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Title

Student engagement and perceptions of blended-learning of a clinical module in a veterinary degree program.

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Keywords

Blended learning; Veterinary education; eLearning; Farm Animal; Clinical; Multimedia; Videos; Student perceptions; Case-based learning; Student engagement.

Abstract (250/250 words max)

Blended learning has received much interest in higher education as a way to increase learning efficiency and effectiveness. By combining face-to-face teaching with technology-enhanced learning through online resources, students can manage their own learning. Blended methods are of particular interest in professional degrees such as veterinary medicine where students need the flexibility to undertake intra and extra-mural activities in order to develop the range of competencies required to achieve a professional qualification. Yet it is unclear how veterinary students engage with blended learning activities and whether they perceive the approach as beneficial.

This article evaluates blended learning through review of student feedback from a 4-week-clinical module in a veterinary degree programme. The module combined face-to-face sessions with online resources. Feedback was collected using a structured-online questionnaire at the end of the module and log data collected as part of a routine teaching audit. The features of blended learning that support and detract from the student learning experience were explored using quantitative and qualitative methods.

Students perceived a benefit from aspects of the face-to-face teaching and technology-enhanced learning resources. Face-to-face teaching was appreciated for practical activities whereas online resources were considered effective for facilitating module organisation and allowing flexible access to learning materials. The blended approach was particularly appreciated for clinical skills where students valued a combination of visual resources and practical activities. Although this study identified several limitations with online resources, which need to be addressed when constructing blended courses, blended learning shows potential in clinical courses to enhance student-led learning.

Introduction

Professional degree courses require a balance of workplace learning opportunities with academic elements of the curriculum (1,2). Like other undergraduate students, those studying for professional degrees have to fit their study around other life commitments, which can complicate and disrupt timetabling academic and workplace commitments (3–5). For example, in the UK professional training of veterinary surgeons is knowledge intensive, applied and focused on omni-competence (6). Historically this has led to heavy lecture schedules and significant contact time with veterinary educators to enable students to attain the competencies required to register as a veterinary surgeon (7). Students are also obliged to complete work experience in clinical practice, undertaken in addition to their academic studies, to develop clinical and workplace skills. Furthermore, as contemporary veterinary practice is becoming more specialised (8), the scope of knowledge expected of veterinary graduates is increasing further, despite the program length remaining the same. Thus, the challenge for today's veterinary educators is to prepare graduates to enter the workplace with the applicable skills set and knowledge to "hit the ground running" by helping them to be time efficient and lifelong learners (9).

In response to student study and life commitments, many higher education (HE) courses are adopting student-centred learning approaches to their teaching (10,11). The aim is to allow students to choose when, where and how they learn course content (10). "Blended learning" (BL) is one of the student-centred learning approaches being adopted by HE institutions. When designing new blended courses, educators aim to balance the use of face-to-face (F2F) with technology-enhanced learning (TEL) resources to meet these personal needs of the learner (12). Technology-enhanced learning resources are often used to replace some of the F2F aspects of the course yet it is integral that all resources still align to course intended learning objectives (ILOs) (13). Increased interest in the TEL aspect of BL is set to continue for students who are increasingly able to choose their mode, pace and place of learning (14), and for organisation of course content. Blended learning techniques may be well suited to veterinary medicine training to balance academic and workplace learning commitments. Blended learning techniques may also encourage independent lifelong learning that is vital to the contemporary veterinary surgeon within their profession (9,15). Although extensive research has been conducted in medical schools (16–19), it is unknown whether BL methods are perceived as beneficial to student learning in the context of veterinary education. A main theme from medical experience is that BL methods are positivity perceived by students, but only if courses are designed to benefit their learning rather than being a replacement for staff F2F teaching time (16).

Deep learning involves stepwise construction and application of knowledge to promote critical thinking in order to embed learning content (20,21). Developing skills in critical thinking and problem solving are vital to the clinical ability of a veterinary surgeon, requiring development throughout undergraduate studies and beyond (22,23). Using multimodal learning methods to teach students can encourage development of critical thinking and problem solving skills (24,25).

The overuse of TEL over F2F methods can lead to student disengagement and promote superficial learning rather than deep learning practices (26). As the quality of student learning could be influenced by the balance of F2F and TEL activities within a BL course, it is important to assess student engagement with these activities.

This paper explores student perceptions and engagement with a novel blended-learning module within a clinical component of a UK five year undergraduate veterinary degree program. Specifically we aimed to establish how students engage with different elements of TEL and F2F activities, including access times and patterns to online resources. We also evaluated the range of student perception of blended learning elements, including workload and relevance of TEL and F2F resources.

Materials and methods

Context

Since 2013, the Glasgow University School of Veterinary Medicine (GU-SVM) Bachelor in Veterinary Medicine and Surgery (BVMS) degree program has undergone a major curriculum restructure with a focus on ensuring the competency and employability of graduating veterinary surgeons. The restructure was more broadly supported by Glasgow University's "E-Learning Strategy 2013-2020" (27) with inclusion of BL principles. Specifically, the new degree program structure champions student-centred learning by encouraging independence, choice and flexibility in the individual students' learning experience. The new BVMS degree was split into foundation (Years 1-2) and clinical (Years 3-4) phases in order to prepare students for the supervised workplace based final year, or professional phase (Year 5). Both the foundation and clinical phases utilised BL via fewer lectures, more practical classes and small group case-based learning (CBL) sessions (28). Case-based sessions were facilitated F2F, complemented through online activities using the University's virtual learning environment (VLE). The new permutation of the BVMS program integrates scientific and clinical disciplines throughout the degree, aiming to promote better application of core knowledge through independent learning.

The first implementation of the two year clinical phase started in 2015-16, with the third year considered as a course incorporating six four week long modules and one two week long module (Figure 1). As part of the third-year clinical phase, a new four week module integrated four core clinical farm animal disciplines. These disciplines included 1. Clinical ruminant medicine and surgery 2. Ruminant parasitology 3. Population medicine/ epidemiology and 4. Pharmacology. The structure of the module was organised through the UG-SVM VLE (Moodle®), where students could access resources at any time of the day. Primarily the module was made up of F2F and TEL activities (Supplementary material 1). For TEL resources, students had availability from day 1 of the module Some of the TEL activities were hosted on another VLE platform (Mahara®) linked to the UG-SVM VLE. Students were guided through the module by being given access to different activities in each of the 4 weeks via the UG-

SVM VLE (Figure 2). To encourage learners to apply the knowledge taught across these disciplines, online TEL resources were designed to complement F2F sessions as self-directed tasks (Figure 2). The self-directed TEL resources fitted into four core clinical farm animal disciplines (Supplementary material 1). Nominal timetable slots were allocated for TEL activities, although it was stated on the VLE that students could choose when to engage with TEL activities. All the TEL resources were designed in consultation with other members of the Farm Animal Clinical Sciences Division.

Compared to other modules in the Clinical phase, this module extended and formalised the use of BL approaches, for example through additional use of TEL activities, such as online CBL activities. In addition, there was an emphasis on designing complementary use of TEL activities to enhance the benefit of F2F sessions, such as online clinical examination videos provided before a practical clinical examination class.

Study design and data collection

To assess student engagement and perceptions of blended learning, we sampled students who were enrolled in the first cycle of the module (January and February 2016).

To assess student engagement in the module, attendance at F2F teaching sessions was recorded by class registers. To evaluate the access and use of the online TEL activities for the module; log data were accessed for each TEL activity within the module through UG-SVM VLE and exported as CSV files for further analysis. Each student access event was defined as the student either starting or downloading the TEL resource, depending on the nature of the resource. For example, a download of a lecture and accessing a quiz from the start were each classified as a singular access. Class attendance and log data was collected for all students enrolled in the module. Data was recorded for 6 weeks, 4 weeks of the module and 2 weeks leading up to submission of the summative assessment was collected from all students enrolled in the module.

To assess student perception of the module, we used student feedback collected as part of routine teaching evaluation and audit. Specifically, student feedback on the module were collected via a structured-online questionnaire. All students enrolled in the module had access to the questionnaire from the middle of the fourth week of the module. An email sent to request students completed the feedback questionnaire, although feedback was voluntary and did not influence academic progression. An email was sent to request students to complete feedback. Students were also reminded in a lecture on the last day of the module. It was assumed that students were familiar with using the UG-SVM VLE feedback tool, as similar methods have been used in previous modules in the Foundation Phase (Years 1 & 2) of the BVMS degree. The questionnaire was created using a survey tool within the UG-SVM VLE (Supplementary material 2). Questions were split into three sections: 1. Quality of module content related to the module Intended Learning Outcomes (ILOs), 2. F2F teaching practices and 3. TEL resources. Questions were predominantly in the form of statements that invited

students to choose their level of agreement with the statement. Options were based on a 5-point Likert scale of "Strongly agree" (SA), "Agree" (A), "Neutral" (N), "Disagree" (D) and "Strongly disagree" (SD) (29). Additional free text questions were added to allow further elaboration on certain aspects of the questionnaire particularly concerning TEL resources.

Data analysis

Both qualitative and quantitative data were anonymised prior to analysis. Quantitative data collected from the questionnaire (including Likert scale responses) and UG-SVM VLE logs were analysed using simple summary statistics (Median and proportions) and descriptive graphs in Microsoft® Excel.

Qualitative data collected through the questionnaire were analysed by the lead author (RK) employing a simple thematic analysis using an inductive approach (30,31). Two researchers were involved in this process. The lead author (RK) was the organiser of the module and has a background in farm animal practice. The second author (JH) is not directly involved with the module, but has an understanding of the curriculum as leader of the final year of the BVMS Programme with a background in small animal practice and veterinary education.

Firstly, qualitative questionnaire data was exported as a Microsoft Excel® spreadsheet. All questionnaire statements were read and re-read to develop a preliminary coding structure. Then the lead author coded all statements to each of the preliminary codes and grouped related codes to from subthemes using colour coding within the spreadsheet. Each response may have had more than one subtheme attributed to it. Once completed, the subthemes were organised into major themes using a second colour code. A second author (JH) reviewed the initial coding approach and both authors discussed areas of difference, agreeing a final coding structure and allocation of comments to codes, related codes to subthemes, and subthemes to themes. Although the aim of the exercise was to represent rather than quantify the range of perceptions captured in the free-text comments, the number of statements associated with each theme and subtheme is reported to illustrate that the themes identified are characteristic of this set of individuals and to illustrate the diversity of perceptions in the group studied(32).

Ethics

The teaching evaluation was conducted at GU-SVM (part of the College of Medical, Veterinary and Life Sciences (MVLS) at the University of Glasgow). Ethical approval for retrospective analysis of routinely collected data has been granted under MVLS VLE research guidance and the GU-SVM privacy notice published on the Vet School General Resource read by all students, and projects are under the oversight of a School Data Custodian to ensure appropriate use under the General Data Protection Regulation. In addition, ethical approval for the evaluation of blended and online learning developments was granted by the MVLS Research Ethics committee under license number 200160080.

Results

Student engagement

In January 2016, 123 students were enrolled in the first cycle of the module. Students had individual timetables for all F2F sessions and 100% of students attended.

The proportion of students accessing each type of TEL resource was recorded over the duration of the module and for 2 weeks after (Figure 3). All 123 students downloaded lecture material and small group teaching (CBL and practical class) guidance. A majority of students accessed clinical examination videos (95.9%), the parasitology textbook (85.4%), farm calendars (72.4%), pharmaceutical online CBL (69.9%) and the end of module quiz (64.2%). Less than half of the students chose to provide end of module feedback (44.7%). There were differences in how often students accessed each type of TEL resource (Figure 4). Most students accessed practical/ CBL guidance, clinical examination videos and parasitology textbooks 2-5 times or less. Lecture material was accessed 6-10 times and the end of module quiz between 21-50 times by the majority of students. The frequency of access to the pharmaceutical online CBL varied much more between students than other TEL resources, with a much wider range of frequency of access. Looking at the time of day when TEL resources were accessed (Figure 5), few students accessed any TEL resources between 0.00-07.00. Lecture material was mainly accessed between 07.00-13.00, whereas most other resources were accessed during the afternoon and evening (13.00-18.00 and 18.00-00.00).

All 123 students undertook the group end of module summative assessment . Students worked in groups of 4-5 students, with a submission deadline 2 weeks after the end of module teaching. A group mark was given to individual students within each group using a grading rubric. Subsequently, all students achieved a passing standard grade in the summative assessment.

Student feedback

Questionnaire statements

The response rate for the feedback questionnaire was 44.7%, which represents less than half of the students enrolled on the module (Supplementary material 2). Student statements to questionnaire statements are summarised in table 1. Overall, students were satisfied with the module and agreed that it was made clear what they were expected to learn. Most students agreed or strongly agreed that module content was pitched at the right level and the workload manageable.

In respect to F2F teaching (Table 1), students agreed that lecturers made teaching material interesting and provided useful feedback. Over half of respondents agreed that group classes and assessment enabled them to work as a team, with less than 10% disagreeing. For TEL resources, most students agreed or strongly agreed that online content was well organised, relevant and easy to navigate. Online communication was appreciated, instructions clear and online support adequate. Half of students agreed that the online calendars and

parasitology textbook were useful. However, the majority of students disagreed that the pharmaceutical online CBL was useful, with the remainder neutral to this activity. Three quarters of students found the formative module assessment interesting and expressed that it brought together module content, with the remainder of students being neutral to the assessment.

Free text statements

The majority of students who undertook the questionnaire, responded to some of the free-text questions with a total of 195 free-text statements (Supplementary material 2). Three major themes were identified relating to student perceptions of blended learning in the statements to the free text questions: "Balance of F2F and TEL resources", "Module design and delivery" and "Participant factors". Table 2 summarises the number of statements coded to major and sub-theme.

Balance of face to face and technology enhanced learning activities

Of the free-text statements, 93 related to balance of F2F and TEL activities within the module. These statements split into two sub-themes: "Synergistic resources" and "Student-lecturer interaction".

Synergistic resources:

Many statements were positive about the mix of F2F and TEL activities (55 statements) within the module. For F2F activities, statements related to appreciation of practical classes and CBL seminars (13/55), complimenting lectures which were pitched at the right level (4/55). A number of students explained they enjoyed these sessions that were complimented by TEL resources as they provided an opportunity to apply theoretical knowledge into a practical setting:

Student 39: " "It (RE: Online farm calendars) made me review a lot of diseases/procedures and think about when in the year they occur. It was very useful to then be given the completed calendar (after the lectures) so that I could begin to build a better idea of when in the farming year certain things occur."

Students expressed their positive impression of TEL activities, mainly commenting on online CBL activities. Similarly, students felt that the pharmaceutical prescription activity assisted applying theory into practice (15/55 statements). For other online CBL activities, such as the farm calendar and parasitology textbook, students felt they were mainly useful for revision by consolidating learning (19/55 statements). For parasitology teaching in particular, students commented that online materials supported F2F practical class teaching (8/55 statements):

Student 29: "You wouldn't understand what you're doing in the parasitology practical without these resources they are very good."

Nonetheless, students expressed that TEL activities should not be used to replace F2F teaching activities (3/55). This was particularly relevant for clinical skill

teaching, where students felt that the physical aspects of activities could not be mimicked online:

Student 12: "I feel like sometimes for the clinical skills practicals they expect you to have already learnt everything on the videos before you arrive. The videos should be an aid to assist your learning and prepare for the class but not a substitute for in class teaching."

Student-lecturer interaction:
A small number of students (18) commented on student-lecturer interaction. For F2F sessions, including lectures and practical sessions, most commented that content was pitched at the right level. Such statements praised staff interaction with them highlighting that the interaction assisted in applying the lecture content to real-life scenarios (7/18) such as in CBL tutorials:

Student 27: "Enjoyed the CBLs case scenario discussion as they help me identify where in my thoughts process did I went (sic) wrong or have done correctly, and eventually guides me to the final diagnosis. Which I felt is really useful"

In contrast, three students expressed that similar interaction was lacking from online CBL sessions. For example, 6 students felt that they lacked guidance for the farm calendar or pharmaceutical prescription online CBLs. Other statements suggested that students felt that they missed out on the opportunity to discuss released answers, which would have helped them prioritise topics for further study.

<u>Module design and delivery factors</u>
In total 67 statements related to module design and delivery. These statements were divided into three sub-themes: "Module content organization", "Time management and allocation" and "Software limitations".

Module content organization:
This theme included both positive and negative comments. The majority of negative comments related to module factors that affected students managing their own learning time (23/67). For example, a small number of participants (12/23) were frustrated that not all module content was hosted on the VLE and found it difficult to locate these resources:

Student 15 (Re: Parasitology textbook): "I was not even aware of this. There's a whole lot of information scattered in a lot of different places, which makes it really hard to keep track of it all, as well as prioritize."

Other negative comments related to late provision of both TEL and F2F teaching. Nine participants reported that some staff arrived late to give lectures and that sometimes lecture materials were uploaded to the VLE after lectures were given. Student's perception were that tardiness made it difficult to prioritise content in their study time. Also, a number of these comments (3/9) expressed dislike of last-minute changes to lecture materials:

Student 47: "There were several occasions throughout this module where lectures had been posted to moodle, but then changed without any notice to students. This is particularly frustrating when students print these lectures out or review them beforehand..."

Specifically, only two respondents commented on appreciating the organisation of online TEL content into folders making content easy to navigate content on the VLE.

Time management and allocation:
Over half of statements related to module design were related to time management and allocation of module activities (43/67). The majority of comments related to TEL activities taking longer than expected, specifically the farm animal calendar and the group summative assessment. A common explanation was that researching for such activities from content elsewhere in the module was too time consuming for the time available to study. Although respondents (6/43) did appreciate the learning experience after the activity was completed:

Student 24 (Re: Farm animal calendar online CBL activity): "(It was) difficult to find the information so it took a long time to find anything relevant, but useful when done."

Despite the extended length of some sessions, only one student negatively commented that F2F activities overran allocated time slots. A number of statements (6/43) commented that to some TEL resources, such as the parasitology textbook and online pre-reading material, were too extensive making it difficult to prioritise what to study in the time allocated. Yet a similar number of statements (5/43) praised the extent of these resources, providing the opportunity for students to study topics more in depth than taught material.

Software limitations:
Nine students commented on the limitations of the software used to design TEL activities, mostly relating to the pharmaceutical prescription online CBL activity. It was highlighted that even if students got the answer right, but their free-text answer was phrased differently to the automated answer, the software marked the answer as incorrect (Figure 6) resulting in much lower global marks in this activity than individual students expected. This student describes the negative impact on learning of these software limitations:

Student 02 (Re: Pharmaceutical prescription online CBL activity): "Many things were marked as incorrect but the correct answers were not given, so cannot review it and learn from mistakes."

Yet students also expressed that the activity was useful in developing prescribing habits. Two students suggested that a potential solution to the software marking limitations would be producing example answers at the end of activity rather than the software marking individual answers. These comments highlight the perceived benefit of the activity, despite the software marking limitations.

Participant factors

Of all free-text statements, 43 related to individual participant factors that influenced perception of, and engagement with, module content. Twenty nine student statements described how engagement in activities was affected by their previous knowledge of module subjects. Respondents who identified as having insufficient background knowledge (ruminant livestock and agriculture), felt that TEL activities were difficult and time consuming to partake in (9/29). This was exemplified in the farm calendar activity:

Student 14: "With no background knowledge in livestock farming, I don't know where to start."

Students also mentioned that some of the module overlapped with content elsewhere in the veterinary degree program. While some perceived too much overlap (3/29), others took overlap as positive (14/29). Overlap seemingly helped students to integrate module content with assumed background knowledge (livestock and agriculture):

Student 6: "Useful to be able to work through a calendar and link up the times of the year to management procedures and diseases to look out for."

Students mentioned that various F2F and TEL activities were relevant to their future career choices (10/43). Responders who specifically intended to go into a career related to the module content, enjoyed engaging with TEL content within the module (3/43):

Student 45: "Really fun module - has made me consider going into mixed (species clinical) practice."

Discussion

Blending learning practices are proposed to encourage students to manage their own learning, around other commitments, whilst still meeting the learning outcomes of a course (12). As a student-centred approach, BL could be useful for professional veterinary degree programmes to support students to balance academic, workplace and personal commitments. The fact that students in this study accessed TEL resources outside of traditional working hours supports this idea. The majority of students engaged with course material, with various TEL activities accessed throughout the day depending on the activity. Blended learning can also encourage students post-graduation to learn independently, which is an important attribute to continued professional development (33). Assessing student engagement and perception of courses can provide an insight into the experience of BL, its impact on learning and highlight areas to consider when designing courses using BL. Although there are well-documented limitations in questionnaire-based student feedback studies (34), this study provided insights into student perceptions on BL. Aspects of F2F and TEL activities were well received by students, particularly activities that integrated and applied course topics. Interaction between students and teachers was also

highly valued. In the wider context, student feedback highlighted a number of BL factors that affected the learning experience of students and should be considered when developing courses based on BL principles.

In our study, we investigated student engagement with F2F and TEL activities. F2F and TEL activities were nominally timetabled in "working hours" (9.00-17.00 hours Monday to Friday), although TEL activities could be completed in their free time, within or out of working hours, if individual students wished. The majority of TEL activities were accessed during working hours, with the trend of lecture material being accessed in the mornings when lectures were timetabled and complementary activities being accessed in the afternoon or evening. Flexibility in students planning their study time is widely seen as a positive step within HE, to allow them to direct their learning to what is most effective for individuals when and wherever it suits them (35,36). It is therefore unsurprising that in our study, individual students managed their time differently and there are likely various reasons for different study strategies. Although we did collect data on individual student study patterns and what factors drives them to manage their own study time, students did not highlight whether they were accessing TEL activities around life commitments. A study by Holley and Dobson looked at a cohort of >1000 undergraduate students undertaking a BL course and their access to online TEL activities over the duration of the course (37). Students particularly accessed TEL activities over weekends to manage their learning around part-time jobs and to work at their own pace. However, veterinary and other professional degree students have additional course related commitments on their time, which potentially restricts their time for other life commitments (38). As BL courses potentially could have negative effects on student work-life balance, the amount of time spent on non-timetabled activities and students' ability to utilise this time, has to be considered when designing BL courses. It is recommended that the amount of time taken to complete course activities, within and outside the academic timetable, should be audited to make sure that students can manage their time with other commitments (13). For the UK veterinary profession in particular, increasing mental health problems have been associated with problems relating to work-life balance (39). Work overload can impact on academic performance, satisfaction and mental health (40,41). Students should be empowered to develop the skills to manage their study, work and life commitments from the early stages of their degree. Although time was allocated to complete TEL activities, the amount of time to complete specific activities was not recommended. In hindsight, this may have led to students spending inappropriate amounts of time on individual activities. "Sign-posting" recommended time to complete a TEL activity, may assist students in time allocation and assist promoting a healthy work-life balance. This is particularly important given our observation that a number of students commented that activities took longer than they expected. There is also an onus on Veterinary Schools to ensure that expectations of student workload are reasonable and clear to applicants.

Students also used TEL activities to prepare for F2F sessions, particularly for practical classes, with students perceiving these materials as a benefit. Just like any educational intervention, motivation to engage with a topic is likely to affect

student engagement (42). In our study, it is possible that students were interested in doing well in F2F practical classes as topics covered were perceived as important to their future career choices as veterinary surgeons (23). Clearly, incorporating relevance and interest in TEL activities is integral in BL courses. For example, students interested in farm animal career pathways particularly commented on the relevance of the module. Highlighting the relevance and transferable skills gained from completing course activities may increase engagement with students less interested in specific topics within a BL course.

Students described both F2F and TEL activities positively but highlighted that F2F and TEL activities should be complementary, rather than TEL used simply to replace F2F sessions. Getting the right "blend" of F2F and TEL activities is integral to the success of a BL course (43). Other research also found that F2F activities followed by TEL activities leads to students engaging with the content more than students access to only TEL activities (44). Blended learning activities within a course should be designed and mapped to the appropriate learning outcomes of the course (45) as certain topics are more suited to F2F or TEL activities. Specifically, we found that students appreciated TEL when its used to complement F2F sessions, such as in preparation for practical classes by studying online videos or a textbook. In other work, Morton and others explored medical and biomedical student engagement with a new BL course in pharmacology through small focus groups (16). Students identified other courses that could be suited to BL approaches, particularly those that taught core principles that moved onto real–life application of the content. Yet in our survey, students had a mixed response to TEL activities that built on background knowledge, particularly where learning built on content from previous studies in their degree course. Getting students to revisit previously learnt material can be a challenge and partly depends on how well they learnt it the first time. Students, who are less familiar with the background knowledge may feel they spend longer than expected on these activities leading to demotivation and failure to meet learning outcomes (46). Students commented that unpredictability in activity participation time made it difficult to prioritise their learning, particularly in TEL activities that required students to research topics beyond core course materials. As previously mentioned, signposting could be a potential solution to this and has been shown to increase students' awareness of what is involved in a TEL activity. For example, signposting has been shown to be useful with flipped classroom techniques (47) and in large online learning environments (48,49). Annotating TEL activities with the expected level of background knowledge, associated course resources and expected time to complete an activity (e.g. signposting) could improve student motivation and engagement with stand-alone TEL activities.

Preserving lecturer interaction is very important in BL courses, as interaction between students and their lecturer can increase the quality and effectiveness of F2F sessions (50). Face-to-face activities encourage lecturer interaction whereas TEL activities emphasise learner-material interactions (24). We found that students missed the interaction with teaching staff and student peers, especially for stand-alone TEL activities. Students requested more guidance to support their learning for TEL activities that were predominately self-directed. Students

felt that in isolation TEL interaction with teachers was not as productive as F2F interaction. Positive interactions with lecturers can improve student learning (51,52) as one-on-one direction can assist individual students learning needs, such as help in prioritising and clarifying course content. Students also value being part of a learning community, as F2F sessions in BL courses can foster a community spirit that encourages students to learn through supported interaction with teachers and their peers (43). Virtual learning environments design can maximise student-teacher interaction through discussion boards and email. For example, a study by Beer and others demonstrated that the more teachers communicate via VLE platforms the more students will engage with the content (53). Although a study looking at veterinary student engagement with an online only course highlighted that even though automated feedback was provided online, students missed personal interaction with their teachers (54). In the study, students particularly missed F2F teacher support in online case-based problem solving activities to assist them with their approach. When designing courses around BL principles, F2F and TEL activities should be synergistic in order to support student engagement and academic achievement as part of a learning community (55). Complementary F2F feedback sessions with teaching staff at the end of the course can provide students with the opportunity to interact with teaching staff directly about TEL resources used in the course.

The online learning environment had an impact on how students engaged and perceived their learning experience. Students were generally able to navigate TEL resources hosted by the university's main VLE (Moodle®) however, students were frustrated when they could not find activities hosted on another VLE (Mahara®). Students also described software problems as a barrier to their learning. Student perception of the format and design of the online learning environment content can make a difference to how students engage with TEL resources (56). There is a complex relationship between emotions, motivation, cognition, metacognition and academic achievements. Thus an individual's emotions, such as frustration, may demotivate and hinder cogitative processes when using BL methodology (57). A large survey of over 500,000 biological science students, undertaking blended learning courses, found that highly frustrated students review less online course content and attain lower grades, than those with low levels of frustration (58). It was clear in our study that on occasion, frustrations related to the online learning environment, were perceived to have hindered student learning. Despite these frustrations, students continued to try to complete aspects of the course that had software problems. For example, the pharmaceutical prescription, farm calendar activities and end of module quiz, were mostly accessed multiple times by individual students. Other studies highlight that software problems led to a drop off in student access with students becoming demotivated and disengaged with TEL activities (59–61). It is important to understand the nature of the frequency of interaction in TEL activities and to establish whether the frequency of interaction is productive. Although we did not ask specifically why students accessed some TEL activities more than others, some of the TEL activities with the highest frequency of access, had a grade associated with the completion of the activity but also had the most negative feedback from students (pharmaceutical

prescription and end of module quiz activities). Drive to achieve higher grades, may have led to students attempting the activity multiple times. The use of grading to encourage students to complete TEL activities has been demonstrated from a variety of formats (49,62,63). In addition, veterinary students are regarded as highly motivated to succeed in their studies due to their passion for their chosen career (64) and might partly explain their persistence with faulty activities, as students perceived it was important to complete this activity as part of their professional training. However, software frustrations may have had a negative impact on the quality of their learning strategies. Parkinson et al, highlighted that although veterinary students are generally motivated, frustration and work overload might encourage them to utilise superficial rather than deep learning approaches (42). Students' that utilise superficial approaches retain knowledge for short-term recall, whilst those that utilise deep learning approaches are able to apply knowledge in different contexts (21). For veterinary training, deep learning is integral to developing clinical problem solving skills (65). Like F2F activities, TEL activities should be aligned with ILOs and software problems mitigated against to minimise student frustration. The majority of the frustrations to software problems were related to automated feedback in TEL activities that marked correct answers incorrectly. Veterinary students appreciate sequential feedback with relevance to their future career (54) and inappropriate feedback could be detrimental to their learning experience. Troubleshooting TEL activities, through piloting new activities and appropriate staff training in using software to design activities, is important to limit the likelihood of software issues (66,67). As this was the first run of the module teething problems were likely and highlights why trouble shooting is particularly important for newly developed TEL activities. In addition, previous experiences with TEL can influence future engagement with TEL (68). Veterinary surgeons in the UK are required to conducted regular continued professional development (CPD) throughout their careers (69). In recent years there has been an increase in distance online based platforms for postgraduate education of veterinary surgeons (9). Thus, it is important in TEL activities within undergraduate veterinary BL courses do not discourage future engagement with TEL.

This study had various limitations that should be considered when planning future research. Our study only examined a relatively small number of students for a snap shot in time on a single course. It is accepted that end of course feedback is often given by students who have grievances about a course (70) and with the course feedback questionnaire being optional, this may have biased our results. However, end of course surveys and log data are useful for understanding an individual's engagement and perceptions of a course (71) and TEL platforms offer opportunities to monitor trends in student learning. Conducting interviews or focus groups might have provided further depth to student perceptions of BL methods (72), however the online questionnaire did facilitate sampling a larger cohort of students. Our approach has been helpful to identify factors to consider when using BL principles to design undergraduate courses as part of routine course feedback. Few studies take advantage of such audit tools (73) to research the use of BL principles in the training of veterinary surgeons. Despite module design being focused around BL principles, the

students that participated in our study had been taught using BL methods for two years. Students with little experience of BL courses, may have different perceptions and encounter additional challenges when participating in these courses for the first time. We did not assess access to online TEL resources from the module as part of pre-exam preparation (four months after the end of the course). Also, we could not investigate the nature of interaction with TEL activities (e.g. depth of engagement) due to limitations in the data provided by the VLE software. Other studies of online courses have identified that students often may utilise TEL material more prior to exams (74). However, it is unclear if such behaviours improve academic outcomes or, in the case of veterinary training, alignment to professional competencies. Further research should focus on improving academic staff's ability to estimate and allocate adequate independent study time for students. For veterinary students in particular, how the design of BL courses impact on students' own allocation of study time, which may relate to their professional development and their wellbeing and mental health. For this reason, future studies could consider whether TEL activity guidance (sign-posting) assists students in managing their study time and further prepares them for future independent study.

Assessing student perception and engagement with a BL course, has highlighted the benefits and challenges of using BL principles in the undergraduate education of veterinary students. Our findings support other work recognising the importance of considering course context, organisation, student time allocation skills, troubleshooting software errors and developing synergistic resources when developing a blended course. Veterinary educators wishing to incorporate BL methods in professional degree teaching, should consider these factors to improve application of course content and support students to become independent learners. While it is clear that a blended learning approach can be effective in training the next generation of veterinary surgeons, there is considerable scope for additional research to establish the most effective techniques for implementing BL in veterinary and medical education.

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Figures

Figure 1. Structure of the curriculum of the BVMS degree program at the Glasgow University School of Veterinary Medicine based on a spiral curriculum model.

(2a) An example of a type of TEL in the form of farm animal clinical examination videos provided on the UG-SVM VLE for the clinical examination practical.
(2b) An example of a type of TEL in the form of a self-directed learning pharmaceutical label CBL. To be worked through in own time to apply clinical skills on prescribing pharmaceuticals by completing the online forms from the provided clinical scenario.
Figure 2. Examples of TEL activities provided throughout the module.

Figure 3. Bar plot of the proportion of students using the online resources within the module and two weeks after (n=123).

Figure 4. Bar plot of the frequency of use of online resources, by students, within the module and two weeks after (n=123).

Figure 5. Bar plot of the times of use of online resources, by all students, within the module and two weeks after (n=123). Squares= Online guidance and lecture material; Lines= Online textbook resources (Videos and images); Diamonds= Online CBLs; Solid black= End of module quiz.

Figure 6. An example of an incorrectly marked answer, from the online pharmaceutical label CBL on the UG-SVM VLE that was actually correct. Also an example of detailed explanatory feedback possible.

Tables

Questionnaire statement		Percentage of students by Likert scale				
State how much you agree with the following statements:	**Number of statements**	**Strongly Disagree (SA)**	**Disagree (D)**	**Neutral (N)**	**Agree (A)**	**Strongly Agree (SA)**
1. Overall, I was satisfied with this module.	55	1.8%	0.0%	9.1%	63.6%	25.5%
2. The module was well organised.	55	1.8%	3.6%	16.4%	54.6%	23.6%
3. I was easily able to find module information on the	55	0.0%	1.8%	12.7%	67.3%	18.2%

virtual learning environment.						
4. Any changes to the module structure were communicated effectively online.	55	1.8%	5.5%	21.8%	56.4%	14.6%
5. It was made clear to me what I was expected to learn in this module.	55	1.8%	3.6%	16.4%	63.6%	14.6%
6. Overall teaching staff made this module interesting.	55	0.0%	0.0%	12.7%	61.8%	25.5%
7. The module content was pitched at the right level.	55	0.0%	1.8%	14.6%	65.5%	18.2%
8. The workload of this module was manageable.	55	0.0%	3.6%	18.2%	61.8%	16.4%
9. Staff during practicals or CBLs provided me with feedback that helped me understand how I am doing and how I could do better.	55	1.8%	1.8%	21.8%	61.8%	12.7%
10. I found the beef/ sheep calendar online CBLs useful.	55	3.6%	9.1%	34.6%	50.9%	1.8%
11. I found the pharmaceutical prescription online CBL useful.	55	7.3%	47.3%	38.2%	5.5%	1.8%
12. I found the additional online ruminant parasitology reference resources useful.	55	0.0%	9.1%	30.9%	52.7%	7.3%
13. The farm scenario assessment within the module stimulated my	55	1.8%	1.8%	20.0%	63.6%	10.9%

interest in the lecture content.						
14. The farm scenario assessment within the module helped tie together the lecture content.	55	1.8%	0.0%	25.5%	63.6%	7.3%
15. I received adequate instructions on the farm scenario assessment.	55	3.6%	3.6%	25.5%	58.2%	3.6%
16. The group work in practical classes, CBL and assessment improved my ability to work in a team.	55	1.8%	7.3%	29.1%	49.1%	10.9%
17. Online material, IT provision and support via forum posts were adequate for my needs.	55	0.0%	3.6%	21.8%	65.5%	9.1%
18. The online resources available were relevant.	55	0.0%	0.0%	18.2%	67.3%	12.7%

Table 1. Student statements to Likert scale questions (n=55). Most frequent response highlighted in grey.

Subtheme	Total number of questionnaire statements	Major theme	Total number of questionnaire statements
Synergistic resources	55	Balance of F2F and TEL resources	93
Student-lecturer interaction	18		
Module content organisation	67	Module design and delivery factors	67
Time management and allocation	43		
Software limitations	9		
Relevance to student career	10	Participant factors	43
Range in student ability	29		

Table 2. Summary of thematic analysis on student questionnaire statements (n=195 statements from 55 students). A response may be categorised to more than one subtheme.

Thus the total number of major or subtheme statements does not equal the total number of questionnaire statements.

Supplementary material

Type of activity	Name of activity	Description of activity	Class size and length (If applicable)
Lectures	Various topics in farm animal clinical medicine	Lecture based module, in a lecture theatre with clinical experts on various subjects.	30x 1 hour lectures with the whole class.
Practical classes	Clinical examination practical	In small groups, students examine 3 cases for 30 minutes each and work out a problem list at the farm animal clinic.	3x 1 case per 30 minute per station with 6-7 students. One clinical teacher per case.
	Population medicine practical	In small groups, students apply herd and flock health clinical skills at 3 practical stations on housing, nutrition and diagnostic sampling at the University farm.	3x 30 minute per station with 6-7 students. One clinical teacher per station.
	Parasitology practical	Students work through 12 diagnostic stations to identify parasites of farm animals and answer questions on treatment protocols.	1x 1 hour class with 11-12 students. One parasitology teachers per group of students.
Case-based learning classes	Anthelmintic and antibiotic selection	Students work on, present and discuss 3 case scenarios on selection of diagnostics and pharmaceuticals. Case scenarios are provided online prior the class to prepare for discussions.	2x 1 hour class with 22-23 students.
TECHNOLOGY ENHANCED LEARNING			
Type of activity	**Name and VLE hosting the activity.**	**Description of activity**	**Class size and length (If applicable)**

Complementary resources for F2F teaching.	Module organisation (Moodle®).	i. Various guidance documents with additional reading references for lectures, practical and CBL classes. ii. Online forum to discuss module topics with staff.	Available throughout the module.
	Clinical examination videos (Mahara®).	Farm animal clinical examination written guidance and narrated videos to prepare students for clinical examination practical.	Available throughout the module.
	Parasitology textbook (Mahara®).	Farm animal parasitology image textbook to prepare students for parasitology practical.	Available throughout the module.
Online case-based learning	Farm animal calendar (Moodle®).	Students are required to create a calendar for example beef and sheep farms. The calendars include key points in the animal production cycle and veterinary interventions. An online form is used to facilitate this.	Available throughout the module.
	Pharmaceutical prescription (Moodle®).	Students work through farm animal cases to design a treatment plan. Subsequently, students calculate drug dosages or write a prescription. The scenarios include individual animal and population cases.	Available throughout the module.
Assessment	End of module quiz (Moodle®).	A combination of free text, multiple choice (MCQ) and extended matching (EMQ) questions on various topics covered in the module.	Available throughout the module.

	End of module summative assessment (Moodle®).[+]	Submission of case-based assessment of a disease investigation report, farmer factsheet and revision poster.	Available throughout the module.

Supplementary material 1. A summary of the F2F and TEL activities in the module. * Attendance recorded by a register. [+] The end of module summative assessment was an obligatory activity.

Question number	Question	Number of statements
Agreement questions (as Likert scale): State how much you agree with the following statements:		
1.	Overall, I was satisfied with this module.	55
2.	The module was well organised.	55
3.	I was easily able to find module information on the virtual learning environment.	55
4.	Any changes to the module structure were communicated effectively online.	55
5.	It was made clear to me what I was expected to learn in this module.	55
6.	Overall teaching staff made this module interesting.	55
7.	The module content was pitched at the right level.	55
8.	The workload of this module was manageable.	55
9.	Staff during practicals or CBLs provided me with feedback that helped me understand how I am doing and how I could do better.	55
10.	I found the beef/ sheep calendar online CBLs useful.	55
11.	I found the drug label online CBL useful.	55
12.	I found the additional online ruminant parasitology reference resources useful.	55
13.	The farm scenario assessment within the module stimulated my interest in the lecture content.	55
14.	The farm scenario assessment within the module helped tie together the lecture content.	55
15.	I received adequate instructions on the farm scenario assessment.	55
16.	The group work in practical classes, CBL and assessment improved my ability to work in a team.	55
17.	Online material, IT provision and support via forum posts were adequate for my needs.	55
18.	The online resources available were relevant.	55
Free-text questions:		
19.	Why did you find/ not find the beef/ sheep calendar online CBL useful?	49
20.	Why did you find/ not find the drug label online CBL useful?	50
21.	Why did you find/ not find the online ruminant parasitology resources useful?	46
22.	Identify any aspects of the teaching of this module that you particularly enjoyed and explain why	23

23.	Identify any issues/problems with the teaching of this module and suggest how this could be addressed	18
24.	Do you have any other comments about this module?	9

Supplementary material 2. Overall structure of the online student feedback questionnaire for the module. Agreement questions were recorded in a Likert scale, categorised as: Strongly disagree; Agree; Neutral; Agree; Strongly agree.