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# Equine virtual farm: A novel interdisciplinary simulation for learning veterinary physiology within clinical context

vorgelegt von

**Maaly Nassar**

Tierärztin, BVSc. and MVSc., Kairo Universität, Ägypten

aus Kuwait

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*"I never teach my pupils; I only attempt to provide the conditions in which they learn"*

*Albert Einstein*

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# INTRODUCTION

Health professions education, particularly veterinary medical education today, faces many challenges in achieving the goal of providing competent practitioners, who are equipped with the core knowledge and skills that are relevant to the constantly changing workplace and by which they could serve their veterinary profession, animals and their wider community. Among these challenges are the explosion of information, heightened awareness of animal-welfare concerns or patient safety issues, the increased number of students and the reduced working hours (**Scalese and Issenberg, 2005, Cavalieri, 2009a).**

Although many veterinary educators attempted to address these challenges through employing problem-based learning (PBL) approaches in small-group practical sessions and recently, through implementing simulations and case studies in their online courses, these approaches served more to motivate students than to deliberately address the fundamental issue of integrating the learning of basic science into clinical practice. Undeniably, such integration is very challenging, especially when the growth of information, the expectations of clinical practice, and the time available to learn the material essential for clinical practice clash head on, but since the solution has been highlighted in Pew Report in the United States, which underlines the need to shift the focus towards the process of learning rather than the content of learning, none seems to bridge basic-clinical science gap and no one seems to try (**Pritchard, 1989; Ertmer and Nour, 2007; Cavalieri, 2009b; Baillie et al., 2010; Summerlee, 2010).** On the contrary, most of the veterinary schools are persistently employing passive didactic forms of teaching (e.g. PowerPoint-based lectures associated with animations and videos, online lectures and podcasts), in the early years of veterinary curricula, to cover the overwhelming and constantly increasing knowledge in pre-clinical studies rather than encouraging students' deep understanding, reflection and further self-learning through independent reading and research (**Forrester, 2005; Gelberg and Gelberg, 2005).** Such traditional approach made students become chronically pressured and overwhelmed by the heavy workload associated with the curriculum, which they described as irrelevant, passive, boring and unrelated bits of information**,** and instead of learning for the innate pleasure of expanding their own knowledge and skills, memorizing knowledge and passing the examinations become the most they can aspire (**Edmondson, 2001; Collins and Foote, 2005; Allenspach et al., 2008; Dale et al., 2008)**. And further upon the beginning of clinical studies, much of the basic knowledge is forgotten and students often struggle to effectively

reason or apply basic sciences to real-life situations that they are unfamiliar with **(Elsheikha and Kendall, 2009).**

The recent growth of interest in simulation has led to a cascade of applications for undergraduate medical education, that seek to teach basic science concepts and disease processes as well as cognitive and motor skills in an interactive way rather than passive lectures and podcasts **(Scalese et al., 2008; Okuda et al., 2009).** This has been true particularly in the realm of human medicine, while veterinary medicine only more recently has began to embrace these simulation modalities that mostly address some clinical or laboratory skills in isolation from the relevant basic knowledge and clinical situations **(Scales and Issenberg, 2005; Kelsey et al., 2002; Keegan et al., 2009; Baillie et al., 2010).** Accordingly, unless these simulations are thoughtfully designed in relevance to basic knowledge and imaginatively situated within the context of clinical experiences, the full potential of such technology in bridging educational gaps may not be realised.

Therefore, the present study designed and proposed a contextualized screen-based simulation; the equine virtual farm (EVF), as an attempt to bridge basic-clinical science gap through immersing students in a virtual learning environment that reflects how problems are encountered in the real clinical life and how physiological knowledge and laboratory/clinical skills are integrated. Consistently, EVF aimed to promote the in-depth learning of veterinary physiology among different students learning styles through:

a) Increasing students' motivation while learning veterinary physiology.
b) Promoting the accurate and the deep understanding of complex physiological mechanisms.
c) Encouraging the application of physiological concepts and the mastery of laboratory skills.
d) Stimulating students' reflection, critical thinking and self-learning, and hence promoting the smooth transition to problem-based learning.

# REVIEW OF LITERATURE

## A. Learning theories

Preparing veterinary and medical health professionals for their future modern workplace is increasingly challenging and difficult to sustain and justify with the increased number of students, reduced working hours, the rapid advances in knowledge and technology, and heightened awareness of animal-welfare concerns or safety issues. **(Baillie et al., 2010)**.

Given these current challenges, medical educators need to renew their interest in the process of learning and become conversant with the different learning theories that could help them in creating the ideal learning environment towards effective learning. Understanding these theories from multiple perspectives provides medical educators with different instructional strategies that can be retrieved from their educational "tool boxes", depending on the specific outcomes that are desired.

Based on the work of previous authors regarding learning theories, **Torre et al., (2006)** discussed the learning theories arising from behaviourist, social, constructivist, cognitivist and humanist learning approaches, and provided further concrete examples of how specific medical educational methodologies are linked to these learning techniques. Although these are widely employed, additional theories which recognise the complexity of learning process and effectively foster the the development of lifelong learning skills and professional identity were proposed.

### 1) Behaviourist learning theory

The behaviorist model involves a teacher-centered approach in which the educator's role is to manipulate the environment for learners to elicit a specific response or behaviour with the total exclusion of the learners' thinking processes and experiences. Therefore, in the view of behaviourist, learning is simply "The acquisition of new behaviour", environment shapes this behaviour and reinforcement is central to the learning process.

In medical education, the behaviourist theory is frequently used for the development of clinical skills. Within this approach, medical educators can demonstrate a specific clinical skill, learners observe the exact manner or technique in which the clinical skill is performed, then some scoring is used to evaluate performance and provide reinforcement.

## 2) <u>Social learning theory</u>

As opposed to a strict behaviourist approach, social learning theory incorporates a cognitive component to deepen the learner's understanding of how, why and for what purpose a certain behaviour or skill is performed in a certain way. In thismodel, learners acquire and reinforce new knowledge or skills by imitating and rehearsing it and not by observing it alone. On the other hand, the teacher is responsible for modelling new rules, guiding behaviours, and providing learners with opportunities to practice these rules and behaviours.

In medical education, the social learning theory is useful for developing competencies, which is achieved when the learners observe their master teachers while practicing a certain behaviour or skill (examining patient) then use these observations to create a memorable model of the desired behaviour then be able to reproduce the desired behaviour and ultimately receive feedback on their performances.

## 3) <u>Constructivist learning theory</u>

Within the constructivist framework, the learning process involves integrating or building new learning activities and practical experiences into existing knowledge, understanding and skills. According to Piaget's (one of the most influential early proponents of a constructivist approach to understanding learning) view of learning, learners within this approach will try actively to replay the current knowledge in their memories, build inferences and relationships between their older perception and the new learning experience (assimilation), reformulate their existing mental knowledge (accommodation) and then develop their own understandings and assumptions (Equilibrium). However, if the new data contradicts with the existing one, it will be rejected. And therefore, educators in this model should foster critical reflection (e.g. asking the learners about what they have learnt, that is replaying, integrating their thoughts and reevaluating the experience) to assist learners in developing their own assumptions and negotiate with the learners to uncover the underlying meaning of these assumptions.

In medical education, this approach could be used in reflective journaling or in helping learners to understand their practice as physicians by asking them to describe a particular case, articulate their thoughts and feeling about such case and finally reflect on what they have learnt. Once this activity is complete, small group learners come

together to discuss similarities and differences in their cases and to describe what their cases mean to them.

## 4) Cognitivist learning theory

Cognition involves all of the mental activities that serve the acquisition, storage, retrieval and further use of knowledge to solve problems.

The cognitivist orientation facilitates the acquisition of knowledge and the development of learning skills (i.e. draw relation ships between concepts; "learn how to learn") that are applicable in other learning situations regardless of the topic or context and hence, the development of critical thinking skills through critical reflection.

To help learners develop reflective thinking, medical educators often begin by asking them to identify and recall a significant clinical experience. After the learner has had a chance to recall the clinical event, he or she is asked to describe what happened (reflection), summarize what was learned from this experience (their own understanding), and speculate on what could have been done differently (critical thinking). Thus, in cognitivist approach, solving problems is the main way of learning.

## 5) Humanist learning theory

Within this theory, learning is viewed as a personal act that is fuelled according to learners' needs and motivation to achieve their full potential and become all that they are capable of becoming. The teacher in this theory assists learners to plan, carry out, and evaluate their own learning experiences.

In medical education, a humanist approach can be adopted in well-designed technology-based learning experiences such as computer-assisted simulations to help learners in understanding their specific roles and their responsibilities for their own continued professional development

## 6) Adult learning theory/Andragogy (Problem-based learning; PBL)

Many of the theories or conceptualizations made about learners and learning is polar opposites (teacher-centered and student-centered, behaviourist and humanist). However in reality, these concepts are overlapping rather than being opposed to each other, especially when the technical aspects of clinical instruction are introduced.

The medical learner at any stage-undergraduate, graduate, or postgraduate- is truly an adult learner that is seen to learn by different methods and for different reasons in comparison with earlier stages in his education **(Okuda et al., 2009).**

Andragogy as defined by **Knowles, (1968)** (the father of Andragogy) involves shifting from traditional didactical education techniques such as lectures to experimental problem-based and self-learning education techniques that make use of the learners' life experiences and their internal needs and interests **(Merriam, 2001).** **Parkinson and St George, (2003)** considered pedagogy (learning by traditional didactic teaching models; lectures) and andragogy to operate simultaneously in veterinary education, recognizing that a surface or traditional approach might sometimes be required as a precursor to andragogical learning. In addition, **Kneebone and Baillie, (2008)** indicated that the role of tutor is crucial, but often under recognized.

Clinical skills, on the simplest level, are psychomotor skills learned via reinforcement and requiring straightforward instruction **(Dale et al., 2008; Okuda, 2009).** Evidence from domains, both within and outside of medicine show that the acquisition of technical expertise requires sustained intense and focused repetition of the practiced skill, supported by feedback from skilled teachers and determination to improve **(Kneebone, 2005; Guest et al., 2001; Ericsson, 2004).** In one recent study, students rated problem-based learning (PBL) sessions, which include academic facilitator, more highly than self-directed PBL in which the problem is delivered online without a facilitator present **(Foster et al., 2010).**

## 7) <u>Experiential learning (Adult theory into application and practice)</u>

More than 20 years ago, **Bushby, (1985)** highlighted the need for problem-solving skills to be developed in the context of a real problem. Kolb's experiential learning cycle was the best to practically illustrate that **(Kolb's, 1985a).** The basis of Kolb's model **(Fig 1)** which owes its origins to the works of Lewin, Dewey, and Piaget, is that learners have a concrete experience, about which they have a reflective observation that leads them to develop an abstract conceptualization (theories, ideas, assumptions) that is tested through active experimentation (problem-solving). This cycle feeds into another cycle of concrete experience, and so on. The model recognizes the need for learners to develop theories, apply them to real problems, evaluate the outcomes, and subsequently refine their understanding, and hence the development of higher cognitive abilities that allow learners to apply and practice what they have learned in authentic contexts **(Dale et al., 2008).**

**Fig 1** : Kolb's experiential learning cycle

Fig 1

Concrete
Experience

Active
Experimentation

Reflective
Observation

Abstract
Conceptualization
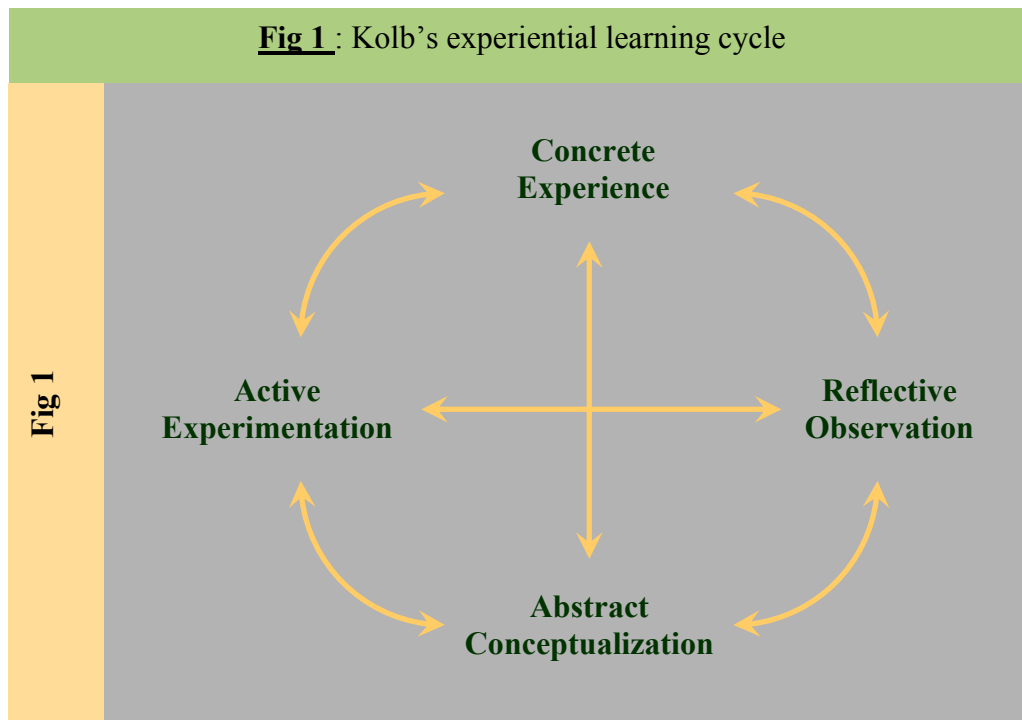
## B. How far veterinary education aligns with learning theories?

The use of curriculum integration in veterinary education represent one approach to delivering a learning experience that aims to mimic more closely the way information and problems encountered in the workplace, and to deliver an authentic learning experience that attempts to meet the educational needs of veterinarians in the twenty-first century. Within the context of veterinary education, a definition of curriculum integration in the teaching of veterinary science was suggested, which involved immersing students in a learning environment that attempts to reflect how problems are encountered in real life and linked to what veterinarian do. In this environment, students are encouraged to see connections and build linkages across different topics, subjects and disciplines, both horizontally (such as anatomy, physiology and biochemistry) and vertically (such as physiology and medicine), thus reinforcing their relevance, and then assess, use and apply the knowledge learned to real-world scenarios and problems and thereby linking knowledge to application. **(Thompson, 2005; Cavalieri, 2009a).**

Recent studies have demonstrated that problem-based learning (PBL) and case-based learning are increasingly widespread components of undergraduate medical **(Jamkar et al., 2006; Owen et al., 2007)** and veterinary education **(Patterson, 2006).** The Bristol school of Veterinary Science, England, has replaced 20% of the first two years

of its five year program with PBL-type processes, with some courses using up to 40% of student contact time for PBL. Similarly, the Purdue School of Veterinary Medicine, Indiana, uses a hybrid approach for the first two years of its four-year program with PBL. Some institutes, for example the Royal Veterinary College, London, have adopted the principles of PBL and include self-directed learning sessions similar to PBL sessions, but these comprise a very small component of the course **(Lane,2008).** These learning approaches are being seen as a novel way to facilitate student interaction and engagement and to deal with increasing class sizes. **(Elsheikha and Kendall, 2009).**

On the other hand, it was interesting to note the adoption of other learning theories, such as socialism and constructivism, into physiology and biochemistry practical sessions at Berlin Free University School of Veterinary Medicine, as an attempt to promote reflection and communications skills. But unfortunately, no literatures have been found regarding their learning outcomes.

## C. Why shifting to curriculum integration and problem-based learning (PBL)?

### 1) Traditional methods lead to superficial learning

Because the volume of information is so overwhelming, and constantly increasing, there is a tendency to cover the material through passive didactic approaches instead of providing opportunities that facilitate students' understanding of that material **(Forrester, 2005).**

Most veterinarians today are educated by means of curricula that primarily used passive learning techniques such as lecture-based delivery of information. It is becoming increasingly that employing these passive didactic forms of teaching (e.g., Lectures) to impart much of the curriculum content in the pre-clinical courses of veterinary medicine and related disciplines encourages a superficial approach to learning rather than a deep one **(Canfield, 2002; Lane, 2008).**

In these traditional approaches, students are pressured to assimilate and memorize a large amount of information, without extracting meaning, relating ideas, developing reasoning or applying their knowledge to real-life situations, but instead they focus on the material on which they expect to be examined and for which they feel they will be rewarded. It is unlikely that these surface approaches will serve graduates well in their future careers, especially, if learners are only extrinsically motivated to pass examinations. This is worrying, as many research studies have

demonstrated that students who consistently adopt a surface approach to their study are less successful in passing examinations than those who consistently adopt a deep approach **(Allenspach et al., 2008; Dale et al., 2008)**.

## 2) <u>Motivating veterinary students is a prerequisite for deep learning</u>

A survey at the University of Sydney was designed to ascertain sources of stress both within and external to the university. Two-thirds of respondents reported experiencing stress from being chronically pressured and overwhelmed by the heavy workload associated with veterinary curriculum, and more than 70% reported being worried about passing examinations and being unable to graduate. When students feel this way, there is a real risk of the educational experience becoming devalued-endured and survived rather than enjoyed **(Collins and Foote, 2005).** In addition, **Lane, (2008)** indicated that rigorous training in foundational sciences without a connection to application can result in a dwindling of initial enthusiasm and motivation early in a course, together with concerns about relevance and doubt as to whether the student actually wishes to pursue a career in veterinary science. In agreement, **Nandi et al., (2000)** has reported that students of traditional curricula are more likely to describe their pre-clinical experience as irrelevant, passive, boring, and based on supervisors' assessment, perform less well after graduation compared with students who graduated from a PBL curriculum.

It seems that although the affective component of learning is very powerful, it is frequently overlooked. A positive emotional climate that stimulates the student's own interest and removes stress can greatly benefit learning, but this needs to be deliberately created rather than left to chance **(Kneebone and Baillie 2008).**

Several studies concluded that vertical integration between basic science knowledge and clinical medicine improves students' motivation and stimulates their interest to look more deeply into biological principles and thereby improve their deep retention of factual knowledge. Thus, enhancing deeper learning was considered an advantage of increasing student motivation **(Dahle et al., 2002; Elsheikha and Kendall, 2009; Cavalieri, 2009b).** Veterinary students also tend to respond favourably to activities that involve interaction with animals and the hands-on application of veterinary skills **(Cavalieri, 2009c),** as in some ways, clinical skills would seem easier to master because students tend to remember 90% of what they do yet only 10% of what they read **(Croley and Rothenberg, 2007).**

Accordingly, **(Cavalieri, 2009a)** indicated that setting knowledge, skills, and attitudes within the context of how they are applied as veterinarians may provide a degree of emotional appeal to students and encourage motivation. For example, physiological processes can be explored using case studies, patient monitors, clinical pathology, and pharmacological alteration of function.

### 3) <u>Veterinary medicine professions are transdisciplinary in nature</u>

The transdisciplinary nature of veterinary medicine professions and the need for veterinarians to solve complex problems that rely on a broad range of relevant knowledge have encouraged the development of transdisciplinary integrated curricula rather than traditional discipline-specific curricula. These transdisciplinary curricula aimed to improve learning outcomes by mimicking more closely the way information and problems are encountered in the real world and to present facts in a relevant and meaningful way **(Lake, 1994; Smith, 2005; Thompson, 2005).**

In integrated curricula (PBL), irrelevant and redundant material can be removed and clinical cases are carefully selected to help students see connections between disciplines, subjects and problems and hence, reinforcing their relevance to students **(Cavalieri, 2009a,b).** Moreover, underlying the design of these integrated/Experiential curricula (PBL) is the assumption that applying what was learned in authentic context and active participation in clinical case discussion is expected to enable the development of professional skills, such as self-directed learning, critical thinking, teamwork and communication skills, which are all critical for professional practice **(Newman, 2005; Dale et al., 2005; Thurman et al., 2009).**

Consistently, PBL strategy of teaching became strongly supported and increasingly popular in veterinary faculties worldwide, encompassing both curriculum content and a process of learning, and has been cited as an attractive curricular alternative for veterinary education (**Whitney et al., 1993; McLennan, 2003**) that improves students' deep understanding of basic sciences (**Finucane et al., 1998**) and clinical performance (**Farnsworth, 1997**) and further supports the development of higher cognitive abilities (**Dale et al., 2008**).

## D. <u>Curriculum integration or PBL in veterinary medicine</u>

Curriculum integration had been applied across a range of educational levels as means of attempting to improve learning outcomes, but it was not until the publication of the Pew Report in the United States **(Pritchard, 1989)** that a new learning paradigm

started to emerge in veterinary education. The major finding of this report was that the universal veterinarian student is required to develop the skills to find information and solve problems, rather than knowing everything there is to know about all species. There followed a number of veterinary case studies of problem-based learning and the related concepts of problem solving, reflection, and collaborative/cooperative learning that supported further the inclusion of PBL within veterinary schools curricula. Most of these improved clinical, problem-solving and communication skills **(Swan et al., 1982; Singer and Hardin, 1997),** while others reinforced learning through creating some links between foundational knowledge and its application **(Doherty and Jones, 2006; Cavalieri, 2009b).**

Although some institutions have included elements of integration within subjects, there are few providers, such as Faculty of Veterinary Medicine at University College Dublin in Ireland, Bristol School of Veterinary Science in England, the Purdue School of Veterinary Medicine in USA, who have adopted a holistically integrated approach to curricular delivery **(Lane, 2008; Cavalieri, 2009b).** Such reluctance had led, accordingly, to a paucity of literature investigating PBL implementation in veterinary curricula **(Blumberg, 2005)**, which was, already, shown to promote independent learning **(Khan et al., 2007)** and other lifelong learning skills **(Azila et al.,2001)** in medical schools.

# E. <u>Problems impeding the integration of PBL in veterinary education</u>

Despite cited advantages conferred on students who have come through a PBL curriculum and their desire for increased problem solving, recognised as an important career skill, both students and faculty identified major impediments, these are:

## 1) <u>Faculty resistance to change</u>

**Pollock (1985)** argues that one of the reasons problem solving has not been implemented in veterinary curricula is that faculty are not prepared to teach it, preferring the familiarity of the lecture-based system of which they themselves are a product, especially if they needed to contribute to areas or disciplines with which they are relatively unfamiliar **(Harden et al., 1984).**

Another contributing reason may be attributed to **Nandi et al., (2000)** extensive report which has seriously questioned the ability of PBL curricula to provide the core knowledge required for entry into the medical profession and which was aligned with the fact that that clinical scenarios, problems, cases, and procedures may

not always illustrate every principle being taught within the basic sciences **(Cavalieri, 2009b).** While some studies have improved understanding of the basic sciences with PBL **(Finucane et al., 1998; Colliver, 2000)**, others seriously questioned the capability of PBL-based curricula to deliver knowledge required to pass professional examinations. One study has reported that although students acknowledged the gains made via PBL process, they preferred subject based tutorials as they felt that these provided information in a more efficient manner **(Azila et al., 2001).**

Therefore, if educators plan to deliver integrated curriculum, they will need to reevaluate their discipline areas and remove material that may be redundant and irrelevant within the context of an integrated curriculum. This in turns will require the downsizing of the dynamically increasing individual discipline content , in addition to staff collaboration, resourcefulness and creativity during selecting the topics, that are most relevant, to simplify the extremely difficult concepts that many veterinary students spend an inordinate time to memorize and to ensure that essential knowledge and skills are taught and not overlooked. Such requirements will demand considerable time and staff resources that can create a degree of insecurity and anxiety in staff from a variety of disciplines and favours more the implementation of familiar discipline-based system **(Buchanan et al., 2005; Grant and Paige, 2007; Cavalieri, 2009a)**

## 2) <u>Students' different ways of learning</u>

Students have different preferences for the ways in which they percieve (visual/audio/read and write/ kinaesthetic (VARK) learning styles; **Fleming and Miles, 1992**), interact with (Grasha Reichmann Student Learning Style Scale (GRSLSS; **Grasha, 1996**) and process information (Kolb's learning styles inventory; **Kolb, 1985b**) **(Bedford, 2006).** One characterization of learning styles is to define the learners' preferred mode of learning in terms of the sensory modality by which they prefer to take in new information: **Fleming and Miles (1992)** defined four sensory modalities of learning: visual, auditory, read-write, and kinaesthetic. Although learners can use all of these sensory modes of learning, some learners have a preference for one of these learning modalities, whereas multimodal learners do not have a strong preference of any single method. For example, visual learners learn through seeing drawings, pictures, and other image-rich teaching tools. Auditory learners learn by listening to lectures, exploring material through discussions, and talking through ideas. Reading/writing learners learn through interaction with textual materials such as textbooks, lecture notes, or handouts. Kinaesthetic learners learn through feeling and

living the experiences that emphasize doing, physical involvement and manipulation of objects. Multimodal learners rather learn via two or more of these modalities. In literature, numerous and diverse inventories of learning styles have been reported. The visual, auditory, reading/writing, kinaesthetic (VARK) questionnaire (http://www.vark-learn.com/documents/german.pdf) is one of the more practical and recently popular used inventories that identify student's preferences for particular modes of information presentation. **(Baykan and Naçar, 2007).**

It is generally accepted that the manner in which learners prefer to approach a learning situation has an impact on their learning performance and achievement of learning outcomes **(Cassidy, 2004).** For this reason, as medical instructors, it is our task to develop appropriate learning approaches that address this diversity of learning styles among students, thus, promoting student motivation and performance **(Miller, 2001).**

It has been shown that active learning strategies reach all types of learners including visual, auditory, read/write, kinesthetic, and tactile styles. With active learning strategies, visual learners are targeted by the presence of models and demonstrations. Auditory learners are reached through discussion during peer instruction, debates, games, and answering questions. Manipulating models and role playing satisfy kinesthetic and tactile learners (**Lujan and DiCarlo, 2006**). This may indicate further that problem-based learning, as an active type of learning, will achieve the same results. However, on investigating how different students' styles interact with PBL, **Novak et al., (2006)** reported that while PBL appears to be a teaching style that is conducive to pharmacy students learning preferences, difficulties have occurred in adapting from a didactic teaching style to PBL, indicating that the introduction of PBL may be an uncomfortable experience for the didactically trained student and that to transform from passive to active learning approaches, students require communication skills, independent responsibility for learning, and further a solid knowledge base prior PBL implementation to refer to, later, in solving problems **(Williams, 1999**; **Cavalieri, 2009a).**

Accordingly, **Lane, (2008)** concluded that it is difficult to advocate the replacement of an entire curriculum with a PBL program, especially in the European setting where students enter an undergraduate course from such diverse academic background and second-level schools that mostly encourages and rewards learning through memorization rather than understanding, indicating that facilitating change in

learning strategies must be considered when dealing with students who are accustomed to traditional teaching methods, especially in the first years of veterinary curricula.

### 3) <u>Lack of animals and laboratory resources</u>

A further issue that acts against the initiation of a PBL-based curriculum is the associated need for animal and laboratory resources.

To be prepared to enter veterinary medicine, students require laboratory training during their intensive professional education program that involves dead, anesthetized, or conscious animals, so that they become proficient in the expected range of veterinary knowledge, skills, and abilities. Undeniably, experience with animals is essential to prepare students for a profession in which animals comprise the total domain. However, the animal welfare issues, the higher acuity of illnesses at academic medical centers (Hospitals and clinics) and the restricted number of examination allowed per animal, especially, in farms which runs as a business, where financial implications must be considered, all contributed to the reduced availability of animals as learning opportunities and to the increasing number of medical schools that had entirely discontinued live-animal use **(Issenberg et al.,1999; Fincher and Lewis, 2002; Hart et al., 2005; Baillie et al., 2005; Knee and Baillie, 2008)**. Moreover, **Lujan and DiCarlo, (2006)** reported further that the scarcity of suitable laboratory equipment, space, and experiments and the expense of live laboratory animals and equipments made experimentation is often neglected in many curricula.

All these challenges made medical educators reconstruct their curricula, develop small-group sessions, and increase self-directed learning and independent research to permit a reduction in the consumption use of animals **(Scalese and Issenberg, 2005; Okuda et al., 2009)**. Nevertheless, the fact that fewer learning opportunities are afforded by animals in the traditional clinical curriculum still problematic because the most identifiable factor in distinguishing the level of professional performance and the mastery in a particular field, is the amount of "deliberate practice" (i.e. intense, repetitive performance, in a controlled setting, of intended cognitive or psychomotor skills within a focused domain) **(Ericsson, 1993)**. Such issue has provided another impetus to the implementation of new innovative technology-based systems that can reproduce a wide variety of clinical conditions and situations on demand.

# F. How far did veterinary educators go to address PBL impediments?

The evolution of the internet and the rapid advancement in computer and information technologies had sparked much interest among veterinary and medical educators to implement these powerful innovative technologies in their education under the term of e-learning.

In the past, the term e-learning referred to computer-assisted learning (also called computer-based learning or computer-based training) that uses computer technology to aid in the delivery of stand-alone multimedia packages for learning and teaching. However, with the advent of the internet and the delivery of online courses (online learning, distance learning or Web-based learning), e-learning has evolved and the term is now defined as learning mediated by technology, such as the World Wide Web, intranet, and multi-media based computer applications **(Kim,2006; Ruiz et al., 2006; Monahan et al.,2008)**

By looking at articles related to veterinary and medical education, it was revealed that implementing technology-based learning was the most common approach adopted by veterinary and medical educators to address educational and PBL impediments. This in turns led to the emergence of two main types of e-learning applications: Learning management systems and, recently, Simulations.

## 1) Learning management systems

Information and communication technologies (ICTs) have been used in the support of veterinary education for number of years to enhance and complement traditional lecture-based classroom teaching. Much of this use has centered on computer-assisted learning (CAL) packages and videos. More recent developments such as learning management systems (LMSs) have extended the ability of ICTs to support and significantly enhance whole programs of study. LMSs take many forms, but they are all based on the principle of bringing together educational, administrative, and communication tools and information and integrating them into a single system. In LMSs, instructors are allowed to efficiently prepare and manage the distribution of course material and assignments, while students are engaged during the course of learning through the various interactive materials that have been designed and developed in these web-based teaching packages. Moreover, LMSs integrate online forums and discussion boards that allow, further, students to communicate with their tutors, thus, empowering them to socialize and learn together online. Such potentialities made LMSs

invaluable learning environments for students (**Monahan et al.,2008; Ong and Mannan, 2004; Ellaway et al., 2003)**.

While LMSs such as WebCT, Blackboard and Moodle were commonly and successfully used worldwide, especially in the universities and colleges of Europe and North America, they are still missing some issues that need to be resolved especially in professional vocational areas such as medicine and veterinary medicine. In this regard, **Ellaway et al., (2005)** highlightened the need for encompassing integration between the elements of veterinary or medical programs in LMSs, especially in the disciplines where course options are minimal and where integration and coherence across a whole program are dominant factors. In addition, **Ertmer and Nour, (2007)**, indicated that despite the noted benefits, learning in LMSs can lead to a great frustration by the heavy reliance on textual information, difficulty of visualizing complex concepts and lack of face-to-face interaction, suggesting that to be effective at a distance, instructors need to use a variety of teaching strategies, often different from those used in a face-to-face environment.

Nevertheless, despite the attempts to address LMSs limitations either by developing a new integrative LMS for medical and veterinary undergraduate programs (**Ellaway et al., 2005)** or by integrating more learning activities including case studies (**Allenspach et al., 2008)**, concept maps (i.e. a graphical, hierarchically arranged knowledge representation that reflects the content of an individual's long term memory), animations and virtual microscopy (**Ertmer and Nour, 2007),** it seems that the faculty resistance against new learning platforms (**Ellaway et al., 2005),** the lack of adaptivity to individual learning styles (**Graf and Kinshuk, 2006)** and the scarcity of contextualized learning activities to facilitate interaction and learning by doing (**Ellaway et al., 2005; Ertmer and Nour, 2007)** are still the current challenges facing veterinary educators in achieving truly learning experiences within LMSs. As a result, the birth of new technology-based learning environments have been witnessed within medical and veterinary educations to provide much more natural, engaging and interactive learning experience for students than browsing through 2D webpages looking for information in online courses or podcasts (**Monahan et al., 2008; Scalese et al., 2008).**

## 2) <u>Simulations</u>

Health professions education during the past two decades has witnessed a significant increase in the use of simulation technology for teaching and assessment. This has been true particularly in the realm of human medicine, while veterinary medicine only more recently has begun to embrace these simulation modalities. The uses

of simulators addresses many issues: They can be readily available at any time, reproduce a wide variety of clinical conditions on demand and allow novices to carry out the practice to master various techniques-including invasive procedures- on real patients in a risk-free environment **(Scalese and Issenberg, 2005; Scalese et al., 2008).**

## Simulation definition

A simulation has been defined as the artificial replication or the imitation of sufficient elements of a real world domain (e.g. real patients, anatomic regions, clinical tasks or real life circumstances in which medical services are rendered) to achieve a specified goal. Simulations are not identical to real-life events; rather, the simulation places the learner in life-like situations that provide immediate feedback about questions, decisions, and actions **(Keegan, 2009).**

## Simulation types

Simulation can take many forms **(Scalese et la., 2008; Okuda et al., 2009)**. These include:

a) Screen-based computer simulations (virtual reality simulations), in which a computer display simulates the physical world, and user interactions are with the computer within that simulated (virtual) world; e.g. the virtual ventilator **(Fig 2a; Keegan, 2009).**

b) Virtual reality haptic systems that provide tactile feedback for training in examination, surgical, endoscopic or rectal examination procedures; e.g. PHANTOM haptic device (**Fig 2b; Baillie et al., 2005).**

c) Single/partial-task simulator, which consists of 3D representation of body parts/ regions with functional anatomy for teaching and evaluating practical skills, such as plastic arms for venipuncture or suturing but with no or little simulator responses **(Fig 2c;** http://www.medicmedia.com.au/contents/en-s/d243_injections_venipuncture.html**)**

d) High-fidelity mannequin simulator or computer-enhanced mannequins that reproduce not only anatomy, but also normal and pathophysiologic functions in response to various user actions; e.g. Human Patient Simulator (**Fig 2d;** http://www.meti.com/products_ps_hps.htm**)**
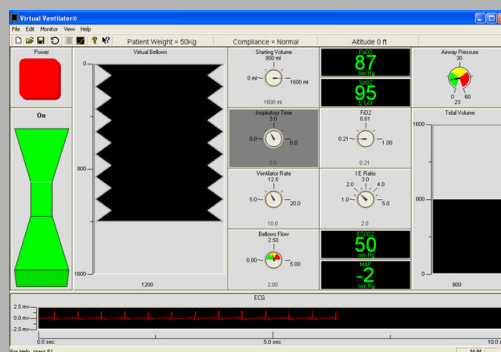
**Fig 2** : Simulation types

Fig 2a



Fig 2b



Fig 2c



Fig 2d

**Simulations in veterinary education**

The recent growth of interest in simulation has led to a cascade of applications as a supplement to or replacement for current models of undergraduate medical education. The reason for this is the that traditional modes of education rely on non interactive classroom lectures and more recently problem-based learning formats to relay basic science concepts and disease processes. On addressing these concepts, simulations offered attractive and effective alternatives for depicting, learning and practicing the complex knowledge and the relevant clinical and laboratory skills repeatedly at any time or place desired by the users through experimentation and trial and error with the ability to rewind and rehearse without jeopardizing the safety of patient (human or animal) and practitioner or the lengthy preparation for the laboratory. Simulations also effectively addressed the diversity of learners and provided a wide range of cases and situations with its adaptable, programmable structures. Such enormous potentialities made out of simulation an exciting field that can revolutionize medical and veterinary education and make the best use of scarce resources, if thoughtfully designed and imaginatively applied **(Buchanan et al.,2005; Kneebone and Baillie, 2008; Okuda et al., 2009).**

To date, very few published reports were found about employing this technology in veterinary education, in contrast with the many hundreds of articles in human medical education literature. For instance, one virtual reality haptic system, the PHANTOM haptic device, was developed and employed in the fourth-year of veterinary curriculum as a worthy tool for teaching undergraduate veterinary students bovine rectal palpation in isolation **(Baillie et al., 2005)** or within the context of clinical scenarios **(Baillie et al., 2010)**. In another example, **Keegan et al., (2009)** highlighted the usefulness of the Virtual Ventilator they developed in teaching undergraduate students the principles of mechanical ventilation in an anaesthesia course. Moreover, other interesting examples of simulations that foster digital 3D animation technology were developed and recommended as valuable tools for promoting the deep understanding of physiological processes, such as vasoconstriction initiated by the stimulation of alpha-1 adrenergic receptors **(Buchanan et al., 2005)** and the complex spatial relationships between the calf and dam during both parturition and dystocia **(Scherzer et al., 2010),** in veterinary curricula.

In conclusion, many might speculate that simulations will replace good educators and substitute clinical environments. However, it is agreed that the ideal setting for clinical education remains the actual clinical environment and that simulations will

never obviate the need for faculty trained in solid educational principles and teaching techniques, but unfortunately, the ideal is not always practical **(Okuda et al., 2009).**

# MATERIAL AND METHODS

## A. Designing Equine virtual farm

### 1) Designing tools and scientific resources

Equine virtual farm (EVF) is an interactive, contextualized, screen-based computer simulation that depicts on-farm scenarios for inspiring students to create connections between physiological knowledge and its application in clinical veterinary medicine.

A well researched scientific script regarding EVF on-farm scenarios was written after reviewing the current knowledge and modern diagnostic techniques in scientific journals, text books (physiology, anatomy and histology text books) and atlases. Then EVF was created using Autodesk Maya (http://usa.autodesk.com/maya/), a professional 3D animation software used in film industry to create 3D movies and effects, and Adobe Flash (http://www.adobe.com/products/flash/whatisflash/), an animation software, which comes with an object oriented programming language called Action Script that makes it a really versatile tool to deliver interactive experiences for computers and mobiles.

### 2) Creating EVF interactive 3D dynamic models

Different 3D models for horses' bodies, eyes, ears, brains, farms and laboratories' furniture and equipments were modelled in Maya virtual space, using multiple angles reference images, acquired from internet, farms, laboratories, clinics, text books and atlases, as guides **(Fig 3a-c).**

**Fig 3a-c** : Screen shots of Autodesk Maya showing examples of the different angles reference images used in creating 3D models for horses' heads **(Fig 3a)**, cerebellum **(Fig 3b)** and right cerebrum **(Fig 3c)**.

**Fig 3a**



**Fig 3b**



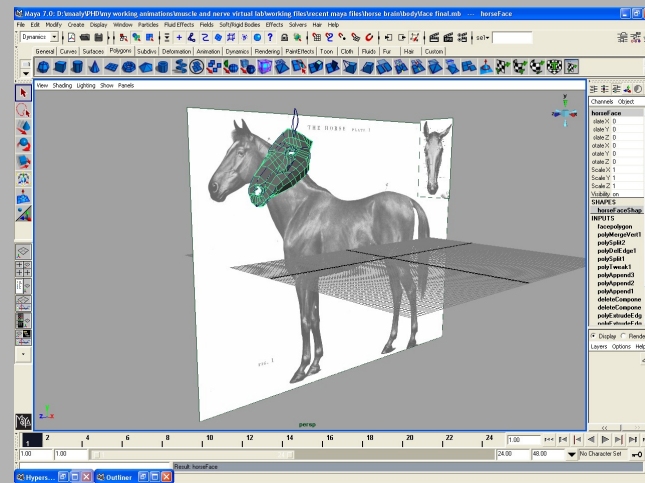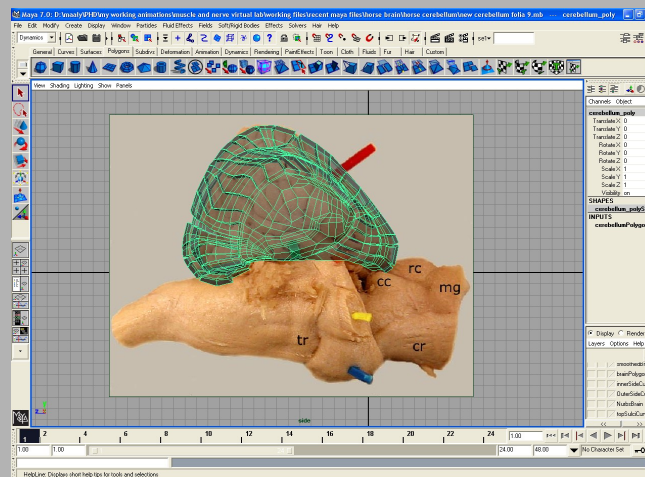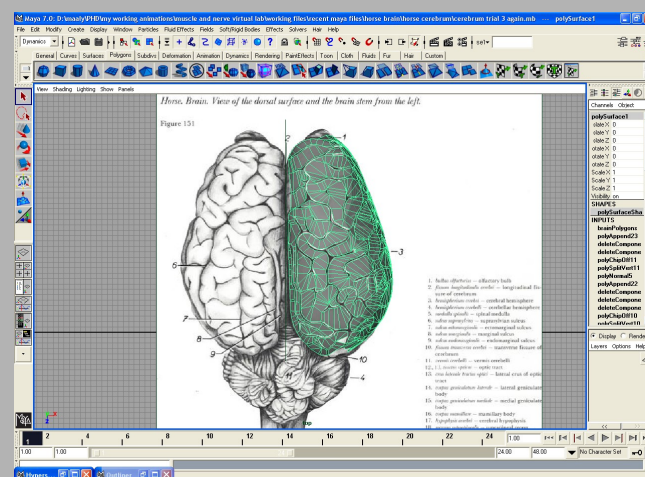**Fig 3c**

These models were then textured, colored and then animated using Maya basic animations, deformers, dynamics and skeletons **(Fig 4a-b).** Virtual lights and cameras were then created and animated to be used in rendering the interplay of 3D virtual models, within different perspectives, into a sequence of 2D Photoshop (*.psd) images.

**Fig 4a-b :** Screen shots of Autodesk Maya showing examples of  deformers (clusters in tied rope), skeletons (horse's skeleton and joints) **(Fig 4a)** and dynamics (pond and trees motion with wind) **(Fig 4b).**


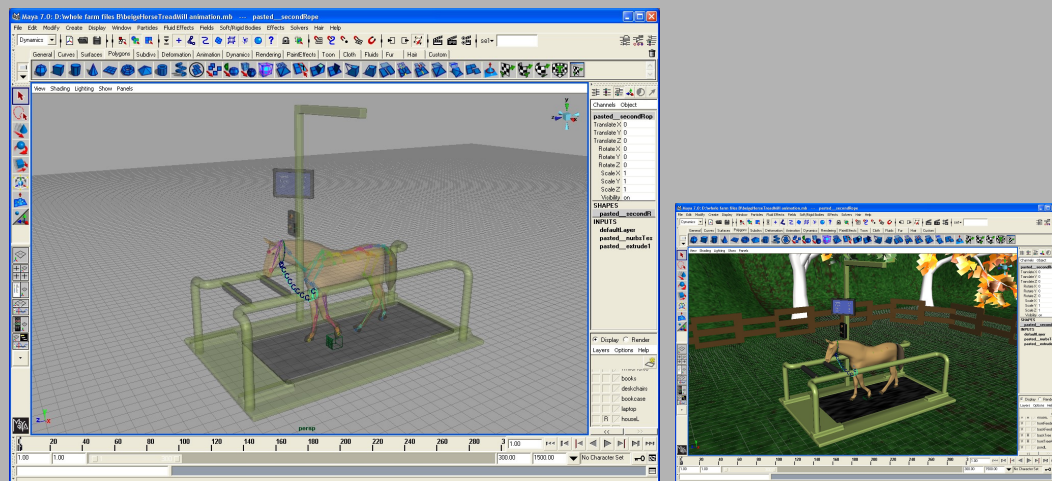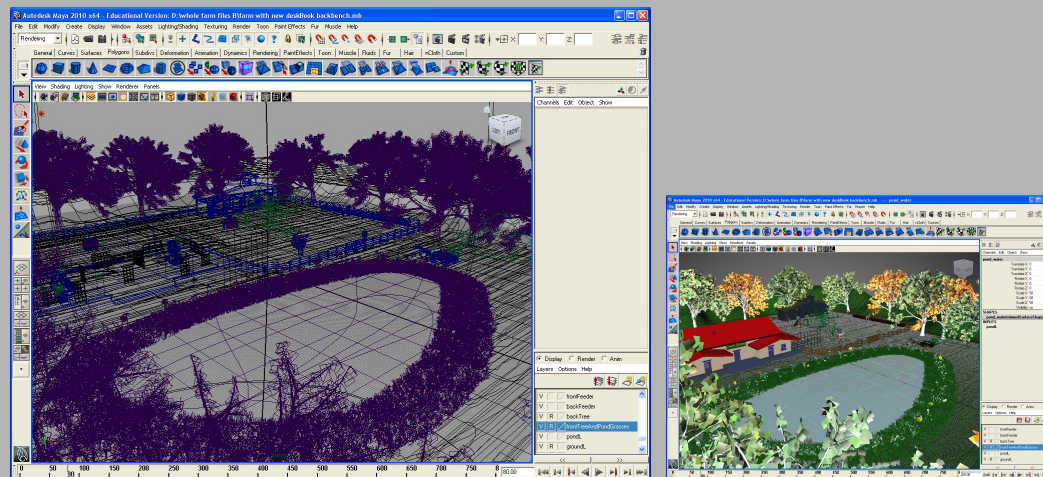
For creating interactivity and EVF user interface, psd images were then imported into Adobe Flash and interactive short scripted movie clips and further multiple Shockwave flash files (*.swf) files were created using Adobe Flash time line and Action Script programming language.

Further programming using Adobe Air was integrated and final executable and air desktop applications were published.

# B. <u>EVF scenarios and students tasks</u>

EVF runs in a problem-based manner depicting five on-farm scenarios, through which the students are engaged, as veterinarians, in examining horses health conditions in EVF horses yard, analysing their blood samples in EVF laboratory and making diagnosis and deciding treatment, if appropriate, with the aid interactive virtual books and internet links in EVF office **(Fig 5-9).**

To take their turns as veterinarians in EVF on-farm scenarios, students are first introduced to the whole virtual farm infrastructure and their different virtual farm tasks through a tutorial that prompts on clicking on the horse wagon button in EVF main scene **(Fig 5).** Additionally, virtual farm notes are included in each virtual environment to remind the students of their tasks regarding the displayed scene.

**Fig 5 :** Screen shots of EVF showing EVF main scene **(top)** and EVF tutorial **(bottom)**

EVF on-farm scenarios start in the horses' yard, to which students can move by clicking on the horses' yard in EVF main scene. In the horses yard **(Fig 6a-c),** five horse cases are included ranging between normal, racing, stressed and unbalanced horses. In this scene, students can examine each horse condition by clicking on it and write reports regarding each case by clicking on the report button, underlying the farm notes.

**Fig 6a-b :** Screen shots of EVF showing horses yard **(Fig 6a)** and horses yard reports **(Fig 6b)**
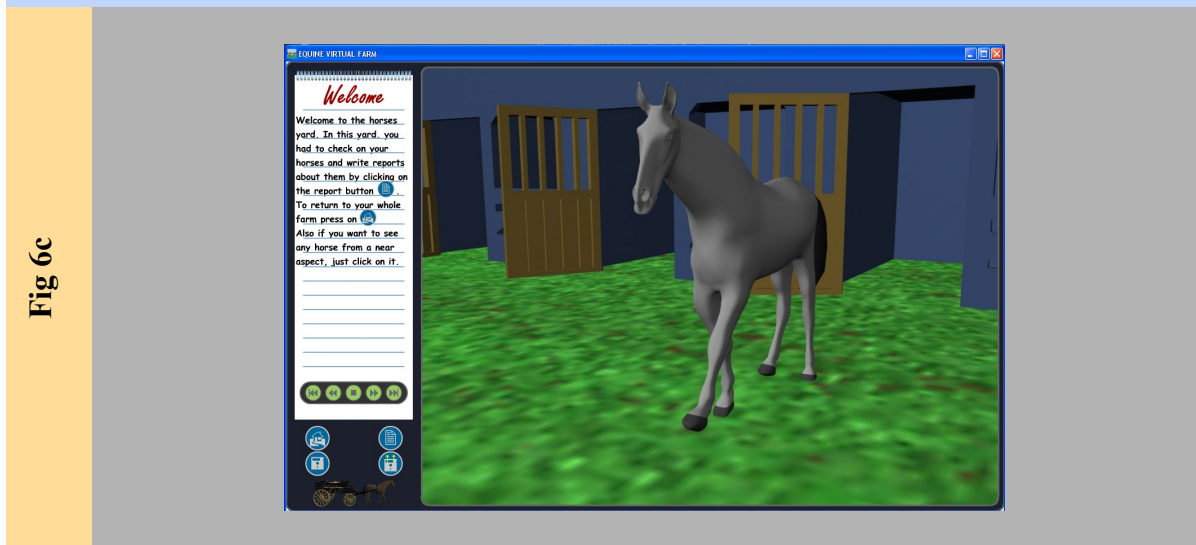
**Fig 6c:** Screen shots of EVF showing one of the horses yard cases.

As a part of the on-farm scenarios within the horse yard and upon examining each horse case, the students are asked whether they want to go to examine other horses or go to laboratory to take blood samples. If they answered by going to the laboratory, they will move directly to the virtual farm laboratory **(Fig 7a)** where they can take and analyse the examined horse blood sample, as a further diagnostic aid. Similarly, the home button underlying the virtual farm notes makes the students move from any displayed virtual environment to the main virtual farm scene where they can click on the next virtual environment (e.g. the laboratory) to which they decided to move.

In the virtual laboratory, the students continue their roles as veterinarians in diagnosing and writing laboratory reports **(Fig 7b)** regarding each horse case through two haematological laboratory techniques; the osmotic fragility test and the differential white blood cells count. In addition, this virtual environment is supplied with a laboratory manual **(Fig 7d)** that can be accessed by clicking on the book button as a scientific and technical laboratory aid for these two diagnostic techniques**.**

**Fig 7a-c :** Screen shots of EVF showing EVF laboratory **(Fig 7a)**, laboratory reports **(Fig 7b)** and one of the procedures while taking blood samples **(Fig 7c)**
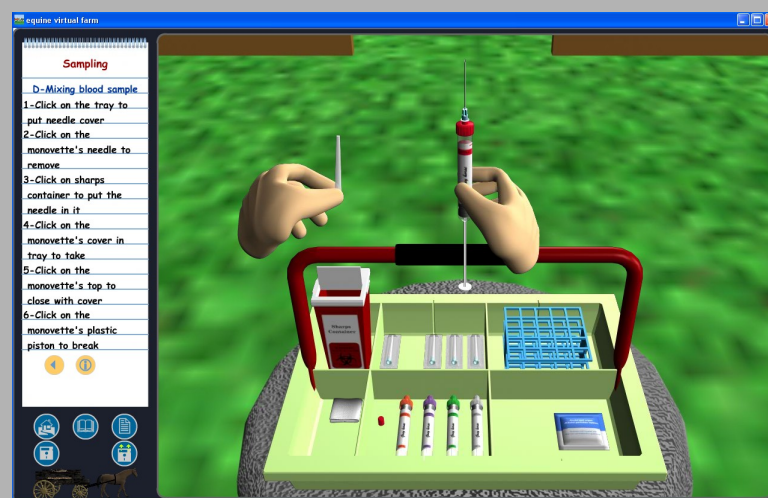
**Fig 7a**



**Fig 7b**



**Fig 7c**

**Fig 7d :** Screen shots of EVF showing laboratory manual book**.**
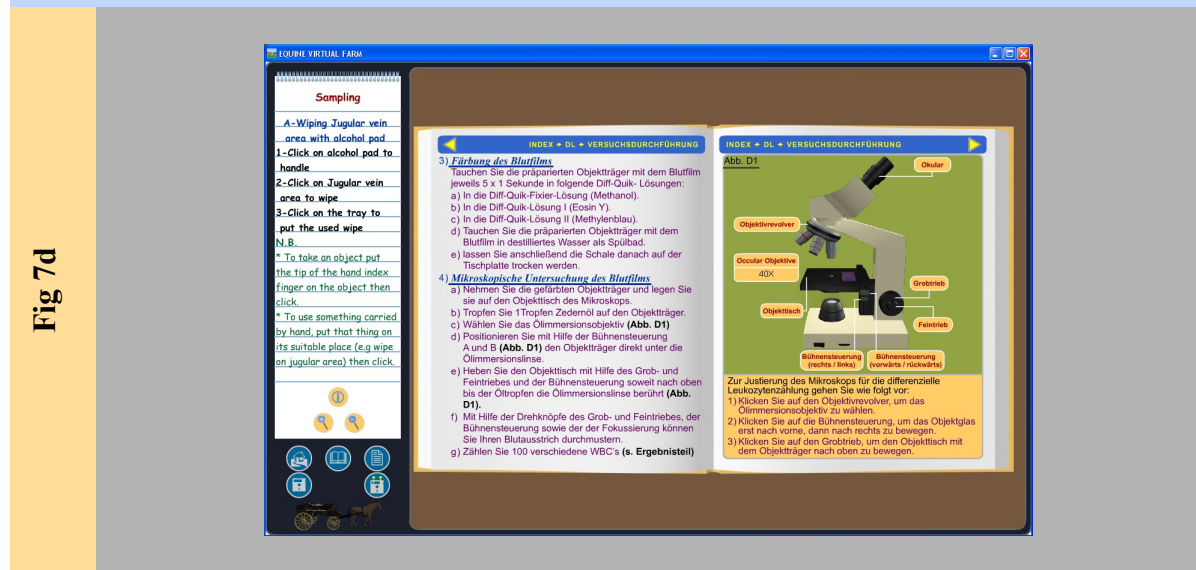
The final part of EVF on-farm scenarios is the virtual farm office **(Fig 8a-d),** in which students are allowed for periods of self-learning, reflection and planning. In the virtual office, students can read the interactive 3D-animated cerebellum and balance book as an aiding diagnostic resource by clicking either on the office book or the book button. Moreover, internet links (Physiology text books and scientific journals links) regarding each case condition, as extra diagnostic resources, can be accessed by clicking on either the office laptop or the laptop button. After reviewing all the aiding diagnostic resources, the students are asked to reflect their experiences in all the virtual environments and plan the appropriate management or treatment for each case condition into their virtual farm final reports, which are all accessed via the report button.

**Fig 8a-c :** Screen shots of EVF showing EVF office **(Fig 8a)**, office reports **(Fig 8b)** and cerebellum and balance book **(Fig 8c)**
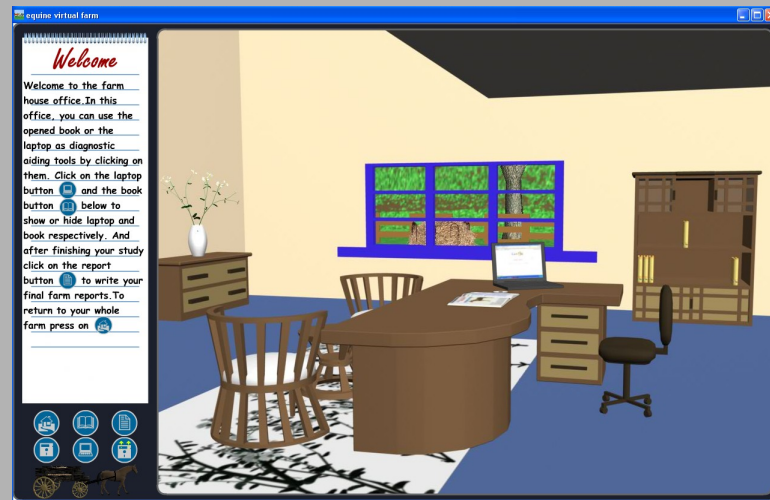
**Fig 8a**



**Fig 8b**



**Fig 8c**

**Fig 8d :** Screen shots of EVF showing EVF office laptop internet links **(Fig 8d)**
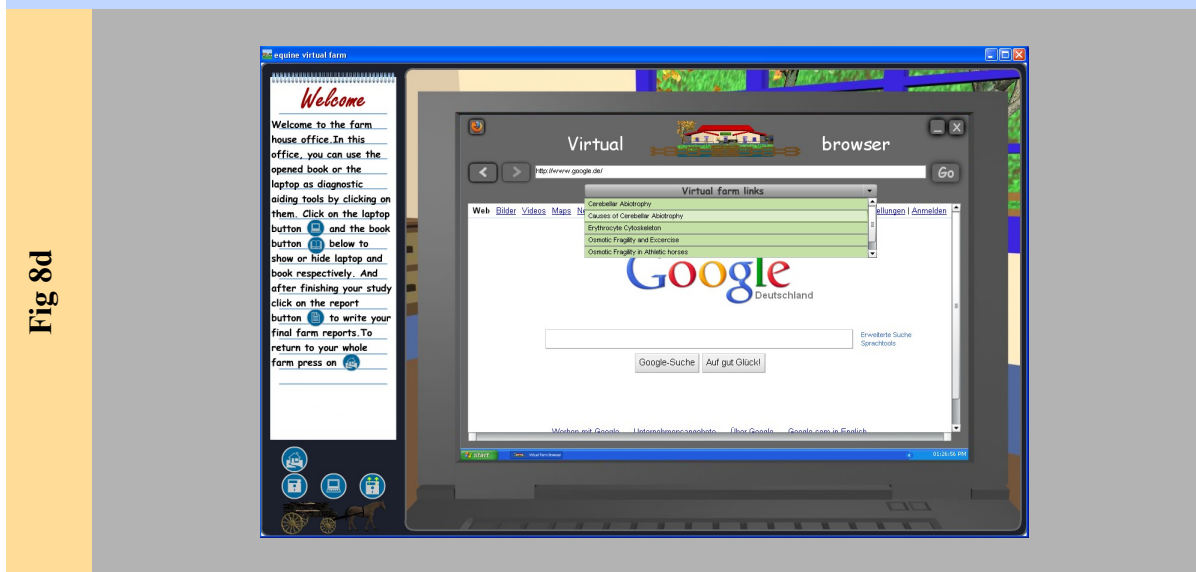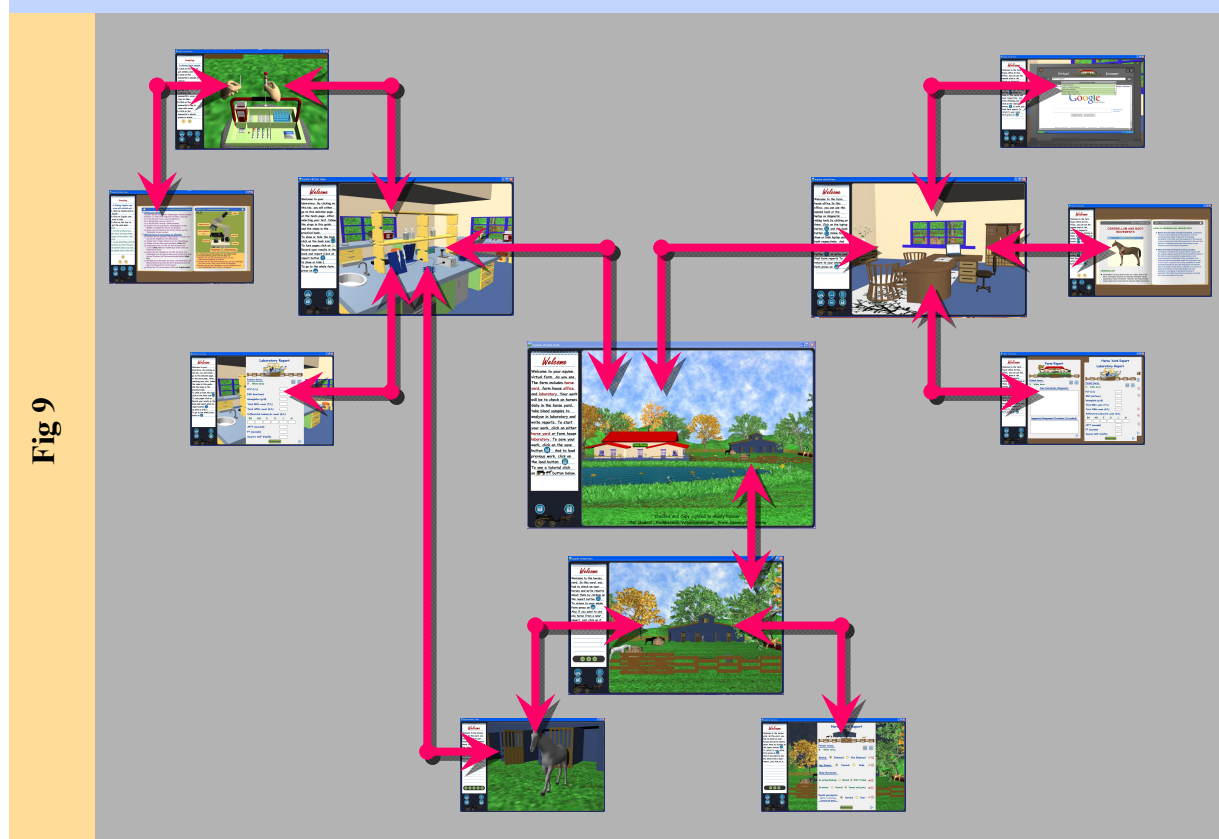


**Fig 9:** EVF navigation map showing EVF whole educational potentialities **(Fig 5-8)**



30

# C. <u>Equine virtual farm evaluation</u>

On introducing new learning environment, it is important to explore whether it meets the students learning styles (needs) or not, whether it is as good as the existing learning environments or not and if it is good, what is missing and how an ideal environment could be achieved.

To address these goals, 3<sup>rd</sup> and 4<sup>th</sup> semester students enrolled in the bachelor of veterinary medicine at the Free University of Berlin were asked to participate in the following:

## 1) <u>Students learning styles survey</u>

The German version of the Visual, Auditory, Read/Write, Kinaesthetic (VARK) questionnaire (http://www.vark-learn.com/documents/german.pdf) was administered at the beginning of the 3<sup>rd</sup> semester to determine students learning preferences. 87 students completed the questionnaires and each learning style was represented graphically as percentage of total. As a result, participants were classified mainly into Visual, Auditory, Read/Write and Kinaesthetic students.

## 2) <u>EVF laboratory versus Bb practical course students' evaluation tutorial (Fig 10)</u>

**Students**

A total of 24 students, out of the 87 participated in learning styles survey, were assigned into two groups; Group A (N=12) and Group B (N=12). Each included Visual (V; N=3), Auditory (A; N=2), Read/Write (R; N=2) and Kinaesthetic (K; N=5) students styles.

**Learning facilities and resources**

Because students' time table was full, PC-pool and veterinary physiology laboratory were scheduled for the trial in the students' free time and two laboratory experiments were only depicted.

Accordingly, participants were allowed to attend freely, among other students, the 3<sup>rd</sup> and 4<sup>th</sup> semester traditional lectures, and to access the relevant Blackboard (Bb) online lecture notes that covered the general physiological concepts and mechanisms regarding animals' bodies and organs functions. However, they were told not to access Bb online practical notes for learning the procedures or the theoretical backgrounds of the two laboratory experiments (i.e. Osmotic fragility test and Differential white blood

cells count), which they will access later in their tutorial self-learning sessions (see tutorial design below).

During the tutorial's Bb self-learning session (see tutorial design below), participants learned osmotic fragility test and differential white blood cells count through their online access to the veterinary physiology practical learning materials, which included notes, PowerPoint presentations and videos. However, during its EVF self-learning session (see tutorial design below), participants practiced these tests procedures in EVF laboratory through interacting with virtual laboratory equipments while reading the integrated interactive virtual laboratory manual.

## Tutorial design

Each group undertakes two 3-hours sessions, including 60-minutes self-learning session in computer laboratory (PC-pool), followed by 30-minutes surface- and deep-learning assessment, 30-minutes break and then 60-minutes laboratory practical session in veterinary physiology institute laboratory.

The first session involved 60-minutes self-learning of either osmotic fragility test or differential white blood cells count, using either EVF laboratory (in Group A; **Fig 10**) or Bb practical course (Group B; **Fig 10**) followed by 30-minutes surface- and deep- learning assessment questionnaire including an essay memory question (maximum score of 8 points) for recalling the test procedures, multiple choice understanding (maximum score of 10 points) and problem-based (maximum score of 4 points) questions**.** Then, after 30-minutes break, students were moved to the laboratory to practice what they have already learnt during the self-learning session and assessment questionnaires **(APPENDIX A, B)** were collected, thereafter.

During the second session, students' participation was reversed. Those EVF participants that learned one test using EVF laboratory were directed to learn the other one using Bb practical course and vice versa. Afterwards, participants were involved in learning assessment and laboratory practice, the same as in the first session.

After both sessions were completed, all participants were given an evaluation questionnaire **(APPENDIX C)** to evaluate both learning environments regarding learning outcomes and impediments, motivation and further modifications and developments.

## Scoring and statistical analysis

Participants scores from both groups (EVF and Bb) regarding each section of the assessment questionnaire, in addition to the total scores, were analyzed with the

non-parametric Mann-Whitney U test, using the statistical software package SPSS for windows (SPSS Inc., Chicago, IL, USA). *P-values $\leq 0.05$* were regarded significant, and *P-values $> 0.05$ and $\leq 0.1$* were regarded showing a tendency (**Glantz, 2005**).

Power analysis was conducted, afterwards, using G\*Power (http://www.psycho.uni-duesseldorf.de/abteilungen/aap/gpower3/) to validate the statistical tendencies and determine how many participants will be needed to detect a moderate effect at P-*value $\leq 0.05$ (Cohen, 1988).*

Further, a scoring system based on ECTS (European commission transfer and accumulation system) grading system (http://en.wikipedia.org/wiki/Grade_%28education%29) was developed for all participants scores **(Table 1)** and grades % per each style and per total were represented graphically as percentage of total.

**Table 1: ECTS grading system**

| Score % | Grade |
|---------|-------|
| 90-100 | **Excellent (Sehr gut)** |
| 80-90 | **Very Good (gut)** |
| 65-80 | **Good (Befriedigend)** |
| 50-65 | **Pass (Ausreichend)** |
| 0-50 | **Fail (Mangelhaft/Ungenügend)** |

**Fig 10 :** Students tutorial outline

**GroupA: EVF**

**1st organization**

| V1 | V2 | V3 | A4 | A5 | R6 | R7 | K8 | K9 | K10 | K11 | K12 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| O | O | D | O | O | D | D | O | D | O | D | O |

STUDYING EXPERIMENTS WITH EVF (60 min)

ASSESSMENT (30 min)

LABORATORY PRACTICE (60 min)

COLLECTING ASSESSMENT QUESTIONNAIRE

BREAK (30 min)

**Group B:Bb**

**1st organization**

| V13 | V14 | V15 | A16 | A17 | R18 | R19 | K20 | K21 | K22 | K23 | K24 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| O | O | O | O | D | D | D | O | O | O | D | D |

STUDYING EXPERIMENTS WITH Bb (60 min)

ASSESSMENT (30 min)

LABORATORY PRACTICE (60 min)

COLLECTING ASSESSMENT QUESTIONNAIRE

BREAK (30 min)

**Group A: Bb**

**2nd organization**

| V1 | V2 | V3 | A4 | A5 | R6 | R7 | K8 | K9 | K10 | K11 | K12 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| D | D | O | D | D | O | O | D | O | D | O | D |

STUDYING EXPERIMENTS WITH Bb (60 min)

ASSESSMENT (30 min)

LABORATORY PRACTICE (60 min)

EVALUATION (30 min)

COLLECTING BOTH ASSESSMENT & EVALUATION QUESTIONNAIRES

**Group B: EVF**

**2nd organization**

| V13 | V14 | V15 | A16 | A17 | R18 | R19 | K20 | K21 | K22 | K23 | K24 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| D | D | D | D | O | O | O | D | D | D | O | O |

STUDYING EXPERIMENTS WITH EVF (60 min)

ASSESSMENT (30 min)

LABORATORY PRACTICE (60 min)

EVALUATION (30 min)

COLLECTING BOTH ASSESSMENT & EVALUATION QUESTIONNAIRES

**V, A, R, K :** Students learning styles; **V** = Visual, **A** = Audio, **R** = Read/Write, **K** = Kinesthetic.

**1-24 :** Volunteers numbers.

**D, O :** Hematological laboratory test; **D** = Differential leuckocytic count, **O** = Osmotic fragility test

# RESULTS

## A. Students learning styles

**Fig 11** demonstrates the distribution of different learning styles among 3$^{rd}$ semester undergraduate veterinary students. 40% (35/87) showed a kinaesthetic preference (K), 23% (20/87) showed an audio preference (A), 13% (11/87) showed a visual preference (V), 13% (11/87) showed a read and write preference (R), and the remaining showed bimodal or multimodal preferences varying between VR (1%;1/87), VK (2%;2/87), AK (5%; 4/87), RK (2%;2/87) and ARK(1%;1/87).

**Fig 11: The distribution of different learning styles (%) among 3rd semester undergraduate veterinary students**
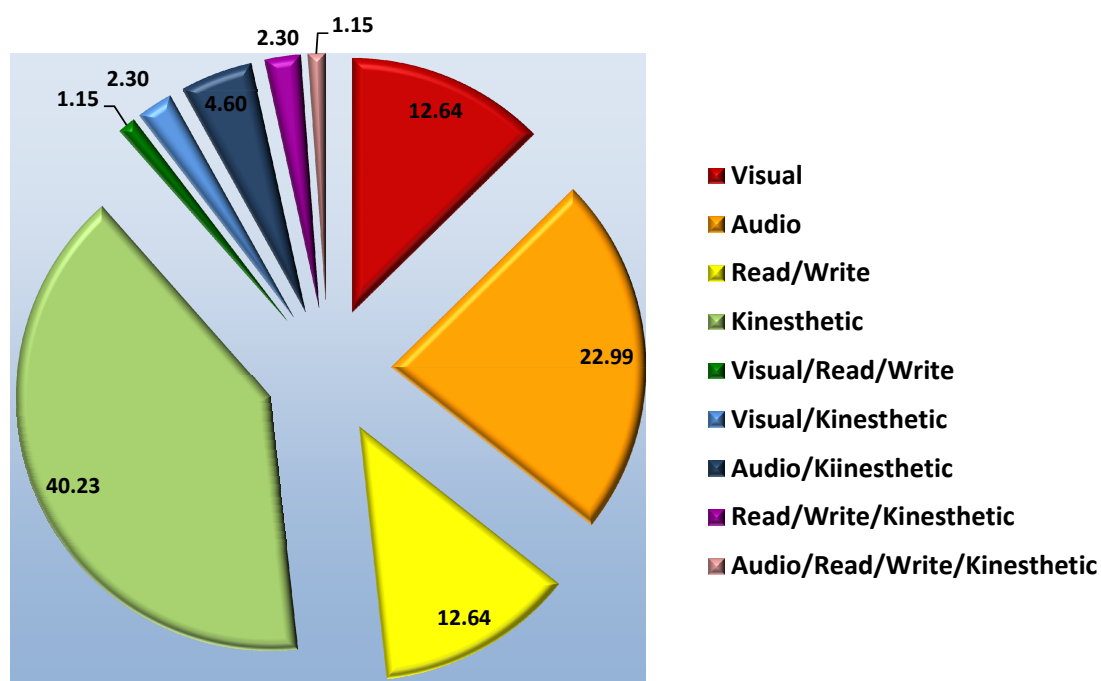
## B. <u>Learning outcomes of EVF versus Bb</u>

After learning osmotic fragility test or differential white blood cells count using either EVF or Bb learning environments and practicing them in laboratory, no significant difference was observed between both learning environments regarding memory essay question scores (*p-value = 0.61, power = 0.68*). However, participants in EVF group tend to achieve higher scores than those in Bb group in understanding *(p-value = 0.07, power = 0.38),* problem-based questions *(p-value = 0.06, power = 0.45),* and subsequently, their overall performances *(p-value = 0.13, power = 0.57)* tended to be higher (**Table 2).**

**Table 2: Students scores regarding recalling procedures, understanding and critical thinking in both EVF and Bb learning assessment questionnaires.**

| Learning outcome | Program | Scores | | | p-value[1] | Power[2] (1-β[3]) | Sample size[4] |
|---|---|---|---|---|---|---|---|
| | | Range | Mean | Median | | | |
| **Recalling procedures (Memory question)** | EVF | 1-8 | 5.04 | 5.00 | 0.61 | 0.68 (β=0.32) | 429 |
| | Bb | 2-7 | 4.71 | 5.00 | | | |
| **Understanding (Understanding questions)** | EVF | 1-10 | 6.79 | 7.50 | 0.07* | 0.38 (β=0.62) | 80 |
| | Bb | 1-9 | 5.75 | 6.00 | | | |
| **Critical thinking (Problem-based questions)** | EVF | 1-4 | 2.29 | 2.00 | 0.06* | 0.45 (β=0.55) | 60 |
| | Bb | 1-4 | 1.83 | 2.00 | | | |
| **All** | EVF | 7-21 | 14.13 | 14.00 | 0.13 | 0.57 (β=0.43) | 65 |
| | Bb | 4-17 | 12.29 | 12.00 | | | |

[1] *p-value was determined by Mann-Whitney U test.*
[2]*Power = The strength of the statistical test in detecting significance when it actually occurs.*
[3]*β = The probability of not rejecting the null hypothesis when the null hypothesis is false (i.e. the probability of incorrect rejection of significance).*
[4]*Sample size (Students number) required to reflect significance at p ≤ 0.05, Power = 0.8 and β = 0.2.*
*Marginal Significance (Tendency).*

# C. <u>Different students' styles performances in EVF versus Bb</u>

Different students' styles performances in both learning environments are shown in **Fig 12-15. Fig 12** demonstrates that in EVF more than 80% of the points available on the memory question ("very good", "excellent" grades) were achieved by 25 % (versus 0% in Bb) of audio and 40 % (versus 10% in Bb) of kinaesthetic participants. However, 25% (versus 0% in Bb) of read and write participants failed to recall more than 50% of experiments procedures.



Fig 12 : Differenent students styles performances regarding memory question in Blackboard (Bb) and Equine Virtual Farm (EVF)
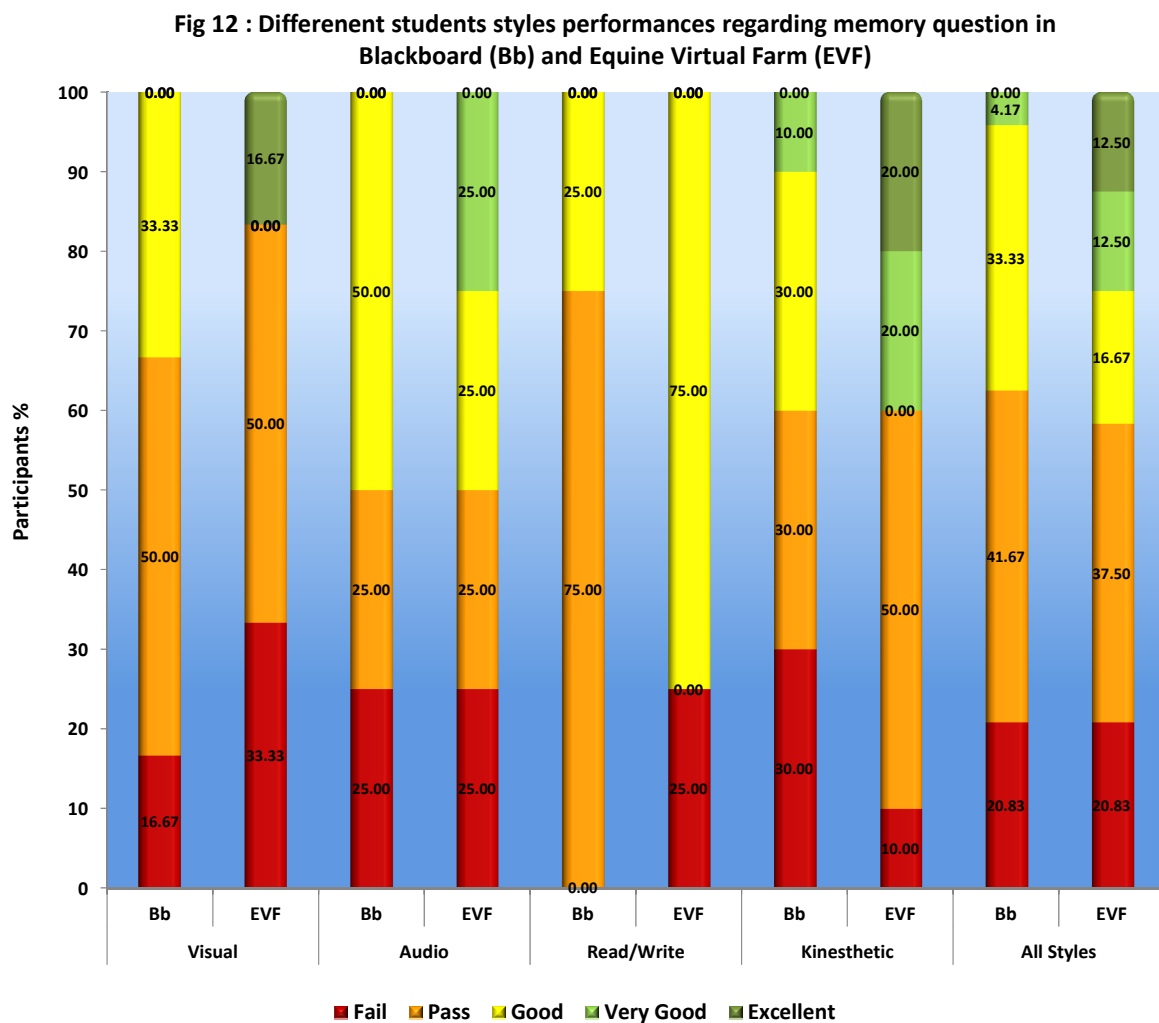
Similar trend in EVF was observed in **Fig 13**, in which 50% (versus 0% in Bb) of audio and 60% (versus 40% in Bb) of kinaesthetic students were shown to achieve the highest grades ("very good", "excellent") in understanding questions. In addition, 40% of Bb kinaesthetic students (versus 10% in EVF) failed to understand more that 50% of experiments procedures. Moreover and on the contrary to memory scores, 75% of read and write EVF students performed better in understanding questions than read and write Bb students (50%).
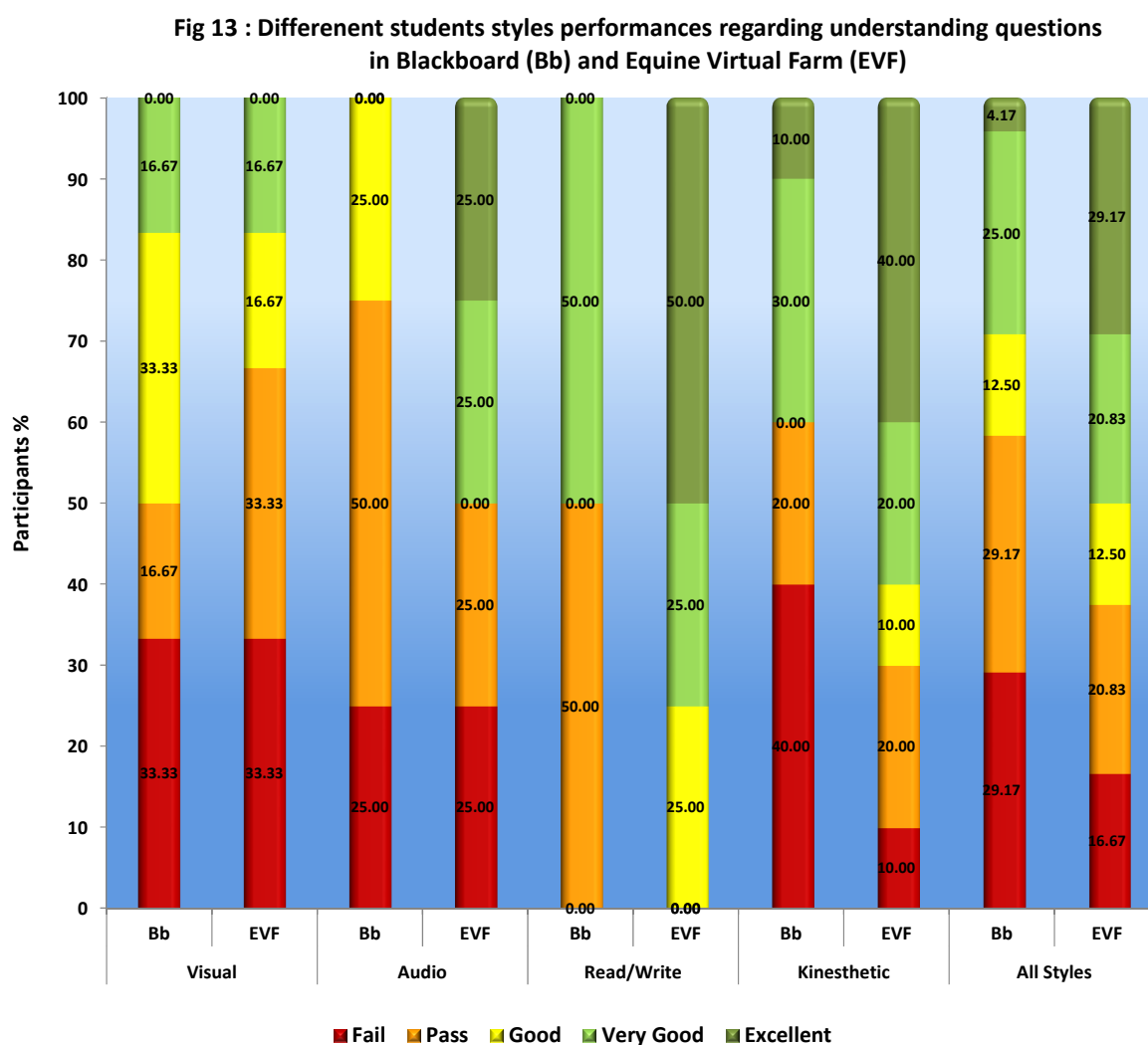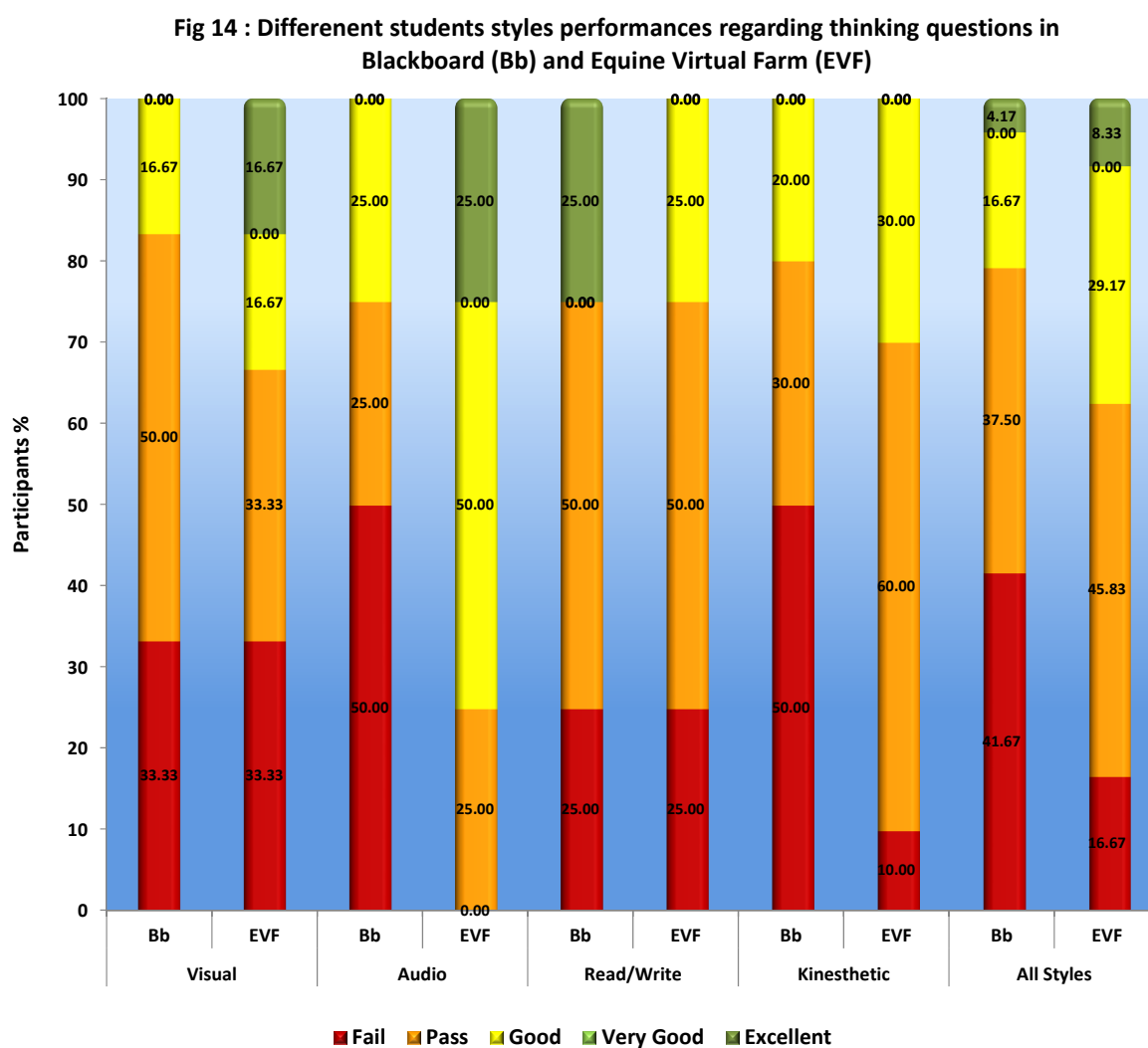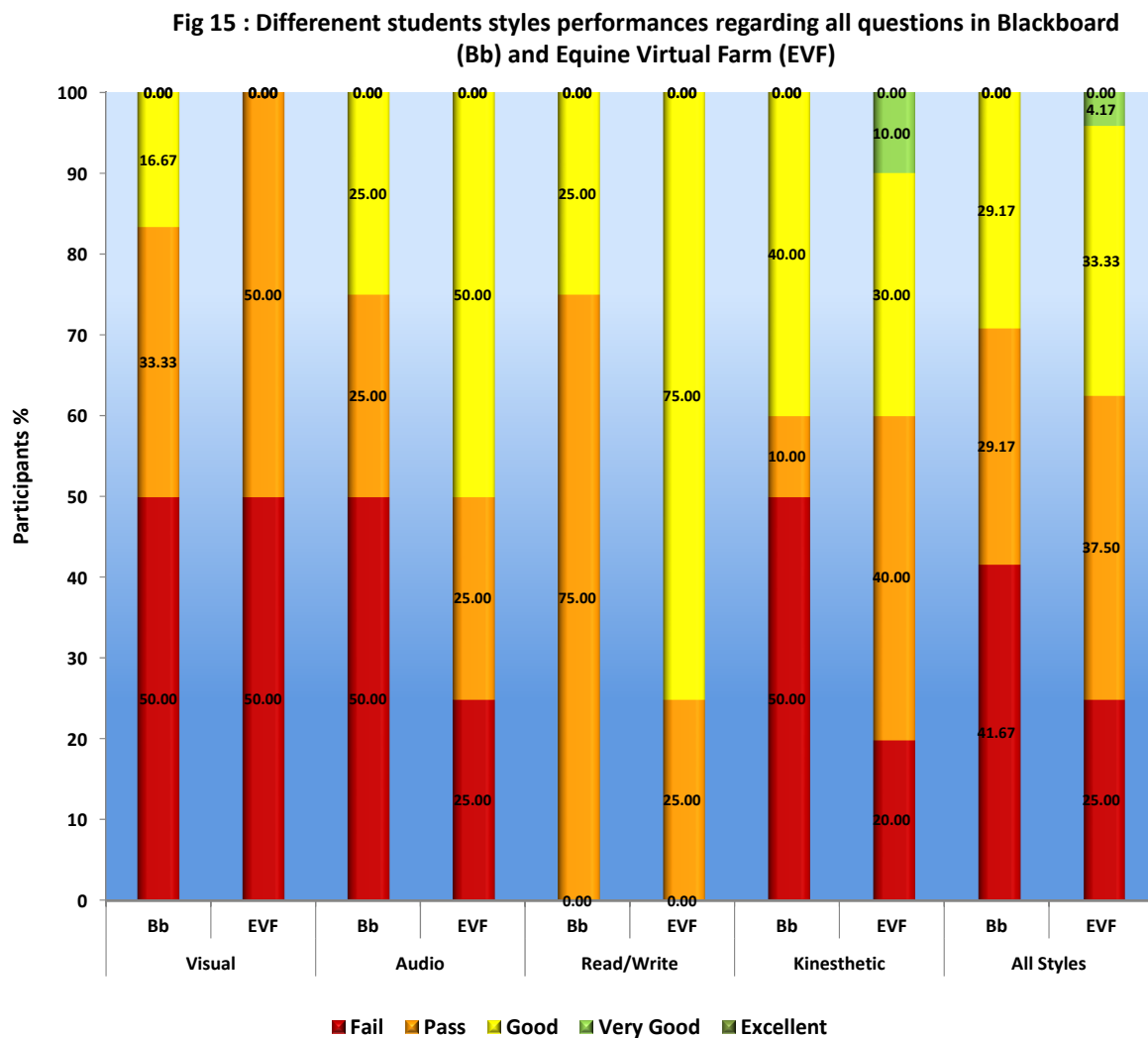
Fig 13 : Differenet students styles performances regarding understanding questions in Blackboard (Bb) and Equine Virtual Farm (EVF)

**Fig 14** reflects students' abilities to apply their gained knowledge and practical experiences from both lectures and tutorial to solve problems. Most of the styles seem to achieve similar passing grades % in both learning environments with 25% of audio EVF students and 25% of read and write Bb students earning more than 80% of the points available on problem-based questions. However, it is interesting to note that in Bb, 50% (versus 0% in EVF) of audio and 50% (versus 10% in EVF) of kinaesthetic participants failed to solve more than 50% of the problem-based questions.

Fig 14 : Differennt students styles performances regarding thinking questions in Blackboard (Bb) and Equine Virtual Farm (EVF)

On comparing the overall scores of each student style against both learning environments, **Fig 15** demonstrates that "good" was the most common highest grade achieved by all styles in both environment and "fail" grade % seems to decrease in EVF participants along all styles except for the visual style, which showed nearly constant performance in both learning environments along all Figures **(Fig 12-15).**



Fig 15 : Differenent students styles performances regarding all questions in Blackboard (Bb) and Equine Virtual Farm (EVF)

# D. Students' practical performance in laboratory

From students' laboratory data, both learning environments participants perform similarly in practical sessions regarding both osmotic fragility test and differential white blood cells count.

# E. Students' evaluation and comments

Students' evaluation questionnaire responses regarding learning needs satisfaction, the need for practical session and motivation are shown in **Fig 16-18.**

When students were asked to rate their learning needs satisfaction in both environments on a 5-point scale (1 = I didn't learn anything, 5 = I learned a lot), 70.83% (17/24) of participants rated Bb from 1-3 while 66.67% (16/24) rated EVF from 4-5 **(Fig 16)**.

**Fig 16 : Students learning satisfaction rating regarding  Blackboard (Bb) and Equine Virtual Farm (EVF)**
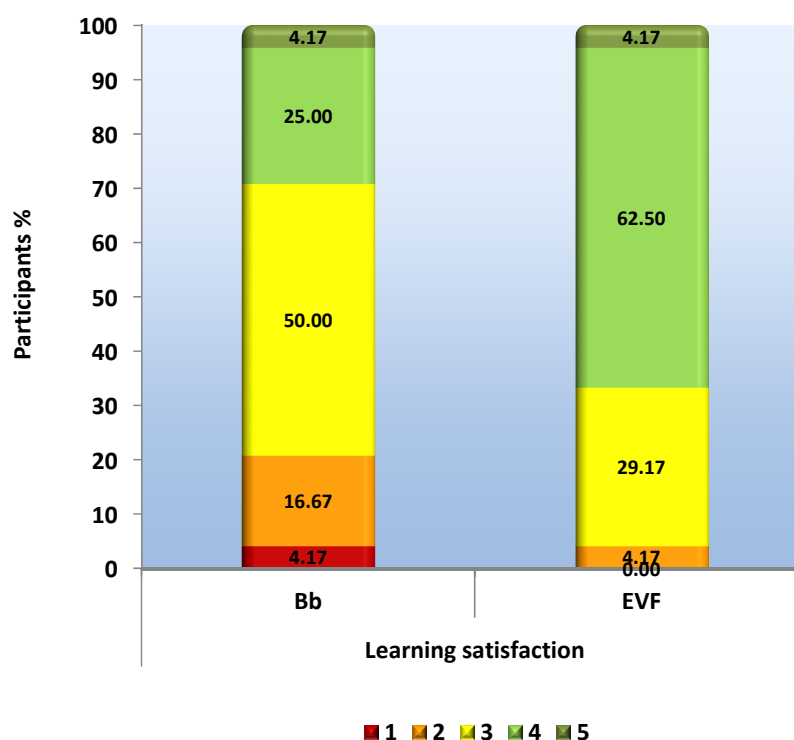
Regarding the need for practical session (**Fig 17**), most of the participants agreed that practical session confirmed EVF and Bb knowledge. However, 91.67% (22/24) and 45.83% (11/24) of the participants agreed that practical session added knowledge to Bb and EVF, respectively, indicating in some of their answers to *"Did practicing the experiments in the laboratory add more knowledge to what you have already learned by blackboard course?"* **(C1-C3)** and to *"Did practicing the experiments in the laboratory add more knowledge to what you have already learned by the virtual farm?"* **(C4-C5)** the following comments:

- *„Ja, im Labor sieht man die Ergebnisse, was man in Blackboard nicht sehen kann.* " (C1)

- *„Laborassistent hat noch andere Methode zur Bestimmung der max. Resistenz erklärt (wenn keine korpuskulären Bestandteile mehr zu sehen sind).* " (C2)

- *„Ja, aber ich fand das Identifizieren der unterschiedlichen Blutzellen nach wie vor schwierig"* (C3)

- *„Praktische Durchführung finde ich wichtig, aber in Virtual Farm konnte man genau das Gleiche üben."*(C4)

- *„Nein, alles was in Virtual Farm gezeigt wurde, war auch im Praktikum"*(C5)

**Fig 17 : Students evaluation regarding the need for practical session in Blackboard (Bb) and Equine Virtual Farm (EVF)**
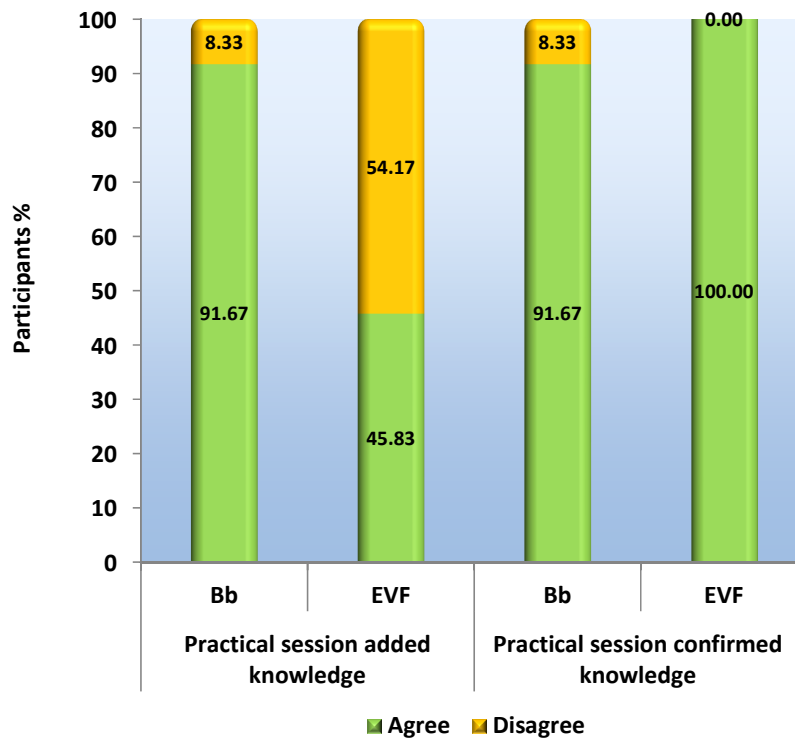


While comments were both positive and negative **(C6-C14)**, most of participants were pleased with EVF and when asked to state which learning environment is motivating, 95.83% (23/24) regarded EVF as the motivating environment for learning **(Fig 18).**

- *„Virtual Farm hat mehr Spaß gemacht, teilweise gab es aber zu wenig Erklärungen zu den klinischen Aspekten (Neutrophilie…..)"* (C6; Student comment on EVF)

- *„Sehr gut und genau wie Praktikumsdurchführung"* (C7; Student comment on EVF)

- *„Die virtuelle Farm macht Spaß beim Arbeiten, könnte auch gerne unser Blackboard bereichern, allerdings kann es in meinen Augen den praktischen Versuch nicht ersetzen"* (C8; Student comment on EVF)

- *„Das Lernen mit dem Blackboard ist im Vergleich zur virtuellen Farm sehr theoretisch (trochen)"* (C9; Student comment on Bb)

- *„Es war leider zu unruhig und eine Einführung wäre gut gewesen. Aber das eigene Erarbeiten hat mir gut gefallen. Versuchsablauf wird sehr gut klar!"* (C10; Student comment on EVF)

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- *„Es bleibt nicht so viel hängen, da es nicht selber erarbeitet war. Das Skript fand ich nicht so gut, aber die Lerneinheit. Der Versuchsablauf wird hier nicht so klar"* (C11; Student comment on Bb)

- *„Die Stimmung war zu hektisch. Ging zu schnell um wirklich die Theorie gut durchlesen zu können. Der Versuch ist sehr einprägsam! → Super! "*(C12; Student comment on EVF)

- *„Die Mediathek war super. Die Versuchsbeschreibung etwas schlechter (Abfolge war nicht so klar & einprägsam, wie im Virtual Farm!"* (C13; Student comment on Bb)

- *„Virtual Farm hat Spaß viel gemacht, ist aber auch ein großer Zeitaufwand (z.B. für des Blutabnehmen, was ja nicht essentiell für der Versuch ist)"* (C14; Student comment on EVF)

**Fig 18 : The distribution of motivation (%) among Blackboard (Bb) and Equine Virtual Farm (EVF)**



4.17

95.83

■ EVF  ■ Bb
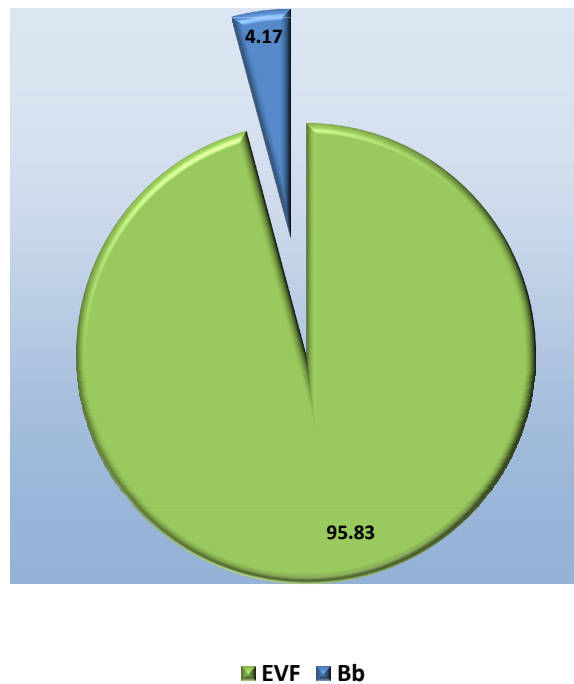
# F. <u>Students' recommendations for improvement</u>

Although most of the participants were motivated with EVF, additional features were suggested to improve both EVF and Bb **(C15-C20)**. Regarding EVF, many students expressed their needs for a short introduction describing how to use the program **(C15)**, a saving possibility between experiment steps to avoid starting from scratch **(C16**) and theoretical background for relevant clinical aspects **(C17)**. On the other hand, in blackboard, all the students highlighted the integration of more pictures, animations and videos **(C18-C19)**. In addition, some students further suggested creating a link between blackboard and virtual farm **(C20)**.

- *„Mehr Zeit. Verknüpfungen, während man etwas macht. Kurze Erklärung zur Benutzung des Programms wäre toll. "*(C15)
- *„Zwischensichern des Ergebnisses & des Versuches, damit nicht bei einem falschen Zwischenschritt der Versuch von vorn begonnen werden muss. "* (C16)
- *„Die Erklärungen den Krankheiten waren nicht zugänglich. "*(C17)
- *„Mehr Bilder & Animationen zum Verdeutlichen des Praktikums/ Versuchsvorganges. "* (C18)
- *„Virtuell den Versuch nachahmen. Videos sind schon eine sehr gute Hilfe!!!"* (C19)
- *„Eine Verknüpfung zw. Virtual Farm und Blackboard wäre toll, so haben wir schon mal ein Bild vom Versuch und können ihn noch mal machen, wenn wir etwas vergessen haben (z.B vor dem Physikum)"* (C20)

# DISCUSSION

The present study proposed and tried a new contextualized virtual environment (EVF) in veterinary physiology education as an approach to bridge basic-clinical science gap through promoting the in-depth learning of veterinary physiology. To meet such educational goal, EVF design focused on:

## A. Increasing students' motivation while learning veterinary physiology

From students' evaluation results, it was clearly demonstrated that the majority of students (95.8 %) were motivated by EVF rather than Bb **(Fig 18)**. A possible explanation was suggested by **Cavalieri, (2009c)** who reported that setting knowledge, skills and attitudes within the context of how they are applied in veterinary medicine may provide a degree of emotional appeal to students and encourage motivation. In addition, using Three-dimensional computer generated imagery (3-D CGI) tools to build EVF world, and which was used to construct and animate virtual worlds on screen primarily for film, television and video games to appeal mass audience **(McGhee, 2010)**, might contribute to students motivation regarding EVF. On the other side, rigorous training in foundational science without a connection to application, as in case of Bb, was found to result in dwindling of initial enthusiasm and motivation early in a course, together with concerns about relevance and doubt as to whether the student actually to pursue a career in veterinary science **(Lane, 2008).**

Moreover, research has shown that students' motivation and performance improves when the instruction is adapted to student learning styles or the ways they prefer to receive information **(Miller, 2001)**. In agreement, while statistical analysis showed no significant differences between the performance of students, in EVF versus Bb, regarding recalling experiment procedures (*p-value = 0.61, power = 0.68*), EVF participants tend to show better performance in understanding *(p-value = 0.07, power = 0.38)* and problem-based questions *(p-value = 0.06, power = 0.45)*, specially, the kinaesthetic and the audio styles, who were the most predominant styles among 3rd semester undergraduate veterinary students **(Table 2; Fig 13; Fig 14).** Such finding, in addition to the high motivation observed, might further suggest that the implemented interactive form of EVF seemed to meet the different students learning preferences through promoting active participation **(C10)**, satisfaction and enjoyment **(C6; C8)** and hence their retention of

factual knowledge **(Elsheikha and Kendall, 2009).** In consistent, **Cavalieri, (2009c)** reported that veterinary students tend to respond favourably to activities that involve interaction with animals and hands-on application of veterinary skills.

However, it is possible that the predominance of kinaesthetic styles among participants may have contributed to these favourable results observed regarding EVF, especially, if the higher performance of kinaesthetic and audio styles shown within EVF was considered **(Fig 12-14).** This possibility makes one wonder whether EVF could achieve the same findings in Nottingham UK veterinary school, where **Foster et al., (2010**) reported the predominance of multimodal (58.6%; they preferred all learning styles) rather than kinaesthetic (11.8%) or auditory (6.4%) style among 1st year veterinary students. Nevertheless, the higher performance observed nearly among all styles within EVF implied that although EVF promoted active participation, which was preferred by the kinaesthetic style mostly, and Bb biased read and write style **(Fig 12),** the motivation and the various learning activities embedded within EVF might contributed to all styles better performance **(Fig 18, Fig 15)**. Consistently, on exploring how student motivation, attitude, and learning styles influenced achievement in web-based courses, **Shih and Gamon (2001)** concluded that motivation was the only significant factor in web-based learning for more than one fourth of student achievement. Moreover, **Brown (2003)** suggested that educators should design a curriculum that expose the learners to various learning activities in order to develop the learning competencies necessary to cope with situations involving a range of learning requirements, indicating that there are benefits to matching teaching and learning styles, but there are no guarantees to greater learning achievements.

Yet, it should be kept in mind that the small number of students learning styles, the implementation of questionnaires without the assessment of their validity (i.e. Does the questionnaire measure whatever it is supposed to measure?) or reliability (i.e. Was their questions language appropriate and understandable?) **(Hecker and Violato, 2009),** and the non employment of EVF full educational potentialities (e.g. horse yard clinical problems) limited the power of the present study (**Table 2**) in providing reliable results and in exploring students' styles performance and attitudes statistically regarding each learning environment, instead of representing them graphically.

## B. <u>Boosting the accurate and the deep understanding of complex physiological mechanisms</u>

An advantage of increasing student motivation includes improved learning outcomes by enhancing deeper learning **(Dahle et al., 2002)**.

Accordingly, it seems that students motivation within the employed form of EVF contributed to their better performance in understanding questions **(Fig 13)**, however, while their performance in problem-based questions was not as good as in understanding questions, students abilities to solve problem were better in EVF when compared to Bb **(Fig 14)**. This was surprising, because problem-based questions relied on recalling and applying the theoretical knowledge gained from passive classroom lectures rather than from the tested learning environments. It is possible that EVF might have facilitated the acquisition of some basic physiological concepts that students applied in solving problems without the need for recalling lecture knowledge, especially through EVF laboratory manual interactive quizzes that questioned theoretical concepts, and which students might attempt to solve by trial and error till they figured out the correct answers. However, it seems that this was not enough, in fact, it made students figure out physiology curriculum limitation and further recommend, regarding further improvements, the implementation of theoretical background and clinical aspects in EVF **(C17),** and which further implied the superficial learning achieved by traditional packed lectures and the need for relevant theoretical physiological concepts in physiology curriculum.

**Azila et al., (2001)** indicated that downsizing the increasing amount of medical information and research, requires the resourcefulness, collaboration and creativity of the staff from a variety of disciplines to select the topics that are relevant and decide how they can be integrated. Moreover, as advances in scientific techniques provide deeper insight in the complexities of physiological concepts (e.g. cell signalling), it is vital that the media we use to teach veterinary students evolve similar **(Buchanan et al., 2005).**

Accordingly, realistic 3D animations were integrated in EVF laboratory book (manual) and further in EVF office book "Cerebellum and Balance" **(Fig 8c)** as an approach to facilitate the deep understanding of osmotic fragility test principle and how complex underlying cerebellar and cerebral neuronal pathways maintain coordinated and balanced body movements, respectively.

One can ask why implementing 3D animations and pictures, while 2D pictures and videos can serve this aspect in text books and lectures? The answer is because videos and 2D pictures can't see through organs and cells and demonstrate, further, the sequences of

different underlying complex physiological mechanisms that occur spontaneously in fractions of millisecond and their contributions to the overall normal and abnormal physiological function and hence, relevance. Another advantage is that employing 3D pictures and animations can substitute a lot of text that pack most of physiology text books to describe the anatomical structure and the spatial relationships, and further can achieve a seemingly precise and scientifically accurate visualisation **(McGhee, 2010)** of physiological mechanisms as a prerequisite for deep learning. Thus, 3D pictures and animations seem vital to be employed in simplifying, downsizing and relating the complex and the immense proportions of basic knowledge that students spend inordinate amount of time trying to imagine and understand and disparately memorize. And consequently, this technology reduces the cognitive overload that occurs when students are asked to comprehend difficult material (troublesome knowledge) and at the same time convert the information given into three-dimensional representation in their imagination **(Buchanan et al., 2005),** and hence enables them to recall facts and understand deeply principles as a cognitive foundation for more complex modes of thinking **(Dale et al., 2008).** Consistently, on testing the effectiveness of 3D animations in learning intracellular processes, **Buchanan et al., (2005)** found that veterinary students taught using traditional media (e.g., figures, flowcharts) are proficient in memorizing the names and the order of intracellular molecules but unable to appreciate the interactions between these elements or their spatial relationships within cells. In contrast, more than 90% of veterinary students taught using 3D animations, in their study, not only recall the facts about the intracellular elements but also develop accurate mental images of the interactions among these molecules and their spatial relationships.

Furthermore, on the level of communication, **McGhee, (2010)** implied the need for creating 3D images out of clinical data (e.g. Magnetic Resonance Images; MRI) that describe the inner body in more accessible and holistic way to engage patients, improve their understanding of disease, recall and adherence to treatment. Such implication if applied in veterinary education, could also promote communicative skills that can be effective in communicating with animals owners in veterinarians future profession.

## C. Encouraging the application of physiological concepts and the mastery of laboratory skills

The most identifiable factor in distinguishing the level of professional performance and the mastery in practical field, is the amount of intense, repetitive performance, of intended cognitive and psychomotor skills, within a focused domain; "deliberate practice" **(Ericsson, 2004).**

Simulations such as high-fidelity (virtual reality ) simulations (e.g. Haptic cow simulator **(Baillie et al., 2010)** or low-fidelity (screen-based) simulations (e.g. Virtual ventilator **(Keegan et al., 2009)** offer the ideal opportunity for students to practice repeatedly clinical data collections and previous laboratories, at any time, in a safe, relatively stress-free environment without the lengthy preparation for the laboratory and putting the animal or the equipment at risk **(Hart et al., 2005)**.Used systematically, such practice can lead to expertise, especially if sustained until learners reach a desired level of skill **(Kneebone and Baillie, 2008).**

Consequently, designing and integrating the virtual laboratory (screen-based simulation) within EVF attempted not only to allow novices to carry out clinical and laboratory procedures deliberately, but to integrate them within the on-farm clinical scenarios context, aiming for knowledge and skills mastery. However, it is acceptable that it is not a substitute for the actual clinical experience, as it is agreed that the ideal setting for clinical education remains the actual clinical environment, but unfortunately, the ideal is not always practical **(Okuda et al., 2009).** In consistent, although EVF laboratory aimed to imitate the real laboratory as close as possible, 46% of EVF participants **(Fig 17)** indicated in some of their comments **(C4)** that the real laboratory practice is essential for gaining some practical experiences (e.g. handling of pipettes and microscope " Umgang mit pipette und Mikroscope") that can't be gained virtually. On the other hand, almost all Bb participants commented that real laboratory added both knowledge and practical experiences, which implied the deficiency of Bb in practical knowledge **(C2; C13).**

In retrospect, the students' tutorial could have been improved if real laboratory practice time was limited and if video tapes were recorded in laboratory for comparing the performance of EVF and Bb participants.

From over viewing literature regarding the effectiveness and the exactness of high-fidelity (virtual reality) simulations in replicating real environment, one can assume that high-fidelity simulations are better than low-fidelity (screen-based) ones, however it seems that this is not the case. On introducing Bovine Rectal Palpation simulator (Haptic

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cow) **(Fig 2b)** into undergraduate veterinary curriculum, as a virtual reality-based teaching tool, either in isolation **(Baillie et al. 2005)** or within on-farm scenarios context **(Baillie et al., 2010)**, veterinary students commented that it was very useful in enhancing their skills in rectal examination, building confidence and promoting communication and decision making skills, however, they indicated that it is still different from the real environment ("no faeces and no contractions") and recommended the need for exploring on their own without being directed by the instructor at all times. Moreover, while high-fidelity simulations do a remarkable job of duplicating, in detail, patients, they require computer, patient manikin, room and apparatus to emulate environment which make them significantly more costly when compared to simulations of lower fidelity (screen-based simulation). Unlike high-fidelity, screen-based simulations may avoid the expenses, because they are totally software-based and require only a desktop or laptop to operate, and further avoid time inflexibility of the manikin-based high-fidelity simulation as they can be accessed at a variety of locations and times, while emulating a real-world event and provide immediate feed back **(Keegan et al., 2009).** These advantages may add more benefits to EVF if one thinks to compare it with similar virtual reality environments, putting into consideration that both can't substitute real environments. Consistently, although **Baillie et al., (2010)** used high-fidelity computer simulation in simulating fertility, they reconsidered using low-fidelity; cheaper simulation in creating further contextualized simulations for other species and clinical scenarios.

## D. Stimulating students' reflection, critical thinking and self-learning.

While students are internally motivated by their strong desire to become veterinarians, they are prevented from undertaking self-learning approach due to the heavy workload associated with their passive crowded curriculum that make little use of external resources (e.g., peer-reviewed journal articles) and facilitates memorizing information given by the instructors, often in the form of class notes **(Parkinson and St George, 2003; Forrester, 2005)**. If veterinarians are needed to solve complex problems that rely on a broad knowledge base, they will require a higher level of cognitive function than factual recall **(Cavalieri, 2009a).** Health, who was among the first to emphasize the importance of adult learning (self-learning) theory in relation to veterinary education, illustrated that the increasing of complex cognitive processes achieved ultimately through problem solving **(Health, 1977).** However, it is difficult to advocate the replacement of an

entire curriculum with a problem-based learning program, especially when students enter veterinary medicine directly from second-level schools that mostly adopt teacher-centered teaching systems, which encourage and reward learning though memorization rather than understanding **(Lane, 2008)**. Thus, facilitating the change from traditional learning environment into integrated form is needed in the first years of veterinary curriculum, which are considered the most stressful years.

Accordingly, implementing 3D-animation in EVF office books (e.g. "Cerebellum and Balance") aimed to facilitate the acquisition of basic relevant physiological concepts, leaving much time for students to search for and understand researches and journal articles that could aid them in solving the posed horse yard problems. Within EVF office **(Fig 8a-d)**, students can replay and return their EVF experiences and relate their old and new physiological knowledge to develop and refine their own understanding and apply it in solving EVF clinical problems. Therefore, EVF office aimed to offer students the environment where they can search and construct knowledge from a variety of sources, develop critical thinking skills through reflection (replaying and returning experiences) and problem-solving, and further promote their confidence and communication skills, while evaluating their EVF final reports with professors. These skills were known as the skills of lifelong learning that are essential for professional education **(Glicken, 2004).**

# CONCLUSION

Although its educational potentialities were not fully implemented in students tutorial, equine virtual farm (EVF) was well perceived by the students as a valuable motivating environment for learning veterinary physiology. Accordingly, there is a need to demonstrate the feasibility of integrating the contextualized form of EVF into physiology curriculum, and to evaluate its learning strategies on a larger number of students (minimum 65-80 students; **Table 2**), before recommending its wide spread to other clinical scenarios and species, especially, after the necessity for integrating clinical aspects had been highlighted in different students' styles feedbacks.

Furthermore, while the present contextualized form of EVF seems to propose a vital approach for bridging basic-clinical science gap, there will be an ongoing need to implement clinical cases, interactive 3D-based animated books and new diagnostic and laboratory techniques to make this learning experience, continuously, effective for undergraduate and postgraduate veterinary students. Consequently, a variety of resources, programmers and graphics designers must be continually available to update and enrich this learning experience with valuable and interactive materials. Undeniably, the set-up and production costs appear to be high, especially 3D modelling, but, once generated, virtual models may be stored and re-used in multiple projects, and hence, cost savings will be offered afterwards.

In conclusion, this research strongly recommends considering contextualized screen-based computer simulations in veterinary education as superior electronic resources for promoting the application and the in-depth learning of basic sciences within clinical and laboratory contexts.

# SUMMARY

Providing competent veterinarians who could solve complex problems that rely on a broad range of basic core knowledge is increasingly challenging, particularly if teaching and learning basic sciences are required to be set within a clinical context. Many of the challenges including the complexity of curricular content and practicing clinical skills in a risk free environment have been addressed using simulations. However, in most of these few veterinary simulations skills were learned in isolation either from clinical practice or from the basic science knowledge, whereas the real life practice requires the integration of both.

Therefore, the present study propose a contextualized screen-based computer simulation, the equine virtual farm (EVF), as an attempt to bridge basic-clinical science gap, through immersing students in a motivating virtual environment that reflects how problems are encountered in real life and how physiological knowledge and laboratory skills are integrated.

EVF was designed to include four virtual learning environments: **1) *Equine farm:*** in which the students are introduced to their different farm tasks as veterinarians through the virtual farm tutorial; **2) *Horses yard:*** where students can check on horses health conditions and write yard reports; **3) *Farm laboratory:*** in which students can analyse horses' blood samples and write laboratory reports; **4) *Farm office:*** where students can use further diagnostic learning resources, including interactive books and internet links, as an aiding tools for writing their final diagnostic reports concerning the farm horses.

To assess its effectiveness, 24 second-year undergraduate veterinary students, in Berlin Free University veterinary program, volunteered to try and evaluate EVF versus Blackboard (Bb) online course in learning two haematological laboratory experiments. Their learning styles were determined using Visual, Auditory, Read/Write, Kinaesthetic (VARK) questionnaire and their learning outcomes were assessed and evaluated using assessment and evaluation questionnaires, respectively. Assessment results' analysis with Mann-Whitney U test revealed no significant differences among volunteers scores regarding recalling experiment procedures in EVF versus Bb (*p-value = 0.61, Power = 0.68*). However, EVF participants tended to achieve higher scores than those in Bb group in the overall *(p-value = 0.13, Power = 0.57)*, understanding *(p-value = 0.07, Power = 0.38)* and problem-based assessment questions *(p-value = 0.06, Power = 0.45)*. Moreover, different students' styles feedbacks indicated that EVF had been more useful and motivating than Bb in learning and practicing laboratory skills and further provided information that helped in the further development of EVF, as a contextualized learning environment.

# ZUSAMMENFASSUNG

**Die virtuelle Pferdefarm: Eine neuartige interdisziplinäre Simulation einer Lernumgebung für das Studium der Veterinär-Physiologie im klinischen Kontext**

Die Ausbildung von kompetenten Tierärzten, die ausgestattet mit einem breitem Grundlagenwissen fähig sein sollen, Lösungen für komplexe Probleme zu entwickeln, stellt in zunehmendem Maß eine Herausforderung dar; insbesondere dann, wenn die Vermittlung und der Erwerb von Grundlagenwissen sich im klinischen Kontext vollziehen soll. Um einerseits der Komplexität des Lehr- und Lernstoffs gerecht zu werden, andererseits aber die Möglichkeit zu eröffnen, klinische Fertigkeiten in einer „risikofreien" Umgebung einzuüben, bediente man sich der Computer-Simulation. Allerdings wurden in den meisten dieser wenigen Veterinär-Simulationen entweder Grundlagenwissen oder klinische Fertigkeiten isoliert voneinander vermittelt. Die reale Praxis erfordert jedoch eine integrative Vermittlung beider Kompetenzen.

Die vorliegende Arbeit schlägt daher eine kontextualisierte interaktive Anwendung, in Form einer virtuellen Pferdefarm (Equine Virtual Farm; EVF) vor und unternimmt damit den Versuch, die Lücke zwischen dem Erwerb von Basiswissen und der Aneignung klinischer Fertigkeiten zu schließen. Damit wird den Studierenden die Möglichkeit eröffnet, sich in eine inspirierende virtuelle Welt zu begeben, die die Probleme, wie sie im wirklichen Leben vorkommen, abbildet und aufzeigt, wie physiologisches Faktenwissen bei der Interpretation von Laborbefunden genutzt wird, was sich wiederum positiv auf die Motivation zum Studium auswirkt.

Die EVF stellt vier virtuelle Lernumgebungen zur Verfügung: **1) Die Pferdefarm:** Hier werden die Studierenden mit unterschiedlichen Aufgaben von Tierärzten im Bereich der Landwirtschaft vertraut gemacht; **2) Der Pferdehof:** Hier überprüfen die Studierenden den Gesundheitszustand der Pferde. Anschließend werden die entsprechenden Berichte geschrieben; **3) Das der Farm angeschlossene Labor:** Hier werden die Blutproben der Pferde analysiert und die Laborberichte geschrieben; **4) Das farmeigene Arbeitsbüro:** Hier finden die Studierenden weitere Möglichkeiten, zusätzliche Wissensquellen zu konsultieren und Diagnosen sicher zu erstellen. Dazu gehören interaktive Bücher sowie Internet-Links, deren Auswertung das Erstellen von Abschlussberichten unterstützen soll.

Um die Effektivität des Einsatzes der EVF im Lehrbetrieb einzuschätzen, haben sich 24 Studierende am Fachbereich Veterinärmedizin an der Freien Universität Berlin freiwillig bereit gefunden, die Anwendung EVF zu testen und sie mit dem am Fachbereich angebotenen Online-Kursus " Blackboard " (Bb, eine Lernplattform) vergleichend zu bewerten, und zwar

anhand zweier virtueller hämatologischer Laborexperimente. Im Anschluss daran wurden die virtuell erworbenen Kenntnisse im realen Laborexperiment praktisch verifiziert. Ziel war die Bewertung der Lernergebnisse und der praktischen Fertigkeiten im Vergleich von Bb und EVF. Der Lernerfolg wurde einerseits an der erreichten Punktzahl in einem Bewertungsfragebogen gemessen und andererseits anhand der Evaluierung durch die Testpersonen selbst mittels Evaluierungsfragebögen ermittelt, wobei nach Lernstilen der Tester (visueller, auditiver, kinästhetischer und Lese/Schreibe − Typ) unterschieden wurde (VARK-Fragebögen). Die Analyse der erreichten Punktzahlen mittels Mann-Whitney-U-Test ergab keine signifikanten Unterschiede im abrufbaren Wissen in Bezug auf Versuchsaufbau und -durchführung beim Vergleich von EVF und Bb *(p-Wert = 0,61, Teststärke = 0,68)*. Allerdings tendierten EVF-Anwender im Vergleich zu Bb-Anwendern alles in allem dazu, höhere Punktzahlen zu erzielen *(p-Wert = 0,13, Teststärke = 0,57)*, bezogen auf "Verständnis" *(p-Wert = 0,07, Teststärke = 0,38)* und bei problembezogenen Fragen *(p- Wert = 0,06, Teststärke = 0,45)*. Darüber hinaus ergab die Auswertung der Evaluierung durch die Tester, dass in Abhängigkeit vom Lernstil des Testers EVF einen größeren Einfluss auf die Motivation sowohl zum Erlernen der Fakten als auch für die praktische Anwendung der Kenntnisse im Labor hat als dies bei der Nutzung von Bb der Fall war. Außerdem lieferten die Rückmeldungen der Tester weitere hilfreiche Hinweise für die Weiterentwicklung von EVF als kontextualisierte Lernumgebung.

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# APPENDICES

## APPENDIX A

### Differenzielle Leukozyten Zählung

### I)  Fragen zur Wiederholung

**Bitte erläutern Sie Schritt für Schritt, wie man verschiedene weiße Blutkörperchen manuell auszählen kann?**

**Schritt 1:**

a)

b)

**Schritt 2:**

a)

b)

c)

d)

**Schritt 3:**

a)

b)

c)

d)

e)

**Schritt 4:**

a)

b)

c)
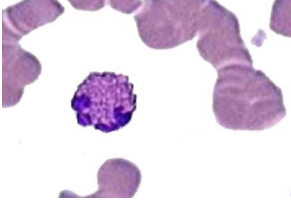
d)

**Schritt 5:**

## II)  <u>Verständnisfragen</u>
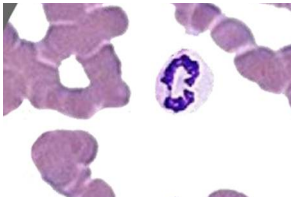
1.  **Die folgenden Fotos wurden während der mikroskopischen Zählung aufgenommen. Um welche der angebenen Möglichkeiten handelt es sich in dem Bild?**

a)
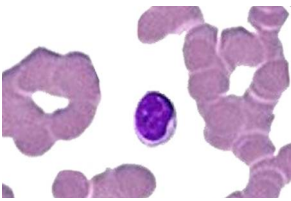


- Neutrophile
- Basophile
- Eosinophile
- Monozyt
- Lymphozyt

b)



- Neutrophile
- Basophile
- Eosinophile
- Monozyt
- Lymphozyt

c)



- Neutrophile
- Basophile
- Eosinophile
- Monozyt
- Lymphozyt

d)
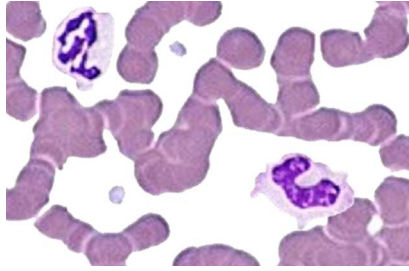


- Band Neutrophile
- Basophile
- Eosinophile
- Monozyt
- Lymphozyt

e)
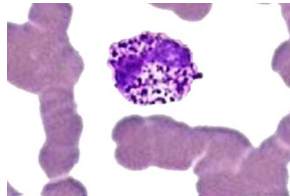


- Neutrophile
- Basophile
- Eosinophile
- Monozyt
- Lymphozyt

f)
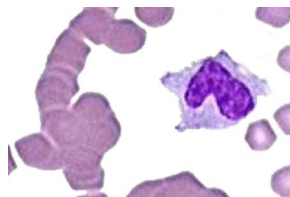


- Neutrophile
- Basophile
- Eosinophile
- Monozyt
- Lymphozyt

2.  **Zu welchen Veränderungen im Blutbild führt „Stress"?**

    - Neutrophilie
    - Eosinopenie
    - Lymphozytosis
    - Monozytopenie
    - Basopenie

3.  **Die sog. "Battlement" Methode eignet sich nicht zur Auszählung weißer Blutkörperchen, weil:**

    - Eine Neutrophilie vorgetäuscht wird
    - Eine Neutropenie vorgetäuscht wird
    - Eine Lymphozytose vorgetäuscht wird
    - Eine Monozytose vorgetäuscht wird
    - Keine der oben genannten

4.  **Welche der folgenden Fälle ist mit körperlicher Bewegung (z.B. Laufen) verbunden?**

    - Neutropenie
    - Basopenie
    - Lymphozytosis
    - Lymphopenie
    - Eosinopenie

5.  **Geben Sie an, welcher Wert als Neutropenie bezeichnet wird !   (Normwerte Pferd: 2,26 bis 8,58 g / l bzw. 22-72% )**

    - 1.5 G/L
    - 20%
    - 3.5 G/L
    - 30%
    - 10%

## III)    Denkaufgaben

1.  **Sie erhalten vom Labor den folgenden Ausdruck  (Spezies: Pferd):**

    |                  | By Coulter Counter | By slide counting |
    |------------------|--------------------|-------------------|
    | Neutrophiler     | 35                 | 70                |
    | Band Neutrophiler| 1                  | 3                 |
    | Eosinophiler     | 0                  | 2                 |
    | Basophiler       | 2                  | 0                 |
    | Monozyten        | 57                 | 33                |
    | Lymphozyten      | 5                  | 2                 |

    Welche Methode wurde verwandt?

    - Battlement Methode
    - Querschnittsverringerung Methode
    - Randzählmethode

2.  **Einem Tierarzt ist mit Mühe gelungen, eine Blutprobe von einem Pferd zu entnehmen, welches sehr aufgeregt war.  Was erwarten Sie?**

    | a) | b) | c) |
    |----|----|----|
    | • Neutrophilie | • Neutropenie | • Neutrophilie |
    | • Basopenie | • Basophilie | • Basophilie |
    | • Monozytose | • Monozytosis | • Eosinophilie |
    | • Eosinophilie | • Eosinophilie | • Monozytose |
    | • Lymphopenie | • Lymphozytose | • Lymphozytose |

3.  **Ein Pferd kommt um 10:00 aus Langensalza in die Pferdeklinik der Freien Universität. Das Pferd ist klinisch stabil. Wann sollte die erste Blutentnahme erfolgen?**

    - Heute
    - Morgan

4.  **Und wenn Sie Blutprobe nehmen um 10:30, was erwarten auf Zählen seinen verschiedenen weißen Blutkörperchen zu sehen?**

    | a) | b) | c) |
    |----|----|----|
    | • Neutrophilie | • Neutropenie | • Neutrophilie |
    | • Basophilie | • Basophilie | • Basophilie |
    | • Eosinophilie | • Monozytose | • Eosinophilie |
    | • Monozytose | • Eosinophilie | • Monozytose |
    | • Lymphopenie | • Lymphopenie | • Lymphozytose |

### IV)  <u>Labor Ergebnisse</u>

| Cell | % |
|---|---|
| Neutrophiler (band) | |
| Neutrophiler (mature) | |
| Eosinophiler | |
| Basophiler | |
| Monozyten | |
| Lymphozyten | |

**Wenn die Summe leukozytäre count = 10 G / L, was wird die absolute Anzahl für jede Zelle werden**

| Cell | Absolute count |
|---|---|
| Neutrophiler (band) | |
| Neutrophiler (mature) | |
| Eosinophiler | |
| Basophiler | |
| Monozyten | |
| Lymphozyten | |

## APPENDIX B

### Osmotische Fragilität – Testfragen

### I) Fragen zur Wiederholung

**Bitte erläutern Sie Schritt für Schritt, wie man die osmotische Fragilität der roten Blutkörperchen erkennen kann.**

**Schritt 1:**

a)

b)

c)

d)

**Schritt 2:**

a)

**Schritt 3:**

a)

b)

c)

**Schritt 4:**

a)

b)

c)

## II) <u>Verständnisfragen</u>

1. **Der Osmotische Fragilitätstest liefert nützliche Hinweise auf Fehlbildungen in der/den**

   - Struktur der Leukozyten-Membrane
   - Viskoelastizität von Neutrophilen
   - Strukturen der roten Blutkörperchen-Membrane
   - Viskoelastizität von Blutblättchen
   - Keine Angabe trifft zu

2. **Die minimale Resistenz =**

   - Die Konzentration von NaCl, bei der 50% Hämoloyse auftritt
   - Die Konzentration von NaCl, bei der 100% Hämoloyse auftritt
   - Die Konzentration von NaCl, bei der 10% Hämoloyse auftritt
   - Die Konzentration von NaCl, bei der Hämoloyse festgestellt wird
   - Keine Angabe trifft zu

3. **Die maximale Resistenz =**

   - Die Konzentration von NaCl, bei der 50% Hämoloyse auftritt
   - Die Konzentration von NaCl, bei der 100% Hämoloyse auftritt
   - Die Konzentration von NaCl, bei der 10% Hämoloyse auftritt
   - Die Konzentration von NaCl, bei der Hämoloyse festgestellt wird
   - Keine Angabe trifft zu

4. **Welche Form (1 , 2 oder 3) nehmen die roten Blutkörperchen in den folgenden Lösungen an:**
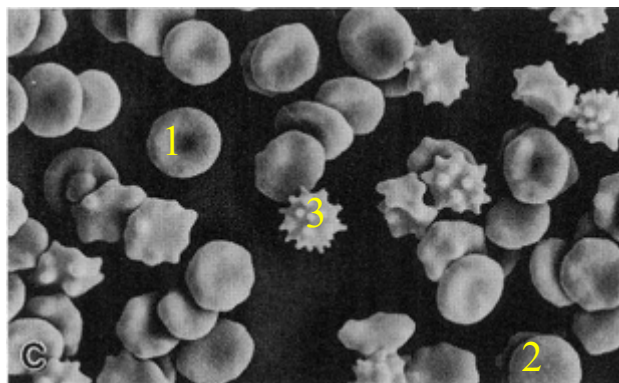


   a) **1-2% NaCl-Konzentration**

   - Discozyt (1)
   - Echinozyt (3)
   - Sphärozyt (2)
   - Keine Angabe trifft zu

71

### b) 0.85%-0.8% NaCl-Konzentration

- Discozyt (1)
- Echinozyt (3)
- Sphärozyt (2)
- Keine Angabe trifft zu
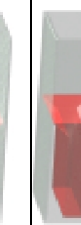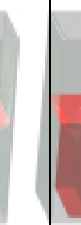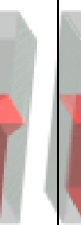
### c) 0% NaCl-Konzentration

- Discozyt (1)
- Echinozyt (3)
- Sphärozyt (2)
- Keine Angabe trifft zu

**5. Die Lösungen in den folgenden 2 Fällen wurden vom osmotischen Fragilitätsröhrchen nach dem Zentrifugieren gewonnen. Bitte bestimmen Sie die minimale und die maximale Resistenz für jeden dieser Fälle:**
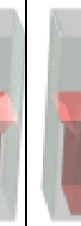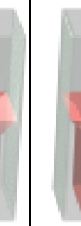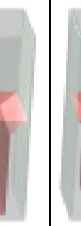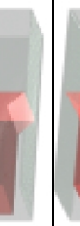
**6.**

### a) <u>Fall 1:</u>

| Nacl conc. | 0.9% | 0.85% | 0.7% | 0.6% | 0.5% | 0.4% | 0.35% | 0.3% | 0.3% | 0.1% |
|---|---|---|---|---|---|---|---|---|---|---|
| Tube | | | | | | | | | | |



- **Die minimale Resistenz =**
- **Die maximale Resistenz =**

### b) <u>Fall 2:</u>

| Nacl conc. | 0.9% | 0.85% | 0.7% | 0.6% | 0.5% | 0.4% | 0.35% | 0.3% | 0.2% | 0.1% |
|---|---|---|---|---|---|---|---|---|---|---|
| Tube | | | | | | | | | | |



- **Die minimale Resistenz =**
- **Die maximale Resistenz =**

## III)   Denkaufgaben

**Einem im Sommer schwer dehydrierten Pferd wurde eine Blutprobe entnommen und ein osmotischer Fragilitätstest durchgeführt. Welche der folgenden Testergebnisse erwarten Sie?**

**a)   Die Form der roten Blutkörperchen ist:**

- 1
- 2
- 3
- Keine Angabe trifft zu
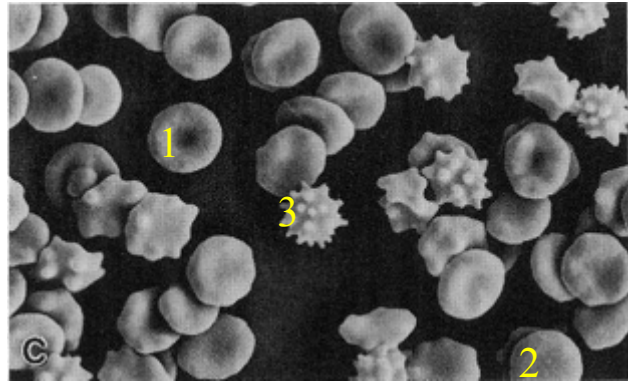


**b)  Die minimale Resistenz wird ... ... ... ... ... ... ... normal**

- höher als
- geringer als
- gleich
- Keine Angabe trifft zu

**c)  Die maximale Resistenz wird ... ... ... ... ... ... .. normal**

- höher als
- geringer als
- gleich
- Keine Angabe trifft zu

**Und was erwarten Sie, nachdem Sie das Pferd mit einer Flüssigkeitstherapy behandelt haben?**

**d)  Der minimale Resistenz wird ... ... ... ... ... ... ... normal**

- höher als
- geringer als
- gleich
- Keine Angabe trifft zu

**e)  Die maximale Resistenz wird ... ... ... ... ... ... … normal**

- höher als
- geringer als
- gleich
- Keine Angabe trifft zu

## IV)   <u>Labor Ergebnisse</u>

- **Die minimale Resistenz =**

- **Die maximale Resistenz =**
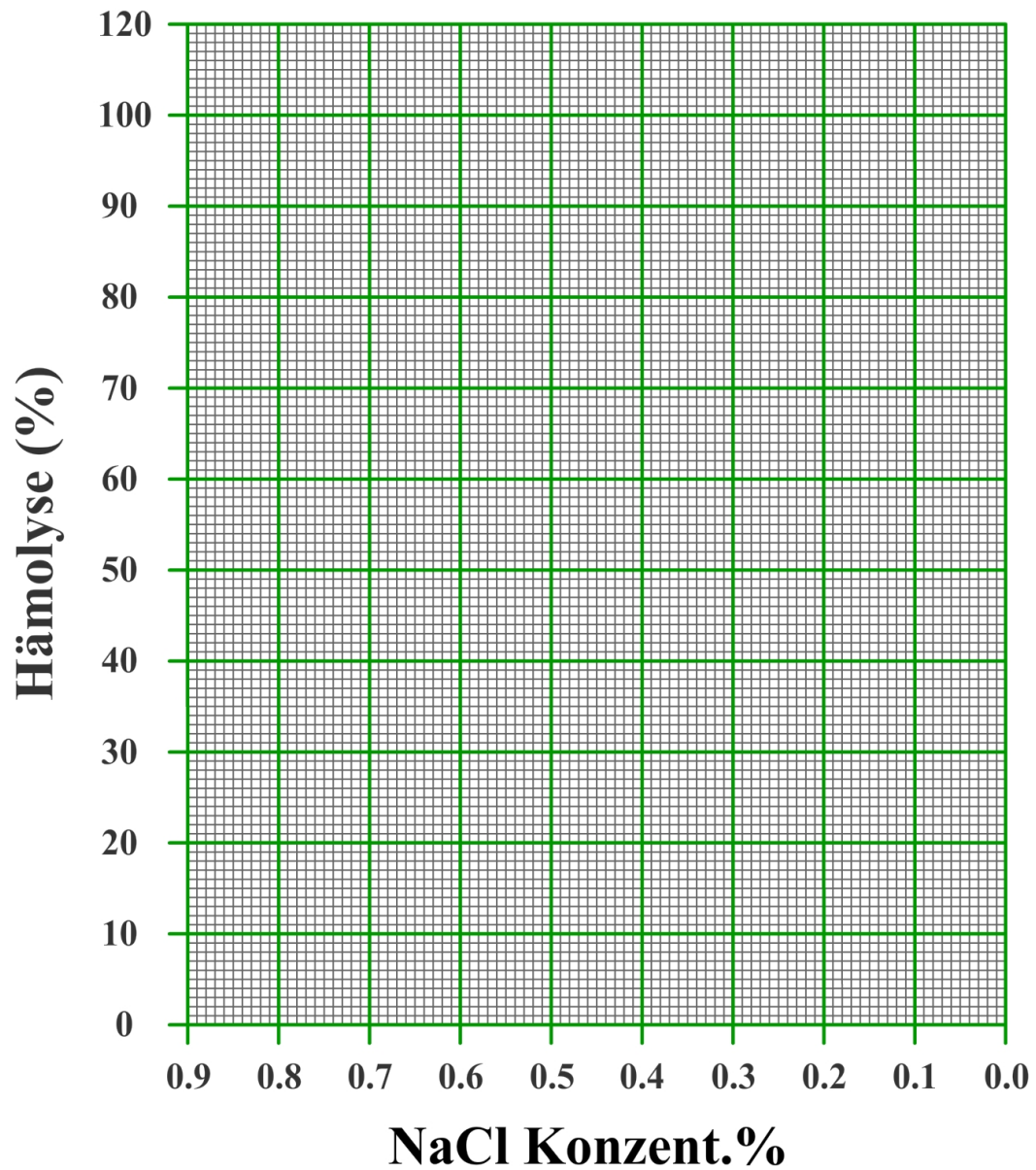


**Mittlere Osmotische Fragilität (MOF) =**

**APPENDIX C**

**Learning Questionnaire**

1. **Wie war Ihr Erkenntniszuwachs durch „Virtual Farm"?**

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|

(1= you didn't learn anything and 5 you learned a lot)

- Wenn Sie mit „4" oder „5" bewertet haben, zählen Sie bitte auf, was Sie gelernt haben!

- Wenn Sie mit „1", „2" oder „3" bewertet haben, geben Sie bitte an, warum!

2. **Wie war Ihr Erkenntniszuwachs durch den Blackboard Kurs?**

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|

- Wenn Sie mit „4" oder „5" bewertet haben, zählen Sie bitte auf, was Sie gelernt haben!

- Wenn Sie mit „1", „2" oder „3" bewertet haben, geben Sie bitte an, warum!

3.  **Konnten Sie durch das Üben im Labor Erkenntnisse sammeln, die Sie nicht aus der virtuellen Farm erzielt hatten?**

4.  **Konnten Sie durch das Üben im Labor Erkenntnisse sammeln, die Sie nicht aus dem Blackboard Kurs erzielt hatten?**

5.  **Konnten Sie durch das Üben im Labor Erkenntnisse bestätigen, die Sie bereits in der virtuellen Farm erzielt hatten?**

6.  **Konnten Sie durch das Üben im Labor Erkenntnisse bestätigen, die Sie bereits im Blackboard erzielt hatten?**

7.  **Welche Lernform (Blackboard oder virtual Farm) fanden Sie motivierender?**

8.  **Wie könnte die Effektivität der „virtual Farm" als Hilfsmittel beim Lernen gesteigert werden?**

9.  **Wie könnte die Effektivität von „Blackboard" als Hilfsmittel beim Lernen gesteigert werden?**

# PUBLICATIONS LIST

1. **Maaly M. Nassar and Heike Tönhardt (2010).** Virtueller Bauernhof: Eine Neue Lernumgebung für das Studium der VeterinärPhysiologie.Grundfragen Multimedialen Lehrens und Lernens - GML, Berlin, 11.-12.3.2010. http://www.gml-2010.de/ausstellung/index.html

2. **Nassar, M. and Tönhardt, H. (2008).** Can a virtual farm motivate veterinary students to learn physiology? Grundfragen multimedialen Lehrens und Lernens - GML, Berlin, 13.-14.3.2008. http://library.vetmed.fu-berlin.de/fb-publikationen/67751.html

# ACKNOWLEDGEMENT

# SELBSTÄNDIGKEITSERKLÄRUNG

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


**Ort, den**                                        **Unterschrift**

**Berlin, 04.11.2011**                              **Maaly Nassar**