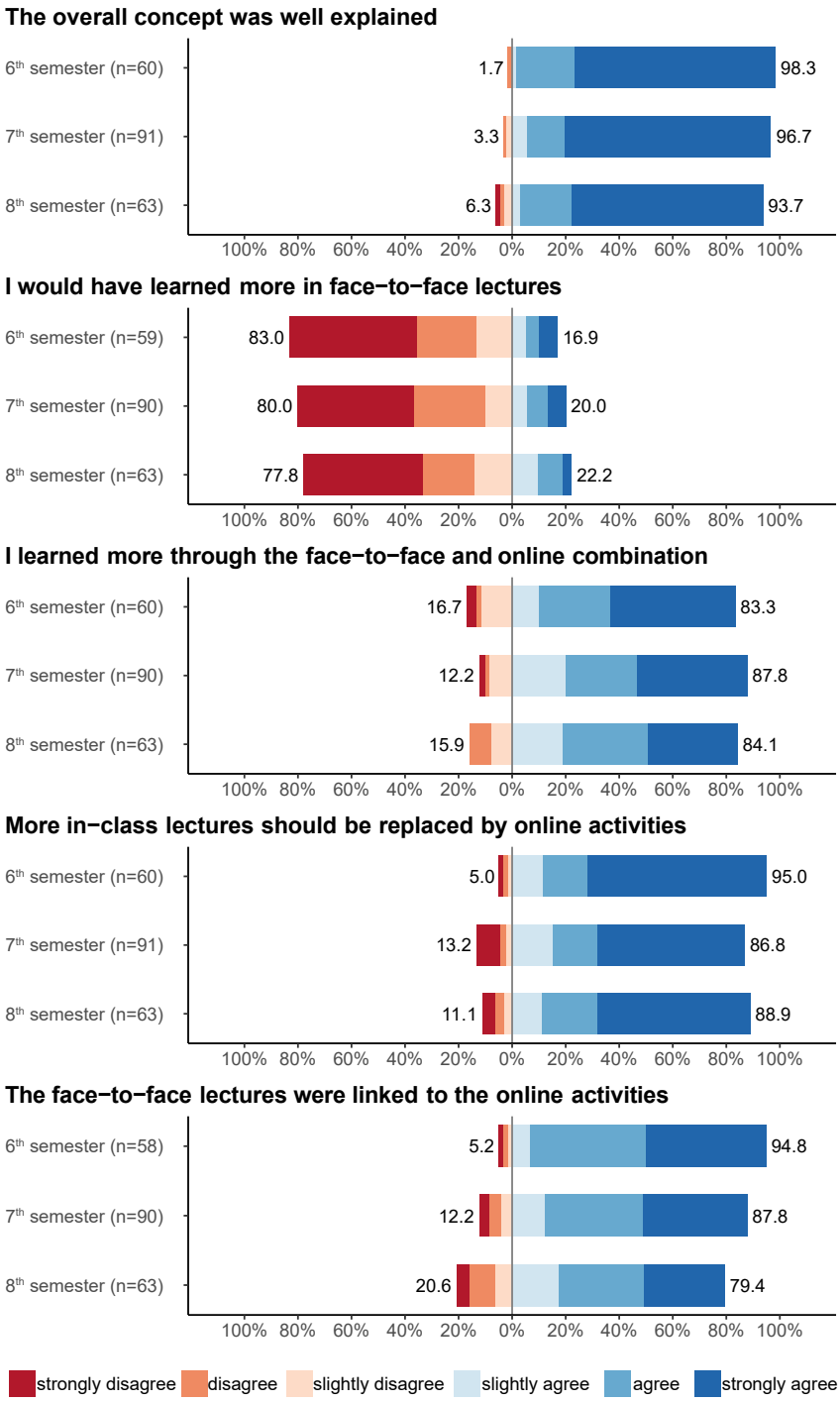

FIGURE 3 Evaluation of the blended learning format of interdisciplinary lectures at Faculty of Veterinary Medicine, Freie Universität Berlin in 6th semester 2017, 7th semester 2017/2018, 8th semester 2018. Assessment on a six-point Likert-type scale from 1 ('strongly disagree') to 6 ('strongly agree') shown on a diverging bar chart with zero line between negative and positive answers. For better comparison between the three semesters, all items were divided in the semesters 6, 7 and 8

Qualitative feedback from lecturers

Feedback from the lecturers (response rate: 63.6%) showed that they considered BL as a useful delivery format for ILs and agreed on a good usability of tet.folio. Additionally, two lecturers expressed the wish to participate in the development of additional cases. One lecturer was not certain about maintaining the high quality of the cases once the funded project ends and another pointed out that there is a higher investment of time at the beginning but saving of time in the long term.

DISCUSSION

In veterinary medicine ILs play an important role in education and preparation for real life situations. However, implementation of such scenarios into the curriculum so far was not

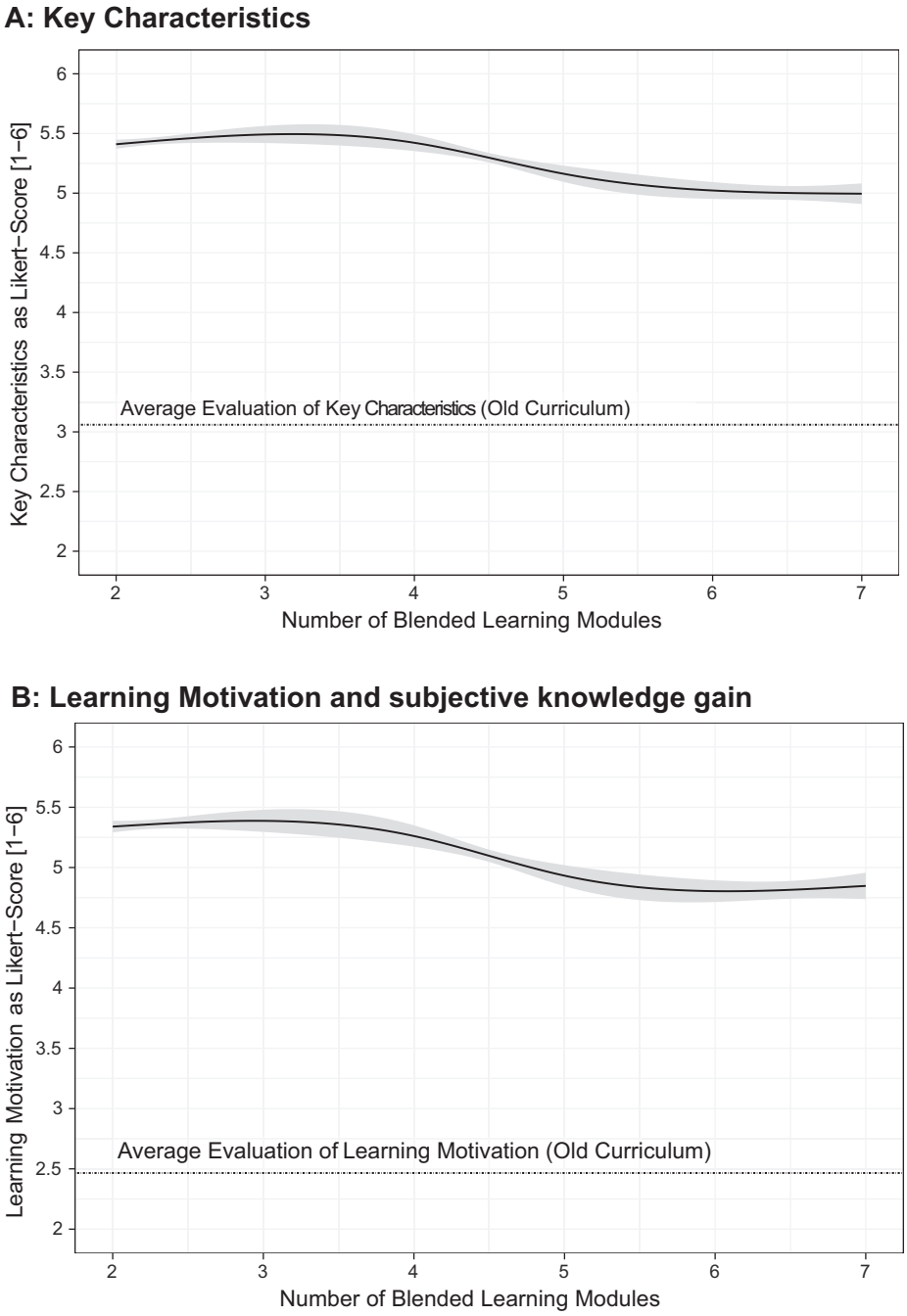

FIGURE 4 Diminishing returns of (a) key characteristics and (b) learning motivation and subjective knowledge gain of interdisciplinary lectures at Faculty of Veterinary Medicine, Freie Universität Berlin as a function of the already completed e-learning modules. The students were surveyed after 2, 4, 5 and 7 blended learning modules. Note that 95% confidence intervals were shown as a shaded area

satisfactory for the students and did not meet the national or international requirements for teaching in veterinary medicine. The innovation in this project is the implementation of BL into a mandatory and complex course concept with a high number of participants over a period of three curricular semesters and a high number of lecture hours in each semester. The ILs in veterinary medicine have not yet been converted into BL nor have they been evaluated for their acceptance by students to this extent.

Results show that the three KCs of the national requirements are much better implemented in the new course concept using BL compared to the traditional approach. We think that especially through the BL format it was possible to implement these KCs more successfully. The institutes and clinics involved were able to integrate their content into the collaborative online cases and coordinate the content to create a convincing and realistic case. The online multimedia format presented a platform to combine the interdisciplinary content optimally and offered a coherent case or patient for the student to work on interactively.

Looking at the learning motivation and the knowledge gain, the students were asked to evaluate subjectively, a direct relation to the improved implementation of the three KCs and the chosen case-based, and BL format can be assumed. This

not only underlines that these characteristics are important to successful interdisciplinary teaching but also that the chosen delivery format enhances student motivation and knowledge gain subjectively. The findings about increased motivation of students taking part in BL coincide with other studies.[28,29]

The BL format was evaluated very positively by the students through all three semesters; this again agrees with previous studies.[7–10] We think that a great impact to the successful implementation and acceptance of this delivery format was given by the predetermined order of action within the BL. The task to address the problem individually first, before meeting for interactive further discussions, presumably led to a better preparation of the course and therefore a better and more meaningful in-class lecture with more focussed discussions and a higher value to the students. This assumption is also affirmed by the good results for learning motivation and knowledge gain and was also shown by previous studies about the combination of CBL and BL.[1,12,30]

The diminishing returns that we observed in our evaluations are considered minor. We conclude that the positive feedback in our continuing surveys was not solely a result of the rather poor perception of ILs prior to the start of this project in 2014,[4] but is related to the general acceptance of the new delivery format over a sequence of seven BL modules.

In other studies, online formats are designed for one single discipline only.[31–33] Considering the individual short surveys of the single online cases regarding the usability, we can say that despite the two different case-structures or subject content both thematic fields of clinical medicine and VPH with all their relating issues were successfully integrated. In this project the VPH content was implemented to the same extent as the clinical content and students' evaluations did not differ between the two veterinary fields or subject content which shows that both thematic fields can be well combined and integrated into a mutual BL format. In both areas it was possible to create a pool of different highly important cases, which enables students to work on every of these cases even if they cannot be seen during the clinical year or VPH internships.

Results show that the acceptance of this implemented BL delivery format is very high. Also, the realisation of the national requirements was achieved much better through BL. The international requirements were also addressed within this BL project. All in all, one can assume that BL is not only a relevant alternative to the traditional course concept but indeed a significant improvement.

A complicated matter especially at the beginning of the project was to encourage the lecturers of different disciplines at our faculty to collaborate and to coordinate the IL content. However, in summary qualitative feedback from lecturers was very positive. The results of the carefully planned surveys aided in convincing lecturers of the approach, and the developed modules now are a regular mandatory part of the curriculum at VM-FUB.

Unlike in medical education where the integrated curriculum has been widely implemented, in German veterinary education the implementation of an entirely integrated curriculum has not yet taken place, and the traditional curricular structure (separation of basic science and applied science) which has already been considered insufficient in health education[2,34] is still present. However, the ILs and their presented revision are a positive step.

As limitations we would consider the lack of objective tests to analyse an improvement of learning efficiency compared to the traditional course concept in addition to the subjective surveys we took. Unfortunately, there are no tests scheduled for the ILs in Germany. To refer to subsequent tests in the following semesters would not show the influence of this modified course correctly as the parallel running courses would result in a mixing of knowledge and learning progress of all courses in the relevant semesters.

Also, the educational staff was not able to spare more time for an experimental setting and run two parallel courses to establish a comparison between the traditional and newly implemented teaching method with the same content.

The survey of the traditional course was only possible in the summer semester 2017 and not in the following semesters as it was gradually adapted to the given requirements due to selection procedures for the remaining lecture times. Therefore, only the summer semester 2017 was a representative semester for the traditional teaching format.

CONCLUSION

This study shows a successful step-by-step implementation of a BL format over several semesters in the ILs, a mandatory course in the German veterinary education. By converting the complete course into online cases with associated classroom sessions, different topics could be integrated in one large coherent course concept, which was very well evaluated and accepted by the students. In contrast to the traditional course concept with face-to-face teaching the chosen BL format was able to implement the teaching requirements for ILs in veterinary medicine much better. Also, it was a useful delivery format to enable interdisciplinary and case-based teaching both in clinical veterinary medicine and in VPH equally good. We hope that this study will motivate and help other universities to implement innovative delivery formats such as BL into traditional interdisciplinary courses as well as extensive courses.

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AUTHOR CONTRIBUTIONS

Lena Vogt, Veronica Duckwitz, Claudia Hautzinger and Marcus G. Doherr designed the study. Lena Vogt and Mechthild Wiegard planned and submitted the request for the animal experiments. Sebastian Haase developed the learning platform and contributed the technical support. Lena Vogt,

Veronica Duckwitz, Claudia Hautzinger and Marcus G. Doherr conducted the study. Lena Vogt and Veronica Duckwitz drafted the paper. Veronica Duckwitz, Lena Vogt and Alexander Bartel analysed the data. Lena Vogt, Veronica Duckwitz, Claudia Hautzinger, Alexander Bartel, Sebastian Haase, Mechthild Wiegard and Marcus G. Doherr discussed the results and contributed to the final manuscript. Marcus G. Doherr, Lena Vogt and Veronica Duckwitz are the guarantors of the overall content.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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Corrigendum

In this article,[1] there was a typographical error in the footnote denoted by an asterisk: "* Joint first authorship. VD un LV contributed equally to this paper."

The footnote should read as follows:
"* Joint first authorship. VD and LV contributed equally to this paper."

In Figure 3, in the legend at the bottom of the figure which details the descriptors for each of the six-points in the Likert-type scale, the text "strongly agree" has mistakenly been cut off due to a formatting error. The corrected version of Figure 3 has been provided here:

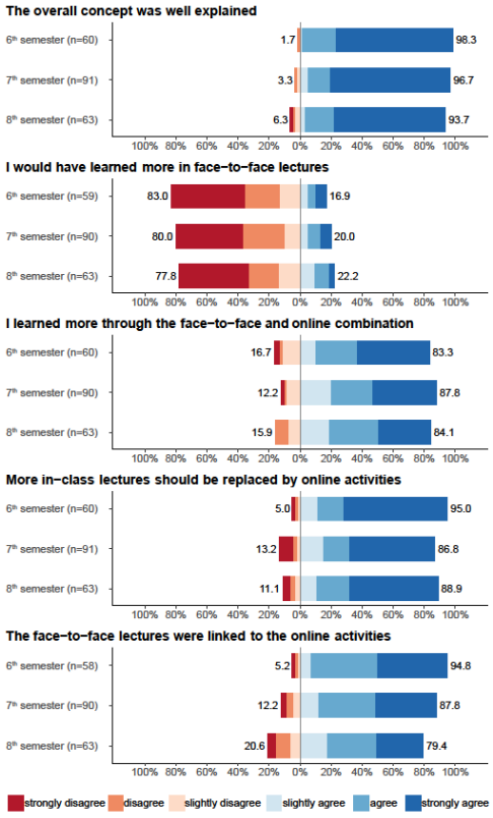

FIGURE 3 Evaluation of the blended learning format of interdisciplinary lectures at Faculty of Veterinary Medicine, Freie Universität Berlin in 6th semester 2017, 7th semester 2017/2018, 8th semester 2018. Assessment on a six-point Likert-type scale from 1 ('strongly disagree') to 6 ('strongly agree') shown on a diverging bar chart with zero line between negative and positive answers. For better comparison between the three semesters, all items were divided in the semesters 6, 7 and 8

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5. Discussion

5.1. Virtual patients

Virtual patients have been used in medical education for many years, for example to facilitate clinical decision making (Round et al., 2009), CBL and clinical reasoning skills (Kononowicz et al., 2015; Consorti et al., 2012; Cook et al., 2010; Huang et al., 2007). Recently their use in veterinary education has also increased (Kleinsorgen et al., 2018; Majernik et al., 2017; Bogert et al., 2016; Byron et al., 2014; Trace et al., 2012). As pointed out in the literature review (Chapter 2.2.2.) VPs have not yet been implemented into the ILs of veterinary education in a BL delivery format. Consequently, their suitability for teaching ILs has not yet been assessed.

Achievement of learning objectives in categories 1-3 of Bloom's taxonomy

Learning objectives categorised in the first three levels of Bloom's taxonomy of educational objectives were surveyed subjectively in the first study relating to three VPs in the module of small animal reproduction. Most students indicated a high level of achievement in all three categories. The positive ratings in the two higher categories are very satisfying and show that, through this didactic approach of including VPs in a BL delivery format, it was possible to also reach higher categories of Bloom´s taxonomy for educational objectives in ILs. These results stand in contrast to the criticism that most teaching formats only fall within the first category (Crowe et al., 2008) and align with the statement of Garde et al. (2007) that CBEL can facilitate the achievement of higher levels of Bloom's taxonomy (Garde et al., 2007).

In the process of the creation and implementation of the VPs in the clinical ILs learning objectives in all categories of Bloom's taxonomy were taken into account to allow students an extensive didactical experience on all cognitive levels. In doing so, the original taxonomy for educational objectives by Bloom was applied. Garde et al. (2007) show very impressively how in CBL every category can be implemented (Garde et al., 2007). Of fundamental importance for lecturers is the fact that, although these categories build upon each other, they are all equally important, as the lower categories enable the subsequent categories (Krathwohl, 2002). However, the surveys in this study contained only the first three categories. This is due to the fact that at the VM-FUB, internal course evaluations of learning objectives related to the first three categories were already established and students were already familiar with this survey structure. Furthermore, a survey of all six categories at the same time would have been very extensive and the higher categories should ideally be assessed through objective examinations.

The learning objectives were presented at the beginning of each case with the aim of giving a distinct overview of the content and objectives of the case, and to point out its relevance. Also,

the creation of the content of each case and the definition of the respective learning objectives were guided by the catalogue of learning objectives for each discipline containing the topics relevant to the courses and examinations. This was done in order to follow the idea of constructive alignment. The learning activities in a VP context that were deemed most likely to enable the achievement of the respective learning outcomes were then identified and chosen, which again is a principle of constructive alignment (Biggs & Tang, 2011). In my view, especially when it comes to preparing students for their future professions, particular attention should be paid to which competences are required and how to best train a student for their future work. For clinical case work, independent thinking and decision-making is of great importance, and in my opinion, this is best facilitated through a student-centred teaching method and an engaging learning environment offering context and experiences. This follows the concept of the constructivist learning theory as outlined in the literature review (Chapter 2.3.).

Comparison of the implementation of the three KCs in the previous and new ILs

In the second study, the implementation of the three KCs was analysed by comparing the previous ILs in an exclusively face-to-face lecture format to the new ILs which integrate VPs and VPH-cases into a BL format (for questionnaire details see Appendix). Results show that both the VPs and the VPH-cases in a BL format were significantly more efficient for the realisation of the three KCs than the previous face-to face ILs.

In the same survey the learning motivation and subjective knowledge gain was subjectively evaluated and rated very high by students in the new ILs compared to the previous ILs. The diminishing returns calculated in the above-mentioned items (KCs, learning motivation and subjective knowledge gain) were minor and even after several semesters the results were consistently good. This result is in contrast to a previous report indicating that students are often motivated by teaching innovations only for a short period of time, and that positive evaluations therefore do not prove the didactical effectiveness of such formats (Kerres, 2003).

The implementation of the VPs in a BL delivery format supported the integration of the German requirements into the ILs and this is presumably due to the flexible and interactive character of BL. The online phase permits the implementation of VPs which by their nature already support interdisciplinary and case-based learning. The lecturers were able to jointly create and coordinate the online content, enable a deep connection between the subjects and focus on relevant competences. The in-class lectures ensured that the students were supported in their assignments but also guided to higher levels of discussion as well as to more complex and difficult tasks.

Consequently, it can be stated that BL and VP are very suitable for presenting IL content and implementing the specific requirements (3 KCs). Furthermore, the successful implementation

of the KCs in the new concept could also be jointly responsible for the student's positive perception of the ILs and the increase in learning motivation and knowledge gain. This in return would confirm the meaningfulness of the specified KCs for ILs.

Acceptance of VPs by students for the delivery of clinical ILs in a BL delivery format

The focus of the first study of the present thesis (Chapter 4.1.) was on the creation, implementation and evaluation of three VPs in the field of small animal reproduction. The analysis of the didactic use of media implemented in the pilot VP showed that alongside a generally very high score for the utility of the implemented media, students rated the videos (animations, video lectures and hands-on videos) as well as the glossary, feedback options and interactive elements as very useful. This conforms with other studies stating that feedback, interactivity and multiple learning strategies build an effective individualised and simulating learning experience (Cook et al., 2010). Also, during a fast moving clinical experience it can sometimes be difficult to connect the important basic science to the ongoing illnesses (Bogert et al., 2016). Through the additional background information students have the opportunity to study and repeat at their own pace and choose their own depth of content.

The hands-on videos were implemented for a more realistic appearance of the VPs and with the aim of helping prepare students for their practical training as these videos can be watched as often as needed and repurposed in other educational situations. In this case, the videos might replace live demonstrations on animals for practical training when lecturers use the media that is made available to demonstrate examinations or procedures instead of a live demonstration.

The usability was analysed for all three VPs in this first study. Students agreed on a very good usability in relation to case structure, difficulty, completeness of information, comprehensibility of content and associated tasks and objectives. The students in the targeted semesters had little experience solving clinical cases on their own, so that in the beginning a mainly guided format of VP was chosen, which was then successively converted into a problem-solving format. This is also recommended in other studies concerning the specific learning outcomes of VPs (Thistlethwaite et al., 2012; Cook & Triola, 2009; C. P. Friedman et al., 1991), and results in our surveys show that the implemented VP formats meet the students educational level to a great extent.

In the first study, the evaluation of the BL delivery format related to three VP in small animal reproduction. Substantially more than 70% of the students gave a positive evaluation of the implemented BL format and favoured BL over a face-to-face lecture with regards to the content addressed in the ILs. In the second study of the present thesis, the BL delivery format of the overall ILs over several semesters was evaluated. Again, students gave very positive answers concerning BL which included clinical modules as well as modules in the field of VPH.

In the second study of this thesis, the acceptance of the BL delivery format for VP and VPH-cases was analysed over several semesters. For that, students evaluated their learning motivation, subjective knowledge gain and general aspects of the BL concept and online case presentations (for questionnaire details see Appendix). The results of all items combined showed a high level of acceptance of this BL delivery format for both thematic fields in equal measure.

All analysed aspects imply successful implementation and very good student acceptance of the VPs for clinical ILs in a BL delivery format. This is consistent with the findings of previous studies regarding students' attitude towards VPs in veterinary and medical education (Lehmann et al., 2015; Trace et al., 2012; Dhein, 2005). One can assume that the high acceptance rate was also due to the fact that it was well embedded into the curriculum with a focus on spiral learning, a relevant choice of topics and effective supervision. The positive effects of a well-implemented curriculum implementation as well as good guidance and support throughout the BL delivery format, is also described in many studies and support the results in this thesis (Lehmann et al., 2013; Hege et al., 2007; Childs et al., 2005).

To summarise, all three hypotheses concerning the use of VPs in a BL delivery format for clinical ILs in veterinary education were proven to be correct. Students are able to reach learning objectives that are present in categories 1-3 of Bloom's taxonomy, and VPs in a BL delivery format are more suitable for the implementation of the three KCs of ILs than the previous ILs with a traditional face-to-face lecture format. Finally, the students' acceptance of VPs for the delivery of clinical interdisciplinary content in a BL delivery format can be confirmed. The confirmation of the first two hypothesis could have a positive impact on the third hypothesis and consequently the third hypothesis could be seen as evidence of an overall acceptance which sums up and is influenced by the aspects of the first two hypotheses. In conclusion, it can be stated that VPs in a BL delivery format are very suited for presenting clinical ILs in veterinary education.

It would have been preferable to underline and confirm the positive results from the students' subjective evaluations with reference to objective assessments. Unfortunately, there are no examinations scheduled for the ILs at VM-FUB. Since the ILs are well implemented in the curriculum and thematically coordinated with other corresponding lectures, a determination of the exclusive influence of the ILs on the general examination results would have been difficult. Furthermore, the lecturers participating in the QuerVet project were not able to spare more time for teaching one topic with two formats consisting of the traditional approach of the previous ILs and the new concept, which would have allowed for an objective comparison. Moving forward, the objective comparison and assessment of VPs in a BL delivery format for teaching ILs in veterinary medicine could be of interest.

Additionally, another focus of future studies could be the further and even more efficient implementation of VPs into the veterinary curriculum in relation to constructive alignment and the use of VPs in examinations.

5.1.1. Tool selection

In order to implement the online content of the ILs, an appropriate software had to be found. The ECCVT recently stated that there are only ´few tools/applications currently independently validated, officially authorised and fully available for education and practice´ (ECCVT, 2020) and similarly, for us the selection of the software was not simple. Many important aspects like licensing costs, technical support, user interface, sustainability and integration into the existing information technology infrastructure were included in this decision (supplemental material of publication in chapter 4.2., see appendix).

At the beginning of the project there was a discussion about the utilisation of the multimedia learning and authoring system CASUS® that has already been used for presentation of CBEL at different veterinary schools (Kleinsorgen et al., 2017; Börchers et al., 2010; Ehlers et al., 2003). The fact that more than one school uses a certain tool offers the great opportunity to share content and VPs. But the case against the utilisation of CASUS® at this point was stronger, arguing that (i) it is a software for which a fee is charged and any payment beyond the scope of this project was difficult to be determined, (ii) the integrated case-presentation path was not flexible enough for the equal implementation of VPs and VPH-cases, and (iii) the desired interactivity for this project was not supported by CASUS®'s technical options. However, the HTML-based authoring and learning tool tet.folio, which was developed at FUB, Department of Physics, Physics Education Unit, was free of charge and offered extensive flexibility and interactivity within each case, as well as the technical support provided by a software engineer within the FUB. Through this flexible case path and a high interactivity with many different types of questions and interactive elements (Chapter 4.1.) we hoped for authentic and realistic case work. Student evaluations did confirm the targeted effects with a high level of acceptance, motivation and subjective knowledge gain.

Furthermore, regarding fidelity and authenticity students prefer more realistic scenarios as they provide a more ´memorable experience´ (Sawras et al., 2020). However, simpler and less elaborately designed VPs may be more cost effective (Cook & Triola, 2009). Nonetheless, utility and technical design are important for students' engagement and acceptance of the VPs, and educators must find a compromise between what is possible with existing resources and fidelity of the VPs (Sawras et al., 2020). In my opinion, the combination of the selected tool and case structure of VPs in this project found a perfect compromise between available resources (technical and personal) and the authenticity of the patients. There is always the

possibility to implement more realism and fidelity in a case, for example, in the SimMed project at the Charité-Universitätsmedizin Berlin. There, VPs are presented to medical students using an interactive tabletop for group work with an extremely high level of fidelity and authenticity (Zadow et al., 2013). Although this concept, as well as the digital technology used, are very tempting, it is important to serve the desired learning outcomes and to critically analyse the efficiency of that goal rather than using available and highly advanced technology blindly (Kneebone & Baillie, 2008).

5.1.2. Content sharing and exchange of VPs

As pointed out in the literature review (Chapter 2.2.2.) the sharing and exchange of VPs can optimise available financial and personal resources (Byron et al., 2014; Conrad et al., 2007). The exchange of VPs is especially uncomplicated when lecturers use the same software. Nonetheless, the sharing of content like videos, animations or case structures can already save valuable resources.

The experiences during the QuerVet project showed that it was not only difficult to encourage lecturers to potentially share their content with other universities but that concerns regarding copyright would already hinder some lecturers from even participating in the process of creating online content. Ehlers et al. (2007) correctly emphasised that ´Veterinary medicine is a rather small discipline which makes it important to cooperate internationally not only in the field of research, but also in education´ (Ehlers et al., 2010). The project KELDAT focussed on the creation of a joint competence centre for e-learning, didactic and educational research with all German speaking veterinary schools from 2012 until 2015 and fostered cooperation and collaboration (Stiftung Tierärztliche Hochschule Hannover, 2021). Similarly, the EU-funded project vetVIP established the cooperation of different veterinary schools that created and shared VPs (Instruct AG, 2018; Kleinsorgen et al., 2017). Unfortunately, we were not able to establish an exchange of VPs or their content with other universities. On the other hand, the above-mentioned problem concerning the rejection of content that is not self-made (Huang et al., 2007) did not occur.

5.1.3. Possibilities for the refinement and reduction of animal experiments in veterinary education through VPs

The amendment of the German Animal Welfare Act in 2013 affected not only the training of scientists for animal experiments in research but also the academic education of veterinary students using animals. The demand for practical training using animals in veterinary education (EAEVE & FVE, 2016; TAppV, 2006), along with the specifications for animal experiments and the implementation of the principles of 3R (Directive 2010/63/EU, 2010;

TierSchG, 2006) present a challenge to educators. VPs could help accomplishing both tasks by giving students the possibility to prepare in a more extensive way before actually training with animals.

Abutarbush et al. (2006) stated that e-learning with instructional videos of a certain procedure is superior to the traditional instruction using animals for demonstration. Consequently, it was reasoned that e-learning presents a valuable alternative when it comes to the preparation of students before the training of hands-on skills using animals (Abutarbush et al., 2006). This statement could also apply to the use of VPs implemented during the QuerVet project at VM-FUB because not only instructional videos but also interactive elements were embedded in the VPs. Accordingly, VPs would then also enable a better preparation for further hands-on training using animals. In the context of 3R, this would include a refinement in ways of improving students' performance when training with animals after engaging with the VP and perhaps entail less attempts needed until mastery. But it would also imply a reduction because the number of animals needed for initial demonstrations would be reduced when replacing the live demonstrations with video instruction embedded in the relevant context of a VP. In contrast to a live demonstration the use of videos allows infinite views with a good perspective of the procedure.

Until now, this potential of VPs has probably not been analysed because the primary purpose of VPs is the training of clinical reasoning skills (Kononowicz et al., 2015; Consorti et al., 2012; Cook et al., 2010; Round et al., 2009) and decision-making skills (Round et al., 2009) rather than practical training. However, through their embedded media such as instructional videos and interactive elements within a clinical context, VPs could contribute to animal welfare and the implementation of 3R into the veterinary curriculum. The combination with other digital as well as physical alternative methods could enhance this impact further. This raises questions about where to position a VP within a learning spiral consisting of a series of different alternative methods.

The sequential implementation and alignment of various alternative methods including VPs would support the further implementation of 3R in academic training. The previous and intensive training with combined digital and physical alternative methods could lead to an even better prepared student when handling and training with an animal for educational purposes, resulting in less distress for the animal, less attempts until mastery and higher self-confidence in the student. Furthermore, it cannot always be guaranteed that all relevant skills and cases can be practised on patients, and already ill patients should not suffer even more through the insecure practising of inexperienced students (Martinsen & Jukes, 2005). The hands-on training with combined alternative methods could counteract this.

In the future, the applicability of VPs as an alternative method for animal use in veterinary education in line with the 3R, and the efficiency of the sequential implementation of VPs with other alternative methods such as simulations and models should be analysed.

5.2. Blended learning

Blended learning is not new to veterinary education and prior studies have shown a high level of acceptance (Kelly et al., 2021; Boller et al., 2018; Little et al., 2018; Ehlers et al., 2010; Koch et al., 2010). The flexibility of e-learning can be combined with the regular support of face-to-face lectures. The absence of a passive face-to-face lecture format allows students to be self-responsible and to refine their thinking skills. It gives students the opportunity for the case-based application of acquired knowledge as well as interconnections between the different subjects. New in this field was the combination of ILs and VPs in veterinary education as well as the large size of the targeted mandatory course. Results show a very successful implementation and a high level of acceptance of this combination by veterinary students, with the request for even more lecture formats like this. These findings align with the aforementioned high acceptance rate of BL in veterinary medicine.

A study in 2010 pointed out that the learning success of BL comes from the fact that students attend the in-class lectures better prepared and more motivated which allows for deeper discussions and better quality in participation (Ehlers et al., 2010). The experiences of this study give the same impression. Also, the online content presented prior to the in-class lectures gave a context and relevance to the topics which likely made it more interesting and meaningful to the students.

The flipped classroom distributes the acquisition of background knowledge to the online phase and the application of the acquired knowledge to the in-class lecture (Moffett & Mill, 2014). The chosen BL format in this project differs from the flipped classroom model as it offers both the acquisition and application of knowledge in the online phase and allows further steps in the in-class lecture in the form of deeper discussions or the handling of more difficult and complex cases that builds upon the cases in the online phase. This concept was chosen to enable more interactivity and to reach higher levels in Bloom's taxonomy of educational objectives.

Moreover, students requested a further expansion and transfer of this concept to other lectures. This should be seen as cause and motivation to disengage oneself more from traditional and passive face-to-face lecture formats, and to allow the learner to become more active and involved. This conforms with the general demand to shift from teaching to learning and therefore a more active and student-centred learning model in medical education (Lammerding-Köppel et al., 2006). Also, feedback from lecturers stated that they consider BL to be a useful delivery format and two lecturers even wished to develop more cases. This demonstrates that not only students but also lecturers have a generally positive attitude

towards a BL delivery format, which is in line with findings from a study analysing the acceptance of CBEL in veterinary medicine with the example of CASUS® (Börchers et al., 2010).

For students to work together and study in groups is important and relevant for the learning experience (Cook et al., 2010). In the lecture format of ILs at VM-FUB many lecturers are involved, but at the same time over 140 students attend these mandatory classes. This made it impossible to integrate group discussions and group work regularly. But it was observed that some students chose to jointly work through the online cases in small groups.

Summarising the results of the two studies, the implementation of BL at VM-FU for ILs has been well accepted by students and a further implementation of BL for other lectures was requested. Additionally, lecturers also confirm the usefulness of BL. In future, the possible application of BL to further lectures could be examined in order to apply more flexibility and interactivity to veterinary education.

5.3. The concept of interdisciplinary lectures

Interdisciplinary lectures hold a significant function in veterinary education when it comes to interlinking different subjects and the application of knowledge (Koch et al., 2010). The objective of this style of lectures is to prepare students for their future profession through their interdisciplinary and case-based character and the choice of relevant topics (TAppV, 2006).

An integrated or modular curriculum promotes the combination of basic science and applied science within learning spirals (Hitzblech et al., 2019; Brauer & Ferguson, 2015), and compared to that ILs hold a similar intention. Interdisciplinary lectures could be considered a preliminary stage or a small segment of an integrated curriculum but they are not embedded in learning spirals or longitudinal teaching approaches within the entire veterinary curriculum. Nonetheless, within the scope of this project the curriculum and the distribution of subjects was analysed for an optimised implementation of the modules with specific thematic focuses. Students were given an overview of the learning objectives and of the previous courses that were relevant to each case. Through the alignment of learning objectives, learning activities and question tasks, implemented in the VPs, this approach is inspired by the idea of constructive alignment.

Most universities are organised around disciplinary departmental boundaries where every department teaches its domain independently. With this model the connection between the content and the application of existing knowledge to new environments is impaired (Holley, 2009). Similarly, in veterinary curricula most subjects are taught ´separately from each other and in this process often the interdisciplinary collaboration of the different disciplines present a certain challenge´ (Koch et al., 2010). At the beginning of the QuerVet project the overcoming

of these boundaries and compartmentalisation at VM-FUB also presented a challenge. To begin with, close communication between individual lecturers and the harmonisation of content had to be established. The experience in this project is in line with the previous criticism of departmental boundaries in higher education (Holley, 2009).

Regarding the previous ILs at VM-FUB several deficiencies were identified. These deficiencies included i) an insufficient interdisciplinary approach, (ii) the unequal distribution of clinical and VPH topics and (iii) poor organisation, visibility and didactic approach (Chapter 2.1.2. and 2.1.3.). Not only the students criticised the ILs; lecturers at VM-FUB did not favour the ILs either (Chapter 2.1.2.). Possible reasons for these problems could come from the already-described departmental structures, the absence of good communication between individual lecturers of different disciplines and a lack of uniform course management.

Within the scope of the QuerVet project, the aforementioned deficiencies were successfully addressed and the new realisation of the ILs at VM-FUB was presented with a coherent course concept and a well-arranged landing page with a balanced display of highly interdisciplinary cases from the fields of clinical medicine and VPH. Furthermore, the newly conceptualised ILs helped unify the teaching staff and improved the overall standing of the ILs at VM-FUB.

Generally, I think the significance of ILs should not be underestimated in veterinary medicine and the concept of ILs should be embraced when it comes to the curriculum design of veterinary education to a much greater extent, as has already been done in medical education.

5.4. Lessons learned

With regards to the project workflow, it was very helpful to engage one scientific employee each for the two fields of veterinary clinical medicine and VPH, as well as several student assistants. Thus, the two different fields were managed separately, the lecturers had specific contact persons and the content was created in collaboration with the lecturers. This experience was also reported in a similar project (Koch et al., 2010). Nonetheless, it would have been more efficient to deploy staff from participating clinics and institutes for in-house content creation without extensive correction loops. Also, we had to address each clinic and institute individually and ask for their participation in this project which required a lot of time and convincing at the beginning of the project. Here, a collective approach to all lecturers and a stronger appeal to participate prior to the project would have simplified the beginning stages a lot. These two aspects led to a prolongation of the project for one year in order to achieve the project goal.

Also, in this case the sharing of content between universities would have created a much more diverse pool of high-quality content to offer to students, while lecturers and project staff would have saved valuable resources (time and costs). This coincides with the opinion of other

studies regarding the sharing of content for educational purposes (Byron et al., 2014; Conrad et al., 2007).

At the beginning the surveys were conducted in a very detailed way, and later reduced in scope. Nonetheless, the evaluation system was very complex and could have been more transparent.

At the end of the project the most important issue was the project sustainability. As a solution, one suitable person with a long employment contract, who was familiar with the project, was assigned the task of the organisation and maintenance of the content of the ILs.

In addition to the students' feedback the lecturers' opinion was also obtained. This was not only important for the realisation of continuous adjustments and improvements but also enabled an unobstructed collaboration between all participating parties. To inform lecturers about intermediary results and the very positive students' feedback seemed to increase their motivation and also changed the perspective of some lecturers about the necessity of this project.

6. Conclusion

The past ILs at VM-FUB showed various deficiencies, and the need for improvement was expressed by both the EAEVE in 2007 and an internal student survey in 2014. In order to address these deficiencies, the QuerVet project started in 2016. The aim was to build interdisciplinary VPs with content relevant to veterinary practice, to implement them in a BL delivery format as part of the mandatory clinical ILs and to analyse their suitability for teaching ILs in veterinary education.

The following hypotheses were all proven correct: (i) through VPs students are able to reach the learning objectives presented in categories 1-3 of Bloom´s taxonomy; (ii) VPs are suited to implement the three KCs of interdisciplinary lectures (interdisciplinarity, case-based approach, and relevance to veterinary practice) better than the previous traditional face-to-face format of ILs; and (iii) VPs are accepted by students for the delivery of clinical interdisciplinary content in a BL format.

On the basis of the results of the studies included in this thesis, it can be concluded that VPs in a BL delivery format are very suitable for teaching clinical ILs in veterinary education. The deficiencies of the previous ILs were successfully addressed through a coherent course concept and a well-arranged landing page with a balanced display of highly interdisciplinary cases from the fields of clinical medicine and VPH. Also, the VPs implemented in a BL delivery format present a more flexible and interactive approach for teaching ILs, with higher student motivation and deeper discussions. It can be stated that the ILs and their overall standing have improved immensely. The new ILs offer students a good variety of relevant cases in a safe and less stressful learning environment, independent of animal patient availability and with good support through lecturers.

While the additional objective assessment of the findings was not possible, the student evaluation clearly showed that students favoured this teaching format and even requested to convert more lectures from the veterinary curriculum into the same format.

The software tet.folio presented the VPs in an authentic and realistic learning environment, with a compromise between available resources and authenticity of the patients. The sharing of VPs and the implemented content would help saving a considerable number of resources, but unfortunately within this project it was not possible to establish a collaboration or encourage the sharing of the jointly created VPs with other veterinary schools.

As an additional benefit, VPs could also offer a contribution to 3R in veterinary education and this could be the aim of future studies.

Overall, ILs play a very important role in veterinary education for the interconnection of subjects and the application of knowledge. Their objective is to prepare students for their future profession through the simulation of realistic cases. My suggestion is to extend the concept of

ILs further within the veterinary curriculum and apply it to more courses, as has already been done in medical education.

7. Zusammenfassung

Evaluierung von virtuellen Patienten in einem Blended Learning Ansatz für den klinischen Querschnittsunterricht in der veterinärmedizinischen Lehre

Das Ziel der Querschnittslehre ist die Verbindung von verschiedenen Fächern, welche im veterinärmedizinischen Curriculum unterrichtet werden, und die Vorbereitung auf den zukünftigen veterinärmedizinischen Beruf durch interdisziplinäre und relevante Fälle in klinischer Veterinärmedizin und dem öffentlichen Veterinärwesen. Hochschulbildung ist oft charakterisiert durch die gegenseitige Abgrenzung der einzelnen Institute der Bildungseinrichtungen, wodurch die Zusammenarbeit und gemeinsame Vermittlung von Inhalten erschwert werden kann. Die Querschnittslehre stellt eine Möglichkeit dar, diese Abgrenzungen zu überwinden und bietet Studierenden hoch interdisziplinäre Fälle für die Verknüpfung von einzelnen Fächern und die Anwendung von Wissen. Leider steht in der Lehre oft nur die unterste Kategorie der Lernzieltaxonomie nach Bloom im Fokus und höhere Kategorien wie Anwendung und Synthese werden vernachlässigt. Folglich werden kognitive Prozesse in höheren Kategorien nicht unterstützt und Studierende erhalten keine Hilfestellung um ihr volles Potenzial auszuschöpfen und um diese hohen Erwartungen ihnen gegenüber zu erfüllen.

Als Konsequenz der EAEVE-Begehung des Fachbereichs Veterinärmedizin der Freien Universität Berlin im Jahr 2007 wurde entschieden, die Querschnittslehre mit Fokus auf die Organisation und Sichtbarkeit sowie ihren Inhalt und didaktischen Ansatz zu überarbeiten. Zudem zeigte eine interne Umfrage im Jahr 2014, dass Studierende kritisierten, dass die Querschnittslehre ihre Anforderungen für interdisziplinäre Lehre nicht erfülle. Infolgedessen startete das Projekt QuerVet im Jahr 2016 mit dem Ziel die Querschnittslehre am Fachbereich Veterinärmedizin der Freien Universität Berlin zu überarbeiten um die deutschen Anforderungen für die Querschnittslehre (gemäß TAppV) zu erfüllen und um auf die Forderungen nach Verbesserung von Studierenden und der EAEVE einzugehen. Für die klinische Querschnittslehre wurden virtuelle Patienten in einem BL Format als möglicher Ansatz ausgewählt um Studierenden interdisziplinäre, fallbasierte Inhalte anzubieten mit Lernzielen, die sich in allen Kategorien der Lernzieltaxonomie nach Bloom befinden.

Diese Arbeit konzentrierte sich auf die klinische Querschnittlehre mit dem Ziel, virtuelle Patienten in einem BL Vermittlungsformat zu erstellen, diese in den Rahmen der Querschnittslehre zu implementieren und ihre Eignung zu analysieren, Querschnittlehre im Veterinärmedizinstudium zu lehren. Dies wurde durch mehrere Studierendenumfragen erzielt, welche die Akzeptanz von virtuellen Patienten in einem BL Vermittlungsformat für die klinische Querschnittslehre durch die Studierenden, das Erreichen von Lernzielen in den Kategorien 1-

3 der Lernzieltaxonomie nach Bloom und die Umsetzung der drei Hauptmerkmale für die Querschnittslehre durch virtuelle Patienten in einem BL Vermittlungsformat analysieren.
Der Schwerpunkt der ersten Studie lag auf der Erstellung, Implementation und Evaluation von drei virtuellen Patienten im Bereich der Kleintierreproduktion. Die Umfragen konzentrierten sich einerseits auf den fallbasierten Ansatz mit Fokus auf dem didaktischen Medieneinsatz und der Benutzerfreundlichkeit der Fälle und andererseits auf das didaktische Konzept mit Gewichtung auf subjektiv erfasste Lernziele und dem BL Konzept.
Die zweite Studie fokussierte die Evaluation des gesamten BL Konzeptes der neuen Querschnittslehre für beide Bereiche der klinischen Veterinärmedizin und des öffentlichen Veterinärwesens. Außerdem wurde die Umsetzung der drei Hauptmerkmale der Querschnittslehre im vorherigen Konzept mit dem neuen Konzept verglichen.
Die Ergebnisse der beiden Studien zeigen eine sehr gute Eignung von virtuellen Patienten in einem BL Vermittlungsformat für die klinische Querschnittslehre.
Die vorgenannten Defizite der vorherigen Querschnittlehre am Fachbereich Veterinärmedizin der Freien Universität Berlin wurden im Projekt QuerVet insgesamt adressiert und ausgebessert. Die neue Querschnittslehre wird auf einer gut arrangierten Startseite mit einem einheitlichen Kurskonzept und einem ausgeglichenen Anteil hoch interdisziplinärer Fälle aus dem Bereich der klinischen Veterinärmedizin und dem öffentlichen Veterinärwesen vorgestellt. Des Weiteren wurden in der klinischen Querschnittslehre nachhaltige, interaktive, interdisziplinäre und praxisrelevante virtuelle Patienten erfolgreich in einem BL Format implementiert. Virtuelle Patienten und BL sollten stärker in das veterinärmedizinische Curriculum implementiert werden, da sie auch dabei unterstützen können, höhere Kategorien der Lernzieltaxonomie nach Bloom zu erreichen, und die Akzeptanz von Studierenden und Dozierenden gut ist. Ferner sollte die Idee der interdisziplinären Lehre weiter ausgebaut werden um Studierenden mehr Möglichkeiten zu bieten ihr Wissen in realistischen Szenarien anzuwenden und die verschiedenen Fächer der veterinärmedizinischen Lehre besser zu verknüpfen.
Die praktische Ausbildung am Tier ist ein Tierversuch und da der oben genannte Ansatz eine Lösung für fallbasiertes Lernen von klinischen Themen für die Querschnittslehre bietet, welche am Fachbereich Veterinärmedizin der Freien Universität Berlin als nicht praktischer Kurs stattfindet, könnten virtuelle Patienten auch helfen, die 3R Prinzipien im Allgemeinen weiter in die veterinärmedizinische Lehre zu implementieren. Die Ergebnisse dieser Arbeit und auch anderer Veröffentlichungen zeigen eine gute Akzeptanz von virtuellen Patienten durch Studierende der Tiermedizin und weiterführende Studien, die sich mit der Effizienz von virtuellen Patienten in Kombination mit anderen Alternativmethoden befassen, sollten von zukünftigem Interesse sein.

8. Summary

Evaluation of virtual patients in a blended learning delivery format for clinical interdisciplinary lectures in veterinary education

The objective of ILs is the interconnection of different subjects taught in the veterinary curriculum and the preparation of students for their future veterinary profession through interdisciplinary and relevant cases in clinical medicine and VPH. Higher education is often characterised by the departmental boundaries in educational establishments which can hinder the collaboration and joint mediation of content. Interdisciplinary lectures present an opportunity to overcome these boundaries and offer students highly interdisciplinary cases for the interconnection of individual subjects and the application of knowledge. Unfortunately, in education, the focus is often only on the lowest level of Bloom's taxonomy for learning objectives, and higher levels such as application or synthesis are left aside. Consequently, cognitive processes on higher levels are not promoted, students are not assisted into exploiting their full potential and are not able to fulfil the high expectations directed towards them.

As a consequence of the EAEVE visit of the VM-FUB in 2007, it was decided to revise the ILs with a special focus on their organisation and visibility as well as their content and didactic approach. Also, an internal survey in 2014 showed the students´ criticism that the ILs did not fulfil their requirements for IT. Consequently, the QuerVet project started in 2016 in order to revise the ILs at VM-FUB to meet the German requirements for ILs (according to TAppV) and to respond to the demands for improvement by students and the EAEVE. For the clinical ILs, VPs in a BL delivery format were chosen as a possible approach to offer interdisciplinary case-based content to veterinary students, with learning goals in all categories of Bloom's taxonomy for educational objectives.

This thesis concentrated on the clinical ILs. The objective of this work was to create VPs in a BL delivery format, implement them into the IL setting and to analyse their suitability for teaching ILs in veterinary education. This was realised through several student surveys analysing students' acceptance of VPs in a BL delivery format for clinical ILs, the achievement of learning objectives in the categories 1-3 of Bloom's taxonomy for educational objectives and the realisation of the 3 KCs for ILs through VPs in a BL delivery format.

The focus of the first study of the present thesis was on the creation, implementation and evaluation of three VPs in the field of small animal reproduction. The surveys concentrated on the case-based approach analysing the didactic use of media and the usability of the cases on the one hand, and the didactic concept on the other hand with an emphasis on self-assessed learning outcomes and the BL concept.

The second study of this thesis focussed on the evaluation of the overall BL concept of the new ILs, for both thematic fields of clinical veterinary medicine and VPH. Furthermore, a

comparative analysis was done of the previous and new concepts related to the implementation of the three KCs for ILs.

The results of both studies showed that VPs are very suitable in a BL delivery format for clinical ILs.

The aforementioned deficiencies of the previous ILs at VM-FUB were collectively addressed and corrected in the QuerVet project. The new ILs are now presented on a well-arranged landing page with a coherent course concept and with a balanced ratio of highly interdisciplinary cases from the fields of clinical veterinary medicine and VPH. Furthermore, in the context of the clinical ILs, sustainable, interactive and interdisciplinary VPs with relevance to veterinary practice were successfully implemented in a modular BL delivery format. Virtual patients and BL should be integrated more extensively into the veterinary curriculum as they can also help reach higher levels of Bloom's taxonomy for educational objectives. Furthermore, there is a high level of acceptance of VPs and BL by students and lecturers. Also, IT should be extended further to offer students more opportunities to apply their knowledge to realistic scenarios and better interconnect the different subjects in veterinary education.

Practical educational training with animals is classified as animal experimentation and as both VP and BL offer a solution to CBL of clinical topics for the ILs, which at VM-FUB are a non-practical course, VPs could also help to further implement the 3R principles in veterinary education in general. The results of this thesis and other publications show a high level of acceptance of VPs by veterinary students and further studies regarding their efficiency in combination with other alternative methods should be of future interest.

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Appendix

IL timetables from summer 2013 until winter 2016/17 at VM-FUB

Planungsgrundlage zu den Querschnitten

SoSe 2013 — 8. Fachsemester — Stand: 08.07.2013

Sem. Wo.	Tag	Datum	Zeit Beginn	Zeit Ende	h	Titel (Kurz)	Dozierende	beteiligte WEs	FS	Teiln. min	Teiln. max		Raum (mit "X" markieren) Klauent.	Patho.	Kleint.	Pferde
1	Mi	10.04.2013	13:15	16:30	4	Anatomie des Hufes, Hufkonformation und -stellung sowie Hufbearbeitung	Stäcker, Dietze	WE17, WE01	8						X	
2	Mi	17.04.2013	13:15	16:30	4	noch offen			8							
3	Mi	24.04.2013	13:15	16:30	4	noch offen			8							
4	Mi	01.05.2013	13:15	16:30	4	**01. Mai**			**8**							
5	Mi	08.05.2013	13:15	16:30	4	Hauttumore (Mastzelltumore, Fibrosarkome, u.a.), Mammatumore	Werner, Stein, Weingart, Klopfleisch	WE 20, WE 12	8	30	120				x	
6	Mi	15.05.2013	13:15	16:30	4	Weißwurstherstellung	Manopas, Reinartz	WE08	8	20	30		Fleischerinnung, Beusselstr			
6	Mi	15.05.2013	13:15	16:30	4	Biosicherheitsmaßnahmen in Tierhaltungen	Fries	WE09	8						x	
7	Mi	22.05.2013	13:15	16:30	4	Einführung in die Bestandsbetreuung von Milchkühen	Feucker , Taffe, Staufenbiel	WE18, Tierseuchenkasse, Data Service	8					X		
6	Mi	29.05.2013	13:15	16:30	4	Weißwurstherstellung		WE08	8	20	30		Fleischerinnung, Beusselstr			
8	Mi	29.05.2013	13:15	16:30	4	Neurologie und Neurochirurgie Kleintier	Loderstedt, Nakladal, Käßmeyer	WE 20	8	30	120				x	
9	Mi	05.06.2013	13:15	16:30	4	Kommunikation Tierarzt Landwirt - Worauf kommt es an? (Bestandsbesuch)	J. Driessen, H. P. Heckert	Fa. Zoetis, WE 18	8		20	x				
10	Mi	12.06.2013	13:15	16:30	4	Schweine am Haken – Was fällt mir dazu ein?	Fries, Kopfleisch	WE09, WE12	8		30		Ort: Campus Mitte Haus 13			
10	Mi	12.06.2013	13:15	16:30	4	Hufrehe	Hünigen, Lischer, Paßlack	WE01, WE17, WE04	8							X
11	Mi	19.06.2013	13:15	16:30	4	Klinische und Pharmakologische Aspekte zur Akuten Metritis beim Rind.	Hamann, Heuwieser	Pharmakologie, Tierklinik für Fortpflanzung	8	10	80		X			
11	Mi	19.06.2013	13:15	16:30	4	Praxismanagement	Trommler, Bartholomäus, Kohn	WE 20	8	30	120				x	
12	Mi	26.06.2013	13:15	16:30	4	Rückenerkrankungen des Pferdes	Lischer, König	WE17	8						X	
13	Mi	03.07.2013	13:15	16:30	4	Enzootische Hauterkrankungen beim Schwein	Lahrmann, Lübke-Becker, Demeler	WE 18, WE 7, WE 13	8		80			X		
13	Mi	03.07.2013	13:15	16:30	4	Lernverhalten und Clickertraining	Heuwieser	WE 19	8				X			
14	Mi	10.07.2013	13:15	16:30	4	Fütterung von Zuchtstute und Fohlen	Handler, Zentek	WE17, WE04	8						X	

J. Handler, S. Birk, 08.07.2013

Planungsgrundlage zu den Querschnitten

WS 2013/14 — Stand: 04.02.2014

Sem. Wo.	Tag	Datum	Zeit Beginn	Zeit Ende	h	verantw. WE	beteiligte WEs	Dozierende	Titel (Kurz)	Teiln. min	Teiln. max	Raum (mit "X" markieren) Klauent.	Patho.	Kleint.	Pferde
1	Mo	14.10.2013	13:30	15:45	3	17	WE17, WE03	Gehlen, Aschenbach, Merritt	Magenerkrankungen beim Pferd					X	
2	Mo	21.10.2013	13:30	15:45	3	18	WE18, WE14	Prof.Müller,Heckert, Haman	Arzneimittelrecht in der Praxis				X		
3	Mo	28.10.2013	13:30	15:45	3	19	WE 19 & WE08	Bertulat, Kleer	Eutergesundheit und Milchqualität beim Rind	20	85	X			
4	Mo	04.11.2013	13:30	15:45	3	20	WE20	Eule/Guthardt/ Weingart	Katzenschnupfen					X	
5	Mo	11.11.2013	13:30	15:45	3	17	WE08	Hildebrandt	Frischfisch + Meeresfrüchte					X	
5	Mo	11.11.2013	13:30	15:45	3	17	WE17, WE12	Schmitz, Klopfleisch	Tumordiagnostik beim Pferd				X		
6	Mo	18.11.2013	13:30	15:45	3	18	WE08	Hildebrandt	Krusten-, Schalen- und Weichtiere				X		
6	Mo	18.11.2013	13:30	15:45	3	18	extern	Müller et al.	Ausgewählte Aspekte des Hygienemanagements in der Nutztierpraxis		80	X			
7	Mo	25.11.2013	13:30	15:45	3	19	WE 19 & Agrartechnikm PM	Fischer-Tenhagen, Hoffmann, Schüller	Wichtige Aspekte der Tierhaltung	20			X		
8	Mo	02.12.2013	12:30	15:00	3	20	WE07	Günther	ESBL				X		
8	Mo	02.12.2013	12:30	15:00	3	20	WE20+extern	Müller, Plendl	Schmerz lass nach! Schmerzmanagement bei Heimtieren	60				X	
8	Di	03.12.2013	08:15	15:00	7	8	WE07, WE17, WE20	Lübke-Becker, Janßen, Walther	Rationaler Einsatz und verantwortungsvoller Umgang mit Antibiotika				X		
8	Di	03.12.2013	08:15	15:00	7	8	WE17, WE01 WE04, WE13	Al Aiyan, Gehlen, Barton, Samson v. Himmelsternja, Zentek	Kolik Pferd	15					X
8	Di	03.12.2013	**15:30**	**19:00**	7	8	WE17+bpt	Handler, Herr Colombel	Betriebswirtschaft				X		
8	Di	03.12.2013	08:15	15:00	7	8	WE18	Prof. Müller, Heckert	Bestandsausfahrten		20				
8	Mi	04.12.2013	08:15	15:00	7	9	WE18	Prof. Müller, Heckert	Bestandsausfahrten		20				
8	Mi	04.12.2012	08:15	15:00	7	9	WE7	Herbel	Probiotika		10	5er-Institut, Raum R50			

S. Birk, 04.02.2014

Planungsgrundlage zu den Querschnitten

WS 2013/14 Stand: 04.02.2014

Sem. Wo.	Tag	Datum	Zeit Beginn	Zeit Ende	h	verantw. WE	beteiligte WEs	Dozierende	Titel (Kurz)	Teiln. min	Teiln. max	Raum (mit "X" markieren) Klauent.	Patho.	Kleint.	Pferde
8	Mi	04.12.2013	08:15	15:00	7	9	WE17, WE01	Gehlen, Hüningen, Plendl	Obere Atemwege Pferd vormittags 8.15-10 Uhr; Echokardiographie Pferd (Nachmittags 14-16 Uhr)	15					X
9	Mo	09.12.2013	13:30	15:45	3	20	20	Vollmar, Dohlen, Kohn	Herzerkrankungen/-therapie beim Kleintier	60				X	
10	Mo	16.12.2013	13:30	15:45	3	19	WE 19 & WE 14	Heuwieser, Hamann	Metritis beim Rind	20			X		
11	Mo	06.01.2014	13:30	15:45	3	20	20+extern	Kohn, Betz, Nakladal	Onkologie beim Kleintier(Chirurgie, Chemotherapie, Bestrahlung)	60				X	
12	Mo	13.01.2014	13:30	15:45	3	17	WE 17; Versorgungswerk der Landestierärztekammer	Prof. Handler, Peer Archilles	„Geheimnisse“ der berufsständischen Versorgung					X	
13	Mo	20.01.2014	13:30	15:45	3	18	WE18, extern	Staufenbiel	Labordiagnostik in der Bestandsbetreuung				X		
14	Mo	27.01.2014	13:30	15:45	3	19	WE 19 & Bibliothek	Arlt, Kosmol	Entscheidungsfindung in der tierärztlichen Praxis	20			X		
15	Mo	03.02.2014	13:30	15:45	3	17	WE17, extern	Prof. Handler	Zuchttierwahl beim Pferd				X		
16	Mo	10.02.2014	12:30	15:00	3	18	WE18, WE09	Lahrmann, Langkabel	Porcines Stress Syndrom	80			X		
16	Mo	10.02.2013	12:30	15:00	3	18	WE7	Tedin	Salmonella in Tierbeständen und zoonotisches Potential			X			
16	Di	11.02.2014	08:15	15:00	7	20	WE20+extern	Brunnberg et al, Loderstedt, Bartholomäus	Muskuloskeletale Erkrankungen beim Kleintier	60				X	
16	Mi	12.02.2014	08:15	15:00	7	17	WE17, WE01	Käßmeyer, Stäcker, Lischer	QS-Tag Lahmheit, Pferdeklinik						X
16	Mi	12.02.2014	08:15	15:00	7	17	WE08	Hühn	Besuch der MLUA (Milchwirtschaftliche Lehr- und Untersuchungsanstalt) in Oranienburg		30				

S. Birk, 04.02.2014

Planungsgrundlage zu den Querschnitten

SoSe 2014 | 6. Fachsemester | Stand: 25.06.2014

Sem. Wo.	Tag	Datum	Zeit Beginn	Zeit Ende	h	verantw. WE	beteiligte WE	Titel (Kurz)	Dozierende	FS	Teiln.		In BB	Raum (mit "X" markieren)			
											min	max		Klauent.	Patho.	Kleint.	Pferde
1	Mo	14.04.2014	15:00	18:15	4	17											
2	Mo	21.04.2014	15:00	18:15	4			**Ostermontag**		6							
3	Mo	28.04.2014	15:00	18:15	4	20	WE20	Urogenitaltrakt:Dysurie, Inkontinenz, Cystitis, FLUTD. Chirurgie Harnwege	Nickel	6						X	
4	Mo	05.05.2014	15:00	18:15	4	8	WE08	"Wie kommt Salmonella auf den Teller? Epidemiologie von Zoonoseerregern in der Lebensmittelkette"	Bernd-Alois Tenhagen	6					X		
5	Mo	12.05.2014	15:00	18:15	4	9	WE09	Die internationale Verflechtung von Tier- und Warenströmen und die Konsequenzen	Fries	6						x	
6	Mo	19.05.2014	15:00	18:15	4	18	WE17	Reproduktion der Stute	Prof. Handler	6							x
7	Mo	26.05.2014	15:00	18:15	4	19	WE19, WE01, WE18, WE17	Kastration bei Großtieren – von der Anatomie bis zur Operation	Plendl, Lahrmann, Handler, Sens, Burfeind	6				X			
8	Mo	02.06.2014	15:00	18:15	4	20	WE20	Gastrointestinaltrakt: chronische Magen-/Darmerkrankungen	Kohn, Hartmann	6						X	
9	Mo	09.06.2014	15:00	18:15	4			**Pfingstmontag**		6							
10	Di	16.06.2014	15:00	18:15	4	17	WE17; WE01	No hoof no horse“ (Huforthopädie)	Prof. Lischer, Dr. Stäcker	6							x
11	Mi	23.06.2014	15:00	18:15	4	8	WE08	Weißwurstherstellung Fleischerinnung Beusselstr.	Stefanie Orquera, Carolin Riedel	6		30					
12	Mi	30.06.2014	15:00	18:15	4	9	9, 10	Zoonoseerreger im Transfer	Fries, Rösler	6						X	
13	Mi	07.07.2014	15:00	18:15	4	18	WE18, WE16	Labordiagnostik i.d. Bestandsbetreuung	Staufenbiel	6						X	
13	Mi	07.07.2014	15:00	18:15	4	18	WE07	Ödemkrankheit Schwein	Wieler	6					X		
14	Mo	14.07.2014	15:00	18:15	4	19	WE19	Tiere richtig behandeln - wie geht das?	Haimerl, Gäng, Arlt	6					X		

J. Handler, S. Birk, 25.06.2014

Planungsgrundlage zu den Querschnitten

SoSe 2014 — 8. Fachsemester — Stand: 25.06.2014

Sem. Wo.	Tag	Datum	Zeit Beginn	Zeit Ende	h	verantw. WE	beteiligte WE	Titel (Kurz)	Dozierende	FS	Teiln. min	Teiln. max		Raum (mit "X" markieren) Klauent.	Patho.	Kleint.	Pferde
1	Mi	16.04.2014	13:15	16:30	4	17	Anatomie	Internistische Sonographie	Dr. Barton, Dr. Winter	8							x
2	Mi	23.04.2014	13:15	16:30	4	8	WE08	Beitrag zur Lebensmittelsicherheit in Europa - Schnellwarnsysteme	David Trigo (BVL)	8						X	
3	Mi	30.04.2014	13:15	16:30	4	9	WE19	Veterinär-Homöopathie; objektiv betrachtet	Arlt	8							X
4	Mi	07.05.2014	13:15	16:30	4	17	WE17; WE01; WE12	Operative Eingriffe am Pferdekopf	Prof. Lischer, Dr. Schulze	8							X
4	Mi	07.05.2014	13:15	16:30	4	17	WE09, WE12	Was erzählen uns die Tiere?	Fries, Klopfleisch	8		35		Campus Mitte			
5	Mi	14.05.2014	13:15	16:30	4	20	WE20	Hauttumore (Mastzelltumore, Fibrosarkome, u.a.) Mammatumore	Werner, Nakladal, Weingart, Klopffleisch	8						X	
6	Mi	21.05.2014	13:15	16:30	4	8	WE08	"Molekulare Epidemiologie bei lebensmittelassoziierten Krankheitsausbrüchen"	Burkhard Malorny (burkhard.malorny@bfr.bund.de)	8						X	
6	Mi	21.05.2014	13:15	16:30	4	8	WE18	People's Signals. Erfolgreiche Kommunikation zwischen Tierarzt und Tierhalter	Prof. Müller, Zieger	8							X
7	Mi	28.05.2014	13:15	16:30	4	18	WE18; externer RA	Rechtsanwalt und Tierarzt	Staufenbiel	8						X	
7	Mi	28.05.2014	13:15	16:30	4	18	WE07	Salmonella in Tierbeständen und zoonotisches Potential	Tedin	8							X
8	Mi	04.06.2014	13:15	16:30	4	9	9, 12, 18	Was erzählen uns die Tiere?	Fries, Klopfleisch, Lahrmann	8		35		Campus Mitte			
9	Mi	11.06.2014	13:15	16:30	4	19	WE19	Arbeitsfeld eines Tierarztes auf einer Rinderbesamungsstation	Fischer-Tenhagen, Ossmer					X			
9	Mi	11.06.2014	13:15	16:30	4	19	WE17; WE02	Lungenfunktion und -diagnostik	Dr. Barton, Dr. Schmitz	8							x
10	Mi	18.06.2014	13:15	16:30	4	20	WE20	Neurologie und Neurochirurgie Kleintier	Loderstedt, Nakladal	8						X	
11	Mi	25.06.2014	13:15	16:30	4	17	WE17; WE01	Anatomie und Pathologie der Pferdesehne	Prof. Lischer, Dr. Stäcker	8							x
12	Mi	02.07.2014	13:15	16:30	4	18	WE18, 07, 13	Enzoot. Hauterkrankungen beim Schwein	Lahrmann, Lübke-Becker, Demeler	8					X		
13	Mi	09.07.2014	13:15	15:00	4	19	WE19	Tipps für die Bewerbung nach dem Studium (Doktorarbeit und Assistentenstelle)	Heuwieser, Liedloff (Finanzplanung für Akademiker)	8					X		
14	Mi	16.07.2014	13:15	16:30	4	20	WE20	Kommunikation	Müller, Eule et al	8						X	

J. Handler, S. Birk, 25.06.2014

Planungsgrundlage zu den Querschnitten

WS 2014/15 — Stand: 26.01.2015

Sem. Wo.	Tag	Datum	Zeit Beginn	Zeit Ende	h	verantw. WE	beteiligte WEs	Dozierende	Titel (Kurz)	Teiln. min	Teiln. max	Raum (mit "X" markieren) Klauent.	Patho.	Kleint.	Pferde	
1	Mo	13.10.2014	13:30	15:45	3	17	WE17, WE01	Gehlen	Herz						X	
2	Mo	20.10.2014	13:30	15:45	3	18	WE18	Müller, Brandt	Komplexe Systeme in der Veterinärmedizin			X				
3	Mo	27.10.2014	13:30	15:45	3	19	WE19	C. Fischer-Tenhagen Prof. T. Jezierski	Spürhunde-Einsatzmöglichkeiten in Medizin und Landwirtschaft.							
4	Mo	03.11.2014	13:30	15:45	3	20	WE20	Eule/Guthardt/ Weingart	Katzenschnupfen					X		
5	Mo	10.11.2014	13:30	15:45	3	17	WE17, WE01	Gehlen	Obere Atemwege						X	
6	Mo	17.11.2014	13:30	15:45	3	18	WE07, WE18	Wieler, Lahrmann	Mikrobiom/Probiotika Schwein				X			
7	Mo	24.11.2014	13:30	15:45	3	19	WE19	Arlt	Veterinärakupunktur – aus Sicht von Praxis und Wissenschaft				X			
7	Mo	01.12.2014	08:15	11:00	3	20	WE17	Handler	Progress-Test							E-Examinations
8	Mo	01.12.2014	12:30	15:00	3	20	WE20	Kohn/Werner /Manchi/Pagel/ Dettling	Onkologie beim Kleintier (Chemotherapie, Bestrahlung, Chirurgie)					**X**		
8	Di	02.12.2014	08:15	15:00	7	8	WE07, WE17, WE20	Lübke-Becker Bethe Walther Janßen	Rationaler Einsatz und verantwortungsvoller Umgang mit Antibiotika bei kleinen Haustieren und Pferden					X		
8	Di	02.12.2014	08:15	15:00	7	8	WE 08	Hühn	Besuch der MLUA (Milchwirtschaftliche Lehr- und Untersuchungsanstalt) in Oranienburg		30					Oranienburg
8	Mi	03.12.2014	08:15	15:00	7	9	WE 09, 12, 18	Fries, Klopfleisch, Lahrmann	Was erzählen uns die Tiere?		30					Campus Mitte
9	Mo	08.12.2014	14:30		3	20	WE 15	bpt-Hochschul-seminar, Herr Colombel	Der Weg in die Praxis – Was Tierärzte zu Betriebswirtschaft und Recht wissen müssen				X			
9	Mo	08.12.2014	13:30	15:45	3	20	WE01, WE20	Müller/Plendl	Schmerz lass nach! Schmerzmanagement bei Heimtieren					X		
10	Mo	15.12.2014	13:30	15:45	3	19	WE19	Bertulat / Reinhold	Sherlock Holmes am Euter – vom Stall bis ins Labor				X			
10	Mo	15.12.2014	13:30	15:45	3	19	WE07, WE08	Eichhorn, Hühn	EHEC-Ausbruch Rückblick			X				
11	Mo	05.01.2015	13:30	15:45	3	20	WE20	Vollmar/Dohlen	Herzerkrankungen/-therapie beim Kleintier					X		
12	Mo	12.01.2015	13:30	15:45	3	17	WE17, WE01	Lischer	Chronische Lahmheit					X		

S. Birk, 26.01.2015

Planungsgrundlage zu den Querschnitten

WS 2014/15 Stand: 26.01.2015

13	Mo	19.01.2015	13:30	15:45	3	18	WE07	Tedin	Salmonella in Tierbeständen und zoonotisches Potential				x		
14	Mo	26.01.2015	13:30	15:45	3	19	WE19	Heuwieser/ Hamann	Aktuelles zur Klinik und Pharmakologie der akuten Metritis beim Rind				x		
14	Mo	26.01.2015	13:30	15:45	3	19	WE07, WE18	Wieler, Müller	Bakterielle Durchfallerkrankungen beim Kalb				x		
15	Mo	02.02.2015	13:30	15:45	3	17	HU-Berlin	Handler/ Kotenbeutel/ Reissmann	Zuchttierauswahl					x	
16	Mo	09.02.2015	12:30	15:00	3	18	WE18, WE09	Lahrmann / Langkabel	Porcines Stresssyndrom				x		
16	Mo	09.02.2015	12:30	15:00	3	18	WE07, WE08	Eichhorn, Hühn	Überblick diagnostische Methoden			x			
16	Di	10.02.2015	08:15	15:00	7	20	WE07, WE18	Lübke-Becker Bethe Walther Janßen	Rationaler Einsatz und verantwortungsvoller Umgang mit Antibiotika bei landwirtschaftlichen Nutztieren				x		
16	Di	10.02.2015	08:15	15:00	7	20	WE20	Brunnberg/ Loderstedt/ Manchi/ M. Brunnberg/ Bartholomäus	Muskuloskeletale Erkrankungen beim Kleintier					x	
16	Mi	11.02.2015	08:15	15:00	7	17	WE17, WE01	Winter	Kolik-Tag					x	

S. Birk, 26.01.2015

Planungsgrundlage zu den Querschnitten

SoSe 2015 — 8. Fachsemester — Stand: 07.07.2015

Sem. Wo.	Tag	Datum	Zeit Beginn	Zeit Ende	h	verantw. WE	beteiligte WE	Titel (Kurz)	Dozierende	FS	Teiln. min	Teiln. max	In BB	Raum (mit "X" markieren) Klauent.	Patho.	Kleint.	Pferde
1	Mo	13.04.2015	15:00	18:15	4												
2	Mo	20.04.2015	15:00	18:15	4	8	WE08/16	Einführung zum Thema Modellierungen	Doherr u.A.	6					X		
3	Mo	27.04.2015	15:00	18:15	4	20	WE20	Urogenitaltrakt	Nickel u.a.	6						x	
4	Mo	04.05.2015	15:00	18:15	4	8	WE 08	Weißwurstherstellung Fleischerinnung Beusselstr.	Doreen Herrfurth, Carolin Riedel	6		30					
5	Mo	11.05.2015	15:00	18:15	4	9	9, 8 und Vet-Behörde Dahme-Spreewald	Gewinnung, Hygiene u. Sicherheit LM Geflügel	Baumann, Feiler, Alter, Winzig (AT Dahme-Spreewald	6		50		Campus Mitte			
6	Mo	18.05.2015	15:00	18:15	4	18	WE18	Ökonomie für Tierärzte	Müller, Brandt	6					X		
7	Mo	25.05.2015	15:00	18:15	4			**Pfingstmontag**		6							
8	Mo	01.06.2015	15:00	18:15	4	20	WE20, WE 06	GI-Trakt: chronische Magen-Darmerkrankungen	Kohn, Hartmann, Volkmann	6						x	
9	Mo	08.06.2015	15:00	18:15	4	19	WE19	Tiere nach aktuellen Standards behandeln, wie geht das?	Haimerl, Arlt, Gäng	6							X
10	Mo	15.06.2015	15:00	18:15	4	17	WE 17	No hoof no horse	Stäcker/Lischer	6							X
11	Mo	22.06.2015	15:00	18:15	4	8	WE08	Epidemiologie von Zoonoseerregern in der Lebensmittelkette	Bernd-Alois Tenhagen	6					X		
12	Mo	29.06.2015	15:00	18:15	4	9	9, 8 und BfR	Gewinnung, Hygiene u. Sicherheit LM Wild	Baumann, Alter, Bandick (BfR)	6		50		Campus Mitte			
12	Mo	29.06.2015	15:00	18:15	4	9	WE 18, WE 16	Spezifische Aspekte der Anwendung der Labordiagnostik in der Bestandsbetreuung	Staufenbiel, Doherr	6					X		
13	Mo	06.07.2015	15:00	18:15	4	18	WE18/WE11	Landwirtschaftliche Nutztierhaltung und Tierschutz	Müller/Thöne-Reinecke	6					X		
14	Mo	13.07.2015	15:00	18:15	4	19	WE 19	Tiertraining, wie kann mir das bei der Therapie nutzen?	Fischer/Tenhagen	6				X			

8. Fachsemester

Sem. Wo.	Tag	Datum	Zeit Beginn	Zeit Ende	h	beteiligte WEs	beteiligte WEs	Titel (Kurz)	Dozierende	FS	Teiln. min	Teiln. max		Raum (mit "X" markieren) Klauent.	Patho.	Kleint.	Pferde
	Mi	15.04.2015	13:15	16:30	4	17	WE 18, WE 01	Internistische Sono	Gehlen/Barton/Winter/Plendl								X
1	Mi	15.04.2015	13:15	16:30	4	17	WE 18	Anforderungen der modernen Landwirtschaftsbetriebe an den Tierarzt – Wie funktioniert moderne Landwirtschaft und welche Erwartungen werden an den Tierarzt gestellt?	Staufenbiel, Dr. Kreher (Tierarzt) Dr. Pieper (Landwirt und Unternehmer)	8					X		
2	Mi	22.04.2015	13:15	16:30	4	8	WE09	Ansätze zur Reduktion resistenter Keime in Lebensmitteln	Bernd-Alois Tenhagen	8					X		
3	Mi	29.04.2015	13:15	16:30	4	9	WE 08	Weißwurstherstellung Fleischerinnung Beusselstr.	Stefanie Orquera, Carolin Riedel	8							
4	Mi	06.05.2015	13:15	16:30	4	17	WE17	Sehnenerkrankungen	Lischer/Schulze	8							X
5	Mi	13.05.2015	13:15	16:30	4	20	9, 12, 18	Tiere am Haken	Fries, Klopfleisch, Lahrmann	8		35		Campus Mitte			
6	Mi	20.05.2015	13:15	16:30	4	20	WE20, WE 12	Hauttumore (Mastzelltumore, Fibrosarkome, u.a.)	Werner, Weingart, Klopfleisch, Manchi, Brunnberg	8						x	
	Mi	20.05.2015	13:15	16:30	4	20	WE 18	Tierarzt und Rechtsanwalt – Grundsätze der Zusammenarbeit und Fallbeispiel aus dem Kaufrecht und Haftpflichtrecht	Staufenbiel, Gastreferent Rechtsanwalt M. Wesser						X		
7	Mi	27.05.2015	13:15	16:30	4	18	07, 13	Enzoootische Hautkrankheiten beim Schwein	Lahrmann, Lübke-Becker, Demeler	8					X		
8	Mi	03.06.2015	13:15	16:30	4	9				8							
9	Mi	10.06.2015	13:15	16:30	4	19	9, 12, 18	Tiere am Haken	Fries, Langkabel, Klopfleisch, Lahrmann	8		35		Campus Mitte			
	Mi	10.06.2015	13:15	16:30	4	19	WE 17	Lunge Physiologie									X
10	Mi	17.06.2015	13:15	16:30	4	20	WE20, WE 01	Neurologie - Neurochirurgie	Loderstedt u.a.	8						x	
11	Mi	24.06.2015	13:15	16:30	4	17		OPs am Kopf		8							X
12	Mi	01.07.2015	13:15	16:30	4	18	18	Hygienemanagement in medizinischen Einrichtungen	Müller, Lorenz	8				X			
13	Mi	08.07.2015	13:15	16:30	4	19	WE19	Überwachung von Milchkühen nach der Abkalbung	Heuwieser	8				X			
14	Mi	15.07.2015	13:15	16:30	4	20	WE20	Kommunikation	Eule u.a.	8						x	

J. Handler, S. Birk, 07.07.2015

Planungsgrundlage zu den Querschnitten

WS 2015/16 Stand: 08.02.2016

Sem. Wo.	Tag	Datum	Zeit Beginn	Zeit Ende	h	verantw. WE	beteiligte WEs	Dozierende	Titel (Kurz)	Teiln. min	Teiln. max	Raum (mit "X" markieren) Klauent.	Patho.	Kleint.	Pferde
1	Mo	12.10.2015	13:30	15:45	3	17	WE17	Handler, Kotenbeutel, Reißmann	Auswahl von Zuchtpferden						X
2	Mo	19.10.2015	13:30	15:45	3	18	WE18	Müller/Heckert/ Schuhmacher	Infektionsprävention u.Hygienemanagment in der Fahrpraxis				X		
3	Mo	26.10.2015	13:30	15:45	3	19	WE 19	Borchardt und Praktiker	Einstieg in die Nutztierpraxis - Erfahrungsberichte						
4	Mo	02.11.2015	13:30	15:45	3	20	WE 20	Eule, Weingart, Guthardt	Katzenschnupfen					x	
5	Mo	09.11.2015	13:30	15:45	3	17		Gehlen/Plendel	Diagnostik oberer Atemwegserkrankungen beim Pferd				X		
6	Mo	16.11.2015	13:30	15:45	3	18	FLI	Müller/Köhler	Gemeinsam gegen die Paratuberkulose-Praktiker und Labor Hand in Hand				X		
7	Mo	23.11.2015	13:30	15:45	3	19	WE 11, WE 19	Thöne-Reineke, Ladwig, Arlt	Hundezucht				X		
8	Mo	30.11.2015	12:30	15:00	3	WE 20	Kohn, Werner, Manchi, Pagel, Dettling	Onkologie beim Kleintier (Chiurgie, Chemotherapie, Bestrahlung)						**X**	
8	Di	01.12.2015	08:15	15:00	7	8	WE07, WE17, WE20	Lübke-Becker, Bethe, Walther	Rationaler Einsatz und verantwortungsvoller Umgang mit Antibiotika bei kleinen Haustieren und Pferden					X	
8	Di	01.12.2015	08:15	15:00	7	8	8	Hühn	Exkursion MLUA	30					
8	Di	01.12.2015	**12:00**	**15:30**	**3**	8	9, 12,18	Langkabel, Lahrmann, Klopfleisch, Ellerbroek (BfR)	Tiere am Haken		40	Campus Mitte, Haus 13			
8	Mi	02.12.2015	**09:00**	**12:00**	3	20	Dekanat		Progress-Test (alle)			E-Exam Center, Fabeckstr. 34–36			

S. Birk, 08.02.2016

Planungsgrundlage zu den Querschnitten

WS 2015/16 Stand: 08.02.2016

Sem. Wo.	Tag	Datum	Zeit Beginn	Zeit Ende	h	verantw. WE	beteiligte WEs	Dozierende	Titel (Kurz)	Teiln. min	Teiln. max	Raum (mit "X" markieren) Klauent.	Patho.	Kleint.	Pferde
8	Mi	02.12.2015	**14:30**	**18:30**	7	9		Colombel	Der Weg in die Praxis – Was Tierärzte zu Betriebswirtschaft und Recht wissen müssen				X		
9	Mo	07.12.2015	13:30	15:45	3	20	WE 20	Müller, Plendl	Schmerz lass nach! Schmerzmanagement bei Heimtieren					x	
9	Mo	07.12.2015	13:30	15:45	3	20	WE08, WE07	Hühn, Eichhorn	EHEC-Ausbruch				X		
10	Mo	14.12.2015	13:30	15:45	3	19	WE 19	Fischer-Tenhagen, n.n.	Tierschutz in der Nutztierpraxis					X	
10	Mo	14.12.2015	13:30	15:45	3	19	WE08, WE07	Hühn, Eichhorn	Diagn. Methoden				X		
11	Mo	04.01.2016	13:30	15:45	3	20	WE 20 + extern	Vollmar	Herzerkrankungen/-therapie beim Kleintier					x	
12	Mo	11.01.2016	13:30	15:45	3	17	WE 17	Lischer	Chronische Lahmheit beim Pferd				X		
13	Mo	18.01.2016	13:30	15:45	3	18	WE 18	Staufenbiel/Kreher/Pieper	Anforderungen der modernen Landwirtschaftsbetriebe an den Tierarzt				X		
14	Mo	25.01.2016	13:30	15:45	3	19	WE 14, WE 19	Heuwieser, Sanders	Klinische und pharmakologische Aspekte der Metritis des Rindes				X		
15	Mo	01.02.2016	13:30	15:45	3	17	WE 17	Gehlen/Plendel	Kardiologie beim Pferd				X		

S. Birk, 08.02.2016

Planungsgrundlage zu den Querschnitten

WS 2015/16 Stand: 08.02.2016

Sem. Wo.	Tag	Datum	Zeit Beginn	Zeit Ende	h	verantw. WE	beteiligte WEs	Dozierende	Titel (Kurz)	Teiln. min	Teiln. max	Raum (mit "X" markieren) Klauent.	Patho.	Kleint.	Pferde
16	Mo	08.02.2016	12:30	15:00	3	18	WE07	Tedin	Salmonella in Tierbeständen und zoonotisches Potential				X		
16	Mo	08.02.2016	12:30	15:00	3	18	WE18	Lahrmann	Porcines Streßsyndrom			X			
16	Di	09.02.2016	08:15	15:00	7	20	WE 20	Brunnberg, Loderstedt, Manchi, M. Brunnberg	Muskuloskeletale Erkrankungen beim Kleintier					X	
16	Di	09.02.2016	**12:00**	**15:30**	3	20	9, 12,18	Langkabel, Lahrmann, Klopfleisch, Ellerbroek (BfR)	Tiere am Haken		40	Campus Mitte, Haus 13			
16	Mi	10.02.2016	**09:00**	**17:00**	7	17	09 + 2 externe Kollegen	Michael Bucher, Stephan Stenzel-Kaiser, Nina Langkabel	From Farm to Fork - Leben und Sterben eines Freilandrindes				X		
16	Mi	10.02.2016	08:15	15:00	7	17	1, 4, 13, 17	Barton, Hünigen, Winter,Samson-Himmelsternja	Kolik des Pferdes aus verschiedenen Blickwinkeln			X			

S. Birk, 08.02.2016

Planungsgrundlage zu den Querschnitten

SoSe 2016 | 6. Fachsemester | Stand: 06.07.2016

Sem. Wo.	Tag	Datum	Zeit Beginn	Zeit Ende	h	verantw. WE	beteiligte WE	Titel (Kurz)	Dozierende	FS	Teiln.		In BB	Raum (mit "X" markieren)			
											min	max		Klauent.	Patho.	Kleint.	Pferde
1	Mo	18.04.2016	15:00	18:15	4	17				6							
2	Mo	25.04.2016	15:00	18:15	4	8	16	Molekulare Epidemiologie in der Lebensmittelkette	Alter, Hühn, Doherr	6					X		
3	Mo	02.05.2016	15:00	18:15	4	20	20	Urogenitaltrakt:Dysurie, Inkontinenz, Cystitis, FLUTD. Chirurgie Harnwege	Nickel	6						x	
4	Mo	09.05.2016	15:00	18:15	4	8	8	Epidemiologie von Zoonoseerregern in der Lebensmittelkette	Tenhagen	6					X		
5	Mo	16.05.2016	15:00	18:15	4			**Pfingstmontag**		6							
6	Mo	23.05.2016	15:00	18:15	4	9	16	Ausbrüche und Ausbruchsuntersuchungen	Doherr, Denzin, Simoneit						X		
7	Mo	30.0.2016	15:00	18:15	4	18	18	**Sensortechnik im Stall**	Müller	6					X		
8	Mo	06.06.2016	15:00	18:15	4	20	WE 6	Gastrointestinaltrakt: chronische Magen-/Darmerkrankungen	Kohn, Hartmann, Volkmann	6						x	
9	Mo	13.06.2016	15:00	18:15	4	19	WE 19 & Bibliothek	Tiere nach aktuellem Wissen behandeln, wie geht das?	Haimerl, Arlt	6					x		
10	Mo	20.06.2016	15:00	18:15	4	17	17	„No hoof, no horse“	Rheinfeld/Rettig	6					X	belegt	
11	Mo	27.06.2016	15:00	18:15	4	8	8	Das Schnellwarnsystem RASFF - Ein Beitrag zur Lebensmittelsicherheit in Europa	Trigo	6					X	belegt	
12	Mo	04.07.2016	15:00	18:15	4	9	16	Kritisches Denken und kritische Denkfehler	Doherr	6					X	belegt	
13	Mo	11.07.2016	15:00	18:15	4	18	18	Anwendung der Labordiagnostik i.d. Bestandsbetreuung	Doherr,Staufenbiel	6					X	belegt	
14	Mo	18.07.2016	15:00	18:15	4	19	WE 19	Einstieg in die Nutztier-Praxis - Erfahrungsberichte	Borchardt, Venjakob, Kr	6						X	

J. Handler, S. Birk, 27.08.2021

Planungsgrundlage zu den Querschnitten

SoSe 2016 | 8. Fachsemester | Stand: 06.07.2016

Sem. Wo.	Tag	Datum	Zeit Beginn	Zeit Ende	h	beteiligte WEs	beteiligte WEs	Titel (Kurz)	Dozierende	FS	Teiln. min	Teiln. max		Raum (mit "X" markieren) Klauent.	Patho.	Kleint.	Pferde
1	Mi	20.04.2016	13:15	16:30	4	17	17, 01	Internistische Sonographie	Barton/Winter	8					belegt	X	
2	Mi	27.04.2016	13:15	16:30	4	8	8	Ansätze zur Reduktion resistenter Keime in Lebensmitteln	Tenhagen	8					belegt	X	
3	Mi	04.05.2016	13:15	16:30	4	9		Antibiotikaeinsatz und Resistenzen	Merle, Rösler, Walther, Käsbohrer	8					belegt	X	
4	Mi	11.05.2016	13:15	16:30	4	17	17, 01	Sehnenerkrankungen	Schulze/u.A.	8					belegt	X	
5	Mi	18.05.2016	13:15	16:30	4	20	12	Hauttumore (Mastzelltumore, Fibrosarkome, u.a.) Mammatumore	Werner, Weingart, Klopffleisch	8						x	
6	Mi	25.05.2016	13:15	16:30	4	8		Weißwurstherstellung Fleischerinnung Beusselstr.	Herrfurth / Riedel	8		30			belegt		
7	Mi	01.06.2016	13:15	16:30	4	18	18,Extern	Rechtsanwalt und Tierarzt	Staufenbiel u.Rechtsanwalt Wesser	8						X	
7	Mi	01.06.2016	13:15	16:30	4	18		Salmonella in Tierbeständen und zoonotisches Potential	Tedin	8				X	belegt		
8	Mi	08.06.2016	13:15	16:30	4	9		Vorlesung Bienen und Fischkrankheiten - Exkursion	Stefan Heidrich	8				Aquarium Postdam			
9	Mi	15.06.2016	13:15	16:30	4	19	WE 19	Tierschutz in der Nutztierhaltung	Fischer-Tenhagen + Münnich	8					X		
10	Mi	22.06.2016	13:15	16:30	4	20	1	Neurologie und Neurochirurgie Kleintier	Loderstedt	8					belegt	X	
11	Mi	29.06.2016	13:15	16:30	4	17	17, 02	Lungenphysiologie	Barton/Loschelder	8						X	
12	Mi	06.07.2016	13:15	16:30	4	18		Enzootische Hautkrankheiten beim Schweinen	Lahrmann,Lübke-Becker,Demeler	8				X			
13	Mi	13.07.2016	13:15	16:30	4	19	WE 19	Zukunftswerkstatt Traumstudium	Pohl et al	8				X			
14	Mi	20.07.2016	13:15	16:30	4	20	Industrie	Kommunikation	Eule et al	8						X	

J. Handler, S. Birk, 27.08.2021

Planungsgrundlage zu den Querschnitten

WS 2016/17 Stand: 28.02.2017

Sem. Woche	Tag	Datum	Zeit Beginn	Zeit Ende	h	verantw. WE	beteiligte WEs	Dozierende	Titel (Kurz)	Teiln. min	Teiln. max	Raum (mit "X" markieren) Klauent.	Kleint.	Patho.	Pferde
1	Mo	17.10.2016	13:30	15:45	3	17	WE17	Handler	Repro Pferd				X		
2	Mo	24.10.2016	13:30	15:45	3	18	WE18	Heckert	Der Kleine Wiederkäuer als Patient-akt.Erkrankungen bei Schaf und Ziege				X		
3	Mo	31.10.2016	13:30	15:45	3	19	WE 19 und Gast	Borchardt/ Schünemann	Innovative approaches in heard health management				X		
3	Mo	31.10.2016	13:30	15:45	3	19	WE 19, WE17	Winter, Eule, Mählmann	Notfälle in der Pferdemedizin			X			
4	Mo	07.11.2016	13:30	15:45	3	20	WE 20	Eule, Weingart, Guthardt	Katzenschnupfen				x		
5	Mo	14.11.2016	13:30	15:45	3	17	WE17, WE01	Gehlen, Hünigen	Diagnostik der oberen Atemwege beim Pferd				X		
6	Mo	21.11.2016	13:30	15:45	3	18	WE18	Staufenbeil/Groen dsp-Agrosoft	Einführung in die Nutzung von Herdendaten in der Bestandsbetreuung				X		
7	Mo	28.11.2016	13:30	15:45	3	19	WE 11, WE 19	Thöne-Reinecke, Arlt	Herausforderungen in der Hundezucht				X		
8	Mo	05.12.2016	12:30	15:00	3	20	WE 20	Kohn, Müller, Stein, Manchi, Pagel, Dettling	Onkologie beim Kleintier (Chiurgie, Chemotherapie, Bestrahlung)				x		
8	Di	06.12.2015	08:15	15:00	7	8	WE08	Herrfurth/Riedel	Exkursion MLUA		30				
8	Di	06.12.2016	08:15	15:00	7	8	WE07, WE17, WE20	Lübke-Becker, Bethe, Walther	Rationaler Einsatz und verantwortungsvoller Umgang mit Antibiotika bei kleinen Haustieren und Pferden				X		
8	Mi	07.12.2016	**09:00**	**12:00**	3	9	Dekanat	Doherr, Birk	Progress-Test (alle)			E-Exam Center, Fabeckstr. 34–36			
8	Mi	07.12.2016	**14:30**	**18:30**	4	9		Colombel	Der Weg in die Praxis – Was Tierärzte zu Betriebswirtschaft und Recht wissen müssen				X		

S. Birk, 27.08.2021

Planungsgrundlage zu den Querschnitten

WS 2016/17 Stand: 28.02.2017

Sem. Woche	Tag	Datum	Zeit Beginn	Zeit Ende	h	verantw. WE	beteiligte WEs	Dozierende	Titel (Kurz)	Teiln. min	Teiln. max	Raum (mit "X" markieren) Klauent.	Kleint.	Patho.	Pferde
9	Mo	12.12.2016	13:30	15:45	3	WE 20	WE 20	Vollmar, Kohn	Herzerkrankungen/-therapie beim Kleintier				X		
9	Mo	12.12.2016	13:30	15:45	3	19	WE 19 und n.n.	Bertulat	Mastitisquerschnitt			X			
10	Mo	02.01.2017	13:30	15:45	3		Urlaubstag								
11	Mo	09.01.2017	13:30	15:45	3	20	WE 01, WE 19, WE 20	Müller, Plendl	Schmerz lass nach! Schmerzmanagement bei Heimtieren				x		
12	Mo	16.01.2017	13:30	16:30	3	17	WE17, WE1	Lischer, Hünigen	Chronische Lahmheit beim Pferd - was nun?				X		
13	Mo	23.01.2017	13:30	15:45	3	18	WE18 + FLI	Conraths, Müller	Vorsicht, der Tierarzt kommt! Was Tierärzte zum Thema Biosicherheit wissen sollten.		90	X			
13	Mo	23.01.2017	13:30	15:45	3	17	WE 20	Kohn, Vollmar	Herzerkrankungen/-therapie beim Kleintier				X		
13	Mo	23.01.2017	13:30	15:45	3	17	WE17, WE01	Mählmann, Hünigen	Kastration des Pferdes			KR Kleintier			
14	Mo	30.01.2017	13:30	15:45	3		Zentral	Doherr	Studium und Lehre				X		
15	Mo	06.02.2017	13:30	15:45	3		Zentral	Doherr und Mitarbeiter	Problem based Learning			X	X		
16	Mo	13.02.2017	12:30	15:00	3	18	WE18, WE09	Lahrmann,Lang-kabel	Porc. Streßsymptom				X		
16	Mo	13.02.2017	12:30	15:00	3	18	WE07	Tedin	Salmonella in Tierbeständen und zoonotisches Potential	Fällt aus					
16	Di	14.02.2017	08:15	15:00	7	20	WE 20	Böttcher, Manchi, Pagel, Dettling	Muskuloskeletale Erkrankungen beim Kleintier				x		
16	Di	14.02.2017	08:15	15:00	7	20	WE07, WE18	Lübke-Becker, Bethe, Walther	Rationaler Einsatz und verantwortungsvoller Umgang mit Antibiotika bei landwirtschaftlichen Nutztieren			X			
16	Mi	15.02.2017	08:15	15:00	7	17	WE1, WE4, WE13, WE17	Barton, Hünigen, Samson-Himmelsternja, Winter, Zentek	Kolik beim Pferd aus verschiedenen Blickwinkeln				X		

S. Birk, 27.08.2021

Appendix Paper 1

Supplement 1

Didactical usage of media (pilot case)

Did you find the following functions and materials of the online case helpful?

	very useless					very useful
Description of learning objectives	O	O	O	O	O	O
Video lectures	O	O	O	O	O	O
Hands-on Videos	O	O	O	O	O	O
Animations	O	O	O	O	O	O
Interactive element swab-sample taking	O	O	O	O	O	O
Interactive element abdominal ultrasound	O	O	O	O	O	O
Glossary	O	O	O	O	O	O
Textual feedback	O	O	O	O	O	O
Optical feedback	O	O	O	O	O	O
Notepad	O	O	O	O	O	O
Button for support contact	O	O	O	O	O	O
Introductory video tutorial	O	O	O	O	O	O

Table S1: Confidence intervals and positive score proportion (numbers agree) of items of the survey for didactic use of media for the pilot case in the winter semester 2016/17. The question was: "Did you find the following functions and materials of the online case helpful?".

	Didactic use of Media			
Items related to didactic use of media	*n*	*Numbers agree*	*Proportion %*	*95% CI*
Description of learning objectives	111	97	87	81-94
Video lectures	118	116	99	95-100
Hands-on Videos	124	121	97	93-100
Animations	112	111	99	95-100
Interactive element (swab-sample taking)	124	106	85	78-91
Interactive element (abdominal ultrasound)	122	114	93	87-97
Glossary	122	120	98	94-100
Textual feedback	117	115	98	93-100
Visual feedback	119	119	100	96-100
Notepad	69	58	84	73-91
Button for support contact	25	18	72	52-86
Introductory video tutorial	58	55	95	85-99

Supplement 2

Usability

Please indicate to what extent the following statements apply to you.

	strongly disagree					strongly agree
I have found all necessary information in the glossary of this online case.	O	O	O	O	O	O
The texts in the online case were easy to read and understand.	O	O	O	O	O	O
The texts in this online case were well structured.	O	O	O	O	O	O
The information given on the cases were sufficient and concrete so that all tasks could be worked on	O	O	O	O	O	O
The work in this case was associated with clear tasks and objectives.	O	O	O	O	O	O

	Far too easy				far too difficult
The level of difficulty of the exercises in this online case was...	O	O	O	O	O

Table S2: Confidence intervals and positive score proportion (numbers agree) of the items analysing the usability of the pilot case in the winter semester 2016/2017 and the complete reproduction module in the winter semesters 2017/2018 and 2018/2019.

Usability				
Items related to usability	*n*	*Numbers agree*	*Proportion %*	*95% CI*
Availability of necessary information	299	285	95	92-98
Comprehensibility of texts	298	290	97	94-99
Structure of texts	294	286	97	94-99
Availability of important content for processing of tasks	297	285	96	93-98
Association of the case with clear tasks and objectives	292	286	98	96-100

Supplement 3

Self-assessed learning outcome

Please indicate to what extent the following statements apply to you.

	strongly disagree					strongly agree
Knowledge						
I can name the different cycle stages of the bitch.	O	O	O	O	O	O
I know the procedure for vaginoscopy with a speculum.	O	O	O	O	O	O
I can describe four different methods for pregnancy examination.	O	O	O	O	O	O
I know the most important anatomical structures of the female genital tract.	O	O	O	O	O	O
I know the most important anatomical structures of the male genital tract.	O	O	O	O	O	O
I am aware of the effects of overnutrition and malnutrition on pregnancy.	O	O	O	O	O	O
I know the differences between resorption and abortion in the bitch.	O	O	O	O	O	O
I know possible therapeutic approaches for pyometra in a dog.	O	O	O	O	O	O
I know the treatment options for benign prostatic hyperplasia in a dog.	O	O	O	O	O	O
Comprehension						
I am able to assign the results of a vaginoscopic examination to the two cycle phases proestrus and oestrus.	O	O	O	O	O	O
I understand the hormonal mechanisms which lead to an increase of progesterone concentration prior to ovulation.	O	O	O	O	O	O
I can predict a possible course of the progesterone concentration in a case of luteal insufficiency.	O	O	O	O	O	O
I can describe and interpret a bitch's body weight development during pregnancy.	O	O	O	O	O	O
I can classify infectious pregnancy disorders that can lead to resorption or abortion by their cause.	O	O	O	O	O	O
I understand the differences between an open and a closed pyometra.	O	O	O	O	O	O
I can describe the etiology of benign prostatic hyperplasia.	O	O	O	O	O	O
I am able to diagnose metropathia.	O	O	O	O	O	O
I am able to diagnose disorders of the	O	O	O	O	O	O

Application						
I can use the methods for ovulation timing to determine the optimal time for mating or insemination.	O	O	O	O	O	O
I am able to interpret progesterone measurement results in terms of hypoluteinism diagnosis and potential necessary supplementation.	O	O	O	O	O	O
I can assess the vitality of canine fetuses/embryos by ultrasound.	O	O	O	O	O	O
I can revise the food ration for a pregnant bitch.	O	O	O	O	O	O
I can evaluate the health and nutritional status of a dog.	O	O	O	O	O	O
I can work with a patient file.	O	O	O	O	O	O
I can create the problem list for a patient.	O	O	O	O	O	O
I can advise patient owners to choose an optimal therapeutic treatment for benign prostatic hyperplasia.	O	O	O	O	O	O

Supplement 4

Blended learning concept

Dear students,
In the following we would like to ask you for your summarized assessment of all courses (combination of in-class lectures and online cases), which you have participated in the interdisciplinary lectures in the current semester. We are interested in your honest opinion. Please try to answer each question.

Please indicate to what extent the following statements apply to you.

	strongly disagree					strongly agree
The overall concept of the course (online cases and associated face-to-face lectures) was sufficiently explained (e.g. allocation of tasks to face-to-face lectures and online activities).	O	O	O	O	O	O
I would have learned more if the topics and tasks had been covered in face-to-face lectures, instead of online.	O	O	O	O	O	O
Overall, I learned more through the combination of face-to-face lectures and online activities.	O	O	O	O	O	O
I hope that in the future, in-class lectures will be increasingly replaced by online activities in other courses as well.	O	O	O	O	O	O
The face-to-face lectures about the online cases were sensibly linked to the contents of the online cases.	O	O	O	O	O	O

Table S4: Confidence intervals and positive score proportion (numbers agree) analysing the blended learning concept of the winter semesters 2017/18 and 2018/19 for the entire course including the reproduction module.

Blended Learning				
Items related to the blended learning concept	*n*	*Numbers agree*	*Proportion %*	*95% CI*
Explanation of the overall concept	182	175	96	92-99
Preference of face-to-face teaching (over online teaching for the covered topics)	180	33	18	13-25
Preference of blended learning	181	142	78	71-84
Wish for expansion of the concept to other lectures	180	150	83	77-89
Meaningful linking of contents of online cases with face-to-face lecture in the modules of the semester	181	154	85	79-90

Appendix Paper 2

Supplement 1

Table S1: Technical and didactical aspects identified by the project team for tool selection.

Aspects covered by the matrix	
Technical	- Sustainability and maintenance requirements - Licensing costs - Integration into the existing IT infrastructure and applications - Data storage - User interface (back-end)
Didactical	- Built in feedback options and task types - Support and enabling of (inter-)active learning process - User interface (front-end)

Supplement 2

Table S2: List of national requirements for the veterinary interdisciplinary lectures[1] which was divided into clinical medicine and VPH and then assembled with the international Day One Competences and corresponding underpinning knowledge and understanding for veterinary education[2].

Domain	National requirements, according to §53 TAppV	Manual of Standard Operation Procedures, according to EAEVE, FVE 2016	
		Day One Competences	**Underpinning Knowledge and Understanding**
VPH	Food safety, Milk hygiene: Risk assessment, Quality management and marketability of food products	Perform ante-mortem inspection of animals destined for the food-chain, including paying attention to welfare aspects; correctly identify conditions affecting the quality and safety of products of animal origin, to exclude those animals whose condition means their products are unsuitable for the food-chain. Perform inspection of food and feed including post-mortem inspection of food producing animals and inspection in the field of food technology.	Veterinary public health issues including […] food hygiene and technology.
	Animal disease control/ Zoonoses ➔ Options for painless killing	Recognize suspicious signs of possible notifiable, reportable and zoonotic diseases and take appropriate action, including notifying the relevant authorities.	Awareness of other diseases of international importance that pose a risk to national and international biosecurity and trade. Legislation relating to […] animal movement, notifiable and reportable disease.
	Animal Welfare Ethology	-	The structure, function and behaviour of animals and their physiological and welfare needs, including healthy common domestic animals, captive wildlife and laboratory-housed animals. Legislation relating to animal care and welfare […]
	Residue problems, environmental contaminants and animal hygiene	-	-

	Epidemiology	Advise on, and implement, preventative programs appropriate to the species and in line with accepted animal health, welfare and public health standards.	Veterinary public health issues, including epidemiology, transboundary epizootic diseases, zoonotic and food-borne diseases, emerging and re-emerging diseases […].
VPH/ Clinical	Animal husbandry herd health management Animal/Livestock breeding	-	A knowledge of the businesses related to animal breeding, production and keeping. The principles of disease prevention and the promotion of health and welfare.
Veterinary clinical medicine	Internal medicine Animal Reproduction Surgery ➔ Identify and process the origin, diagnosis and treatment of diseases with specific cases ➔ Considerate specially the impact of the use of ionising radiation or radioactive substances	Prepare accurate clinical and client records, and case reports when necessary, in a form satisfactory to colleagues and understandable by the public. Obtain an accurate and relevant history of the individual animal or animal group, and its/their environment. Perform a complete clinical examination and demonstrate ability in clinical decision-making. Develop appropriate treatment plans and administer treatment in the interests of the patients and with regard to the resources available. Collect, preserve and transport samples, select appropriate diagnostic tests, interpret and understand the limitations of the test results. Understand the contribution that imaging and other diagnostic techniques can make in achieving a diagnosis. Use basic imaging equipment and carry out an examination effectively as appropriate to the case, in accordance with good health and safety practice and current regulations. Perform aseptic surgery correctly.	The aetiology, pathogenesis, clinical signs, diagnosis and treatment of the common diseases and disorders that occur in all common domestic species.

	Assess and manage pain. Recognise when euthanasia is appropriate and perform it with respect of the animal, using an appropriate method, whilst showing sensitivity to the feelings of owners and others, with due regard to the safety of those present; advise on disposal of the carcass.	
Pathological and topographical anatomy	Perform a systematic gross post-mortem examination, record observations, sample tissues, store and transport them.	-
Clinical pharmacology	Access the appropriate sources of data on licensed medicines. Prescribe and dispense medicines correctly and responsibly in accordance with legislation and latest guidance. Safely perform sedation, and general and regional anaesthesia; implement chemical methods of restraint.	Medicines legislation and guidelines on responsible use of medicines, including responsible use of antimicrobials and antiparasitic drugs.
Animal nutrition	Assess the physical condition, welfare and nutritional status of an animal or group of animals and advise the client on principles of husbandry and feeding.	-
Veterinary professional legislation	-	-

[1] Bundesministerium der Justiz und für Verbraucherschutz. Verordnung zur Approbation von Tierärztinnen und Tierärzten vom 27. Juli 2006 (BGBl. I S. 1827), die zuletzt durch Artikel 7 des Gesetzes vom 15. August 2019 (BGBl. I S. 1307) geändert worden ist. [Federal Minister of Justice and Consumer Protection. Ordinance on the licensing of veterinarians of July 27, 2006 (Federal Law Gazette I p. 1827), last amended by Article 7 of the Act of August 15, 2019 (Federal Law Gazette I p. 1307)]: TAppV 2006.

[2] European Association of Establishments for Veterinary Education (EAEVE), Federation of Veterinarians of Europe (FVE). European System of Evaluation of Veterinary Training (ESEVT): Manual of Standard Operating Procedures 2016. Available at:
https://www.eaeve.org/fileadmin/downloads/SOP/ESEVT_SOP_May_2016_amended_Annex_8_approved_by_ExCom_on_29_May_2019.pdf
Accessed May 22, 2020.

Supplement 3

Table S3: List of all cases in the interdisciplinary lectures (clinic in blue, VPH in green) at the Faculty of veterinary medicine at Freie Universität Berlin over the semesters 6,7 and 8. Also the different clinics and institutes are listed who collaborated together while building the cases (the pilot cases are marked with *).

Case count	Case diagnosis	Species	Module	Interdisciplinary Collaboration	Sem.
1	Equine Colic - Relocation of the colon ascendens	Equine	Gastrointestinal diseases	Equine Clinic; Institute of Animal Nutrition; Institute of Veterinary Anatomy; Institute of Parasitology and Tropical Veterinary Medicine	6
2	Castration of unanaesthetised piglets	Swine	Animal Welfare	Institute of Animal Welfare, Animal Behaviour and Laboratory Animal Science; Institute of Animal Nutrition; Institute of Virology; Institute of Pharmacology and Toxicology; Ruminant and Swine Clinic	
3	Illegal puppy trade	Canine			
4	Inappropriate animal husbandry	Canine			
5	Pregnancy diagnosis with suspected luteal insufficiency*	Canine	Animal Reproduction	Clinic of Animal Reproduction; Institute of Animal Nutrition; Institute of Veterinary Anatomy, Institute of Veterinary Pathology; Small Animal Clinic	7
6	Pyometra	Canine			
7	Benign prostatic hyperplasia	Canine			
8	Atrial fibrillation, Mitral valve insufficiency	Equine	Cardiology	Equine Clinic; Institute of Veterinary Physiology; Institute of Pharmacology and Toxicology; Institute of Veterinary Anatomy	
9	Outbreak of *campylobacter**	Human (Zoonosis)	Outbreak investigation and zoonosis	Institute of Food Safety and Food Hygiene; Institute for Veterinary-Epidemiology and Biostatistics; Institute of Microbiology and Epizootics; Clinic of Reproduction	
10	*Listeria* outbreak	Sheep (Zoonosis)			
11	*Vibrio* outbreak	Human (Zoonosis)			
12	*Salmonella* outbreak	Human (Zoonosis)			
13	Lid-edge tearing	Equine	Ophthalmology	Small Animal Clinic – Ophthalmology and Internal Medicine; Institute of Veterinary Anatomy, Institute of Microbiology and Epizootics	8
14	Hypertensive Retinopathy, Hypertension and chronic kidney insufficiency	Feline			

15	Uveitis, Glaucoma, Feline infectious peritonitis	Feline		
16	Equine recurrent uveitis, Leptospirosis	Equine		
17	Cataract, diabetes mellitus	Canine		
18	Equine Asthma, laryngeal paralysis	Equine	Complex diseases	Equine Clinic; Institute of Pharmacology and Toxicology; Institute of Veterinary Anatomy; Institute of Animal Nutrition
19	Laminitis, Endocrinopathies	Equine		
20	Anthrax outbreak	Ruminant	Epizootic outbreak	Institute of Microbiology and Epizootics; Institute of Food Safety and Food Hygiene; Institute for Veterinary-Epidemiology and Biostatistics; Institute for Animal Hygiene and Environmental Health; Institute of Pathology, Institute of Veterinary Biochemistry
21	American Foulbrood outbreak	Bees		
22	Outbreak of pseudotuberculosis	Ruminant		
23	*Salmonella* outbreak	Galliformis		

Questionnaire (KCs, learning motivation and subjective knowledge gain, BL concept, online cases)

Liebe Studierende der Veterinärmedizin,

im Folgenden bitten wir Sie um Ihre zusammenfassende Einschätzung ***der ab dem 12. Juni*** durchgeführten Lehrveranstaltungen (Kombination aus Präsenzveranstaltungen und Online-Fällen), an denen Sie im Rahmen der ***Querschnittslehre*** im laufenden Semester teilgenommen haben. Dabei sind wir an Ihrer ehrlichen Meinung interessiert. Bitte versuchen Sie, jede Frage zu beantworten.

Dieser Bogen wird maschinell ausgewertet. Markieren Sie eine Antwort bitte **KRÄFTIG** (nicht mit Bleistift) in der folgenden Weise: ○⊗○ . Wenn Sie eine Antwort korrigieren möchten, füllen Sie bitte den falsch markierten Kreis und noch etwas darüber hinaus aus, ungefähr so: ○●⊗ .

Vielen Dank, dass Sie sich die Zeit nehmen, diesen Fragebogen auszufüllen. Sie unterstützen damit die die Neugestaltung der Querschnittslehre am Fachbereich Veteriärmedizin!

	trifft gar nicht zu					trifft völlig zu	k.A.
Ich hatte das Gefühl, dass es sich bei den behandelten Themen um echte Situationen aus dem Berufsalltag handelt.	○	○	○	○	○	○	○
Ich weiss jetzt, was ich bei vergleichbaren Themen wie den behandelten zu tun hätte.	○	○	○	○	○	○	○

	trifft gar nicht zu					trifft völlig zu	k.A.
Bei den behandelten Themen konnte ich gut an mein Vorwissen anknüpfen.	○	○	○	○	○	○	○
Bei den behandelten Themen konnte ich Wissen aus verschiedenen Fachgebieten verknüpfen.	○	○	○	○	○	○	○

	trifft gar nicht zu					trifft völlig zu	k.A.
Die behandelten Themen wurden stets aus verschiedenen fachlichen Perspektiven vorgestellt.	○	○	○	○	○	○	○
Die einzelnen Schritte innerhalb eines Themas bauten aufeinander auf und ich konnte so einen „roten Faden" erkennen.	○	○	○	○	○	○	○
Die vorgestellten Themen hatten stets einen eindeutigen Bezug zur beruflichen Situation.	○	○	○	○	○	○	○

	trifft gar nicht zu					trifft völlig zu	k.A.
Ich habe gerne an den genannten Veranstaltungen der Querschnittslehre teilgenommen.	○	○	○	○	○	○	○
Die Teilnahme an den genannten Veranstaltungen der Querschnittslehre hat mein Interesse an den jeweiligen Themen verstärkt.	○	○	○	○	○	○	○
Ich verfüge jetzt über ein grundlegenderes Verständnis als vor den genannten Lehrveranstaltungen des Querschnitts.	○	○	○	○	○	○	○
Mein Verständnis der praktischen tierärztlichen Tätigkeit hat sich durch die genannten Lehrveranstaltungen des Querschnitts weiterentwickelt.	○	○	○	○	○	○	○
Ich habe in den genannten Lehrveranstaltungen des Querschnitts etwas Sinnvolles und Wichtiges gelernt.	○	○	○	○	○	○	○

	trifft gar nicht zu					trifft völlig zu	k.A.
Das Gesamtkonzept der Veranstaltungen (Online-Fälle und dazugehörige Präsenzveranstaltungen) wurde ausreichend erläutert (z.B. Verteilung von Aufgaben auf Präsenztermin und Online-Aktivitäten).	○	○	○	○	○	○	○
Ich hätte mehr gelernt, wenn die online bearbeiteten Themen und Aufgaben im Rahmen von Präsenzterminen behandelt worden wären.	○	○	○	○	○	○	○
Insgesamt habe ich durch die Kombination von Präsenzterminen und Online-Aktivitäten mehr gelernt.	○	○	○	○	○	○	○
Ich wünsche mir, dass auch in anderen Lehrveranstaltungen in Zukunft verstärkt Präsenztermine durch Online-Aktivitäten ersetzt werden.	○	○	○	○	○	○	○
Die Präsenzveranstaltung zu den Online-Fällen hat sinnvoll an die Inhalte der Online-Fälle angeknüpft.	○	○	○	○	○	○	○
Ich wusste zu jeder Zeit, an welcher Stelle innerhalb der Online-Fälle ich mich befinde.	○	○	○	○	○	○	○
Ich hatte von Anfang an eine Übersicht über die einzelnen inhaltlichen Abschnitte der Online-Fälle.	○	○	○	○	○	○	○
Ich wusste nach kurzer Einarbeitung, wie ich die verschiedenen Funktionen der Online-Fälle (z.B. Glossar, Notizzettel, Hilfebutton) verwenden kann.	○	○	○	○	○	○	○
Die Online-Fälle und ihre einzelnen Elemente sind insgesamt übersichtlich aufgebaut.	○	○	○	○	○	○	○
Sind während der Nutzung der Online-Fälle technische Probleme aufgetreten?	○ Ja	○ Nein					

Falls technische Probleme aufgetreten sind, welche? Bitte nennen Sie den Online-Fall, bei dem die Probleme aufgetreten sind.

Fanden Sie die folgenden Funktionen und Materialien der Online-Fälle nützlich? Falls Sie einzelne Funktionen oder Materialien nicht genutzt haben, wählen Sie bitte die entsprechende Antwortoption rechts.

	gar nicht nützlich					sehr nützlich	nicht genutzt
Beschreibung der Lernziele in der Einführung	○	○	○	○	○	○	○
Lehrvorträge als Video	○	○	○	○	○	○	○
Videos aus der Praxis	○	○	○	○	○	○	○
Animationsvideos	○	○	○	○	○	○	○
Interaktive Elemente	○	○	○	○	○	○	○
Filmszenen	○	○	○	○	○	○	○
Glossar	○	○	○	○	○	○	○
Text-Feedback zu den Übungen	○	○	○	○	○	○	○
Optisches Feedback zu den Übungen	○	○	○	○	○	○	○
Notizzettel	○	○	○	○	○	○	○
Hilfe per Mail (Anforderung über Kontaktbutton)	○	○	○	○	○	○	○
Videotutorial zur Einführung in die Bedienung der Fälle	○	○	○	○	○	○	○

Haben Sie mit Blick auf die neu konzipierten Lehrveranstaltungen im Rahmen der Querschnittslehre (Online-Fälle und dazugehörige Präsenzveranstaltungen) Verbesserungsvorschläge, Hinweise oder Anregungen?

22103.2

Poster GMA Jahrestagung, 2017 Münster

Freie Universität Berlin

QuerVet

Ein Projekt für die veterinärmedizinische Querschnittslehre

Veronica Duckwitz[*1], Lena Vogt*[*1], Claudia Hautzinger[2], Jeelka Reinhardt[2], Stephan Birk[1], Jochen Dietz[2], Sebastian Haase[3], Nadine Schunter[1], Marcus G. Doherr [1]*
**geteilte Erstautorenschaft, [1]Fachbereich Veterinärmedizin, [2]Center für digitale Systeme, [3]Fachbereich Physik*

Die veterinärmedizinische Querschnittslehre an der Freien Universität Berlin ist eine Lehrveranstaltung für die Studierenden des 6. bis 8. Semesters mit einem Umfang von 14 SWS – bisher in 3-stündigen Frontalvorlesungen. Die Inhalte sollen nach Approbationsverordnung (TAppV) mithilfe von praxisrelevanten, interdisziplinären Fallbeispielen angeboten werden. Bei der Umsetzung dieser Vorgaben knüpft das Projekt QuerVet an.

Projektstart Juli 2016

- Festlegung inhaltlicher Rahmen für Querschnittslehre
- Auswahl der Lernplattform und Weiterentwicklung

Pilotphase

Konzeption & Aufbau

- Blended Learning Konzept
- 2 Pilotfälle aus den Bereichen Veterinary Public Health (VPH) & Klinik

Durchführung

- Studierende des 7. Fachsemesters
- N=135
- Wintersemester 2016/17

Evaluation

- Fallbezogen zu Nutzung, Nutzerfreundlichkeit, Fallbasierung und Medieneinsatz
- Blended Learning Konzept & Erfassung subjektiver Lernziele

Projektziel

- Weitere praxisnahe & interdisziplinäre Fallbeispiele im Blended Learning Format
- Verbesserung der interdisziplinären Lehre (Querschnittslehre)
- Vorbereitung auf das Berufsleben (Day One Skills)

Blended Learning Konzept der Pilotphase

Zentrale Fragestellung: Wird das neue Lehrformat von den Studierenden akzeptiert und werden die fallspezifischen Lernziele erreicht?

Evaluation zur Bewertung des Falls
- 131 Studierende (VPH-Fall: N=131; Klinik-Fall: N=128)
- Evaluation von Nutzung, Nutzerfreundlichkeit, Fallbasierung und Medieneinsatz
- Nutzung einer 6-stufige Likert Skala (1= trifft gar nicht zu, 6= trifft voll zu)

Evaluation zur Bewertung des Blended Learning Konzeptes und Erfassung der subjektiven Lernziele
- 115 Studierende (VPH-Fall: N=115; Klinik-Fall N=95)
- Nutzung einer 6-stufige Likert Skala (1= trifft gar nicht zu, 6= trifft voll zu)

Ausgewählte Ergebnisse

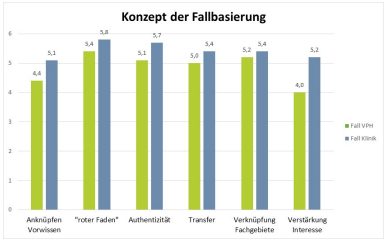

Abb.1: Wahrnehmung des Konzepts der Fallbasierung durch Studierende (Mittelwerte)

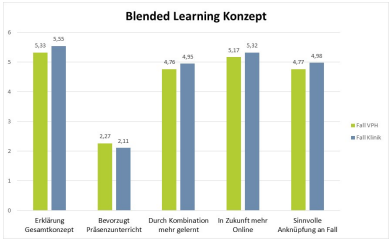

Abb.3: Bewertung des Blended Learning Konzepts durch Studierende (Mittelwerte)

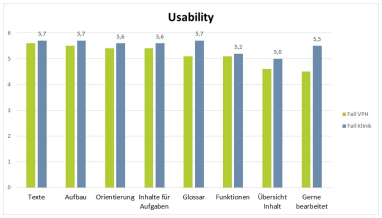

Abb. 2: Bewertung der Usability innerhalb der Falldarstellung durch Studierende (Mittelwerte)

Subjektive Lernziele

Das Erreichen der subjektiven Lernziele durch Studierende mit gut bis sehr gut bewertet (globaler Mittelwert: 5,01).

Ausblick

- Die Lernplattformen sowie das Blended Learning Format werden gut angenommen
- Studierende haben subjektiven Wissensgewinn

  ➢ Erstellung weiterer Blended Learning Module für die Querschnittslehre sowie weitere Evaluationen
  ➢ Fortlaufende Diskussion über Integration von objektiven Wissenstests

Danksagung
Herzlichen Dank an alle beteiligten Institute und Kliniken, die bei der Erstellung der Pilotfälle mitgewirkt haben.

GMA Jahrestagung, 2017 Münster

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Poster GMA Jahrestagung, 2018 Wien

QuerVet

Phase 2: Fallbeispiele für die Veterinärmedizin

Lena Vogt[*1], Veronica Duckwitz*[*1], Claudia Hautzinger[2], Jeelka Reinhardt[2], Stephan Birk[1], Marcus G. Doherr [1]*
**geteilte Erstautorenschaft, [1]Fachbereich Veterinärmedizin, [2]Universitätsbibliothek - Center für Digitale Systeme*

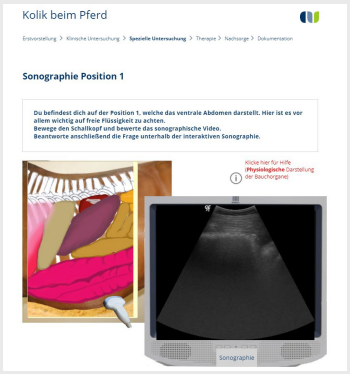

Abb.1: Beispielseite (tet.folio) aus dem Kolikfall mit interaktiver Sonographie

Das Projekt QuerVet strukturiert die Querschnittslehre des 6. bis 8. Semester mit fallbasierten, interdisziplinären und praxisnahen Inhalten seit Juli 2016 um.
Nach einer abgeschlossenen Pilotphase mit zwei Fallbeispielen[1] wurde ein neues Semester mit weiteren virtuellen Fällen und einer komplexeren Blended-Learning-Struktur mit zwei Modulen und insgesamt 5 Wochen Online-Lernzeit gestaltet und evaluiert.

Die Studierenden des 6. Semesters im Sommersemester 2017 behandelten einen interdisziplinären Fall zur Kolik beim Pferd und mehrere Problemstellungen aus dem Bereich Tierschutz.

Des Weiteren wurde das neue Konzept im Vergleich zu dem bisher gelehrten Format (Frontalvorlesungen) in Bezug auf die drei Säulen Fallbasierung, Interdisziplinarität und Praxisnähe[2] sowie Lerngewinn und –motivation evaluiert.

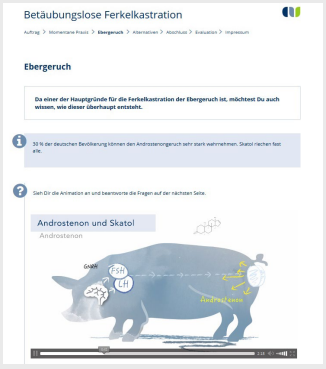

Abb.2: Beispielseite (tet.folio) aus dem Fall Betäubungslose Ferkelkastration mit Animation

Vergleich des bisherigen und des neuen Formats

- Werden die Vorgaben der TAppV bezüglich des Querschnitts im neuen Format besser erfüllt?
- Sind die Studierenden motiviert sich auf diese Weise mit den Themen zu beschäftigen und erreichen sie einen subjektiven Lerngewinn?
- Vergleich der Erfüllung der TAppV-Vorgaben durch die drei Säulen Fallbasierung (2 Items), Interdisziplinariät (3 Items) und Praxisnähe (2 Items)
- Lernmotivation und –gewinn im bisherigen und neuen Querschnitt (5 Items)
- Bisheriger Querschnitt n=109 Studierende nach der ersten Semesterhälfte des SoSe 2017
- Neues Format n= 60 Studierende, Ende des SoSe 2017
- Nutzung einer 6-stufigen Antwortskala (1= trifft gar nicht zu,
- 6= trifft voll zu)

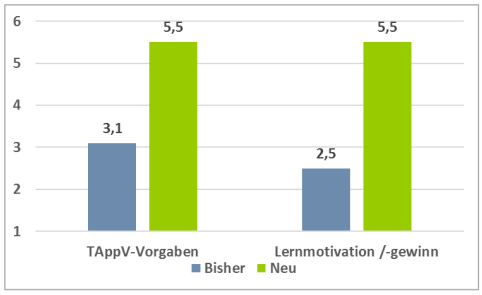

Abb.3: Vergleich des bisherigen und neuen Formats (Abbildung der Mittelwerte als Skala)

Evaluation des Blended Learning Konzeptes im 6. Semester

- Umfrage zum Semesterende mittels 5 Items, n=60 Studierende
- Nutzung einer 6-stufigen Antwortskala (1= trifft gar nicht zu, 6= trifft voll zu)

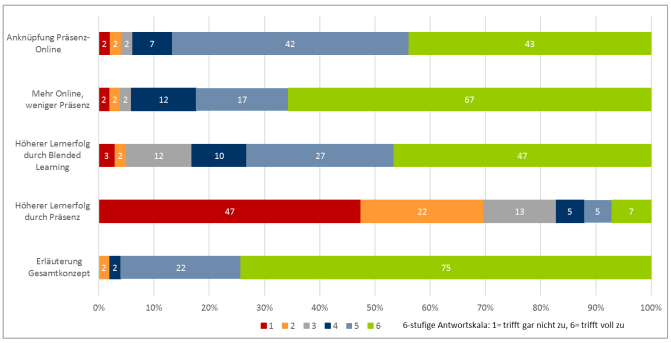

Abb. 2: Bewertung der Usability innerhalb der Falldarstellung durch Studierende (Mittelwerte)

Zusammenfassung der Ergebnisse

In der subjektiven Bewertung durch die Studierenden des 6. Semesters erzielt das neue Format im Vergleich zum bisherigen Format bessere Ergebnisse in Bezug auf die Vorgaben der TAppV. Noch größer ist der Unterschied im Bereich Lernmotivation und Lerngewinn. Das Blended Learning Konzept wird von den Studierenden sehr gut bewertet und mit einem höheren Lernerfolg verbunden.

Ausblick

- Vollständige Anpassung der Querschnittslehre in das neue Format sowie Integration bestehender Veranstaltungen in die Blended Learning Module
- Sukzessive Übergabe der Organisation und Verantwortung für die Querschnittslehre an Fachvertreter
- Fertigstellung eines Handbuchs für eigenständige Erstellung weiterer Fälle

Literatur

[1]Duckwitz V, Vogt L, Hautzinger C, Reinhardt J, Haase S, Birk S, Dietz J, Doherr M. (2017): QuerVet – Ein eLearning Projekt für die veterinärmedizinische Querschnittslehre. In: Gemeinsame Jahrestagung der Gesellschaft für Medizinische Ausbildung (GMA) und des Arbeitskreises zur Weiterentwicklung der Lehre in der Zahnmedizin (AKWLZ). Münster, 20.-23.09.2017. Düsseldorf: German Medical Science GMS Publishing House; 2017. Doc104.
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GMA Jahrestagung, 2018 Wien

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List of publications

Publications included in this work

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Duckwitz, V; **Vogt, L;** Hautzinger, C; Bartel, A; Haase, S; Wiegard, M; Doherr, MG

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Selbstständigkeitserklärung

Hiermit bestätige ich, dass ich die vorliegende Arbeit selbständig angefertigt habe. Ich versichere, dass ich ausschließlich die angegebenen Quellen und Hilfen Anspruch genommen habe.

Berlin, den 16.02.2022

Lena Vogt

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