FACULTY PERCEPTIONS OF PROBLEM-BASED LEARNING IN A VETERINARY COLLEGE

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ABSTRACT

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Problem-based learning (PBL) has been embraced by several veterinary colleges as one approach to manage the ever-growing body of knowledge in the profession. The goal is to foster the development of problem-solving and critical thinking skills in students, enabling them to make logical and informed decisions, rather than rely on the rote memorization of facts. PBL comes in many different forms, which causes difficulties with making inferences on student learning and the development of these thinking skills. Moreover, there are a range of possible reasons why and how PBL is implemented i.e. the decision how to implement PBL is dependent on a variety of factors. This qualitative study utilized the concepts of Situated Perspective Theory (Bruce, 1993) and Academic Plans (Stark & Lattuca, 2009) to better understand the contextual, historical, and contingent reasons for the specific manner in which PBL was implemented in the veterinary courses at Michigan State University's College of Veterinary Medicine. Data was collected using semi-structured interviews with instructors that are actively using PBL in their courses.

The goal of this study was to develop a rich description of which instructors have integrated PBL into their courses, the specific forms of PBL that were being utilized, and to explore the unique factors in each course that influenced PBL adoption and evolution. This study contributes to the current literature on the use of PBL in veterinary education in specific (and to the application of PBL to professional education, in general) by expanding the manner in which

we think about PBL and the contexts of its implementation, thereby informing instructional decision making by instructors and other faculty groups working in institutions of higher education. The results of this study indicate a high degree of variation in PBL implementation at the College, and the absence of a single, unified approach for using this method. Despite faculty perceptions that it is an effective instructional tool, this study indicated a lack of standardized methods for accurately measuring the true impact of PBL.

DEDICATION

I dedicate this dissertation to Jennifer, Ellie and Katie, as they have constantly supported me since I began this adventure over seven years ago. It wasn't always easy, so I appreciate their patience and perseverance as this has truly been a team effort. I know Dad and Bailey have been looking out for me as well.

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CHAPTER 1

INTRODUCTION

Individuals pursuing a career in the profession of veterinary medicine are faced with challenges that have become even more pronounced in today's fast-paced, information-intensive world. The vast repository of existing knowledge, along with the increasingly voluminous amount generated each year, has become impossible to transfer to the mind of a learner during a typical four-year medical program. Despite this, veterinarians are expected to be functional in a wide variety of areas that require, at minimum, a baseline level of competence in a staggering number of academic subjects. In fact, the very definition of a "career-ready veterinarian" is currently being re-evaluated by the Association of American Veterinary Medical Colleges (Schuring, 2011). Skills that didn't exist a decade or two ago must now be mastered in order to achieve baseline competence in general veterinary practice. Today's veterinarian exists at the convergence of many diverse disciplines. New graduates need to have working knowledge of the many tangential fields in which veterinary medicine is intertwined, including epidemiology, public health, food safety, economics and business management. As an added challenge, tuition costs and student debt loads have dramatically increased, without an equivalent increase in starting salaries, effectively eliminating the possibility of extending the length of the curriculum in order to deliver this additional knowledge. Given this set of challenges, it quickly becomes obvious that the current system of veterinary medical education is drastically in need of reform.

Alternate pedagogical approaches, specifically problem-based learning (PBL), may be able to overcome some of the limitations that are evident in the current veterinary educational models. Problem-based learning is a different approach to teaching, designed to simulate what

students would actually be challenged with in real life. It requires them to be self-directed, analytical, and to utilize all available resources in order to solve the ill-defined problems they encounter. Through the use of PBL, students are better able to integrate information from different subject and improve their problem-solving skills (Maudsley, 1999). PBL is intended to foster development of critical thinking skills in students, as well as ground learning in contexts that value these tangential skills, even while emphasizing traditional learning goals. The desired end product is a learner that can parse and synthesize available information to make informed, logical decisions –skills that are essential to possess in a clinical environment. These arguments for PBL have often remained at the level of theory, and have not received the research and empirical attention they deserve.

Statement of the Problem

Despite the potential positive impacts that PBL could have, the implementation and evaluation of it comes with its own challenges – specifically around the uniformity or standardized nature of its implementation across institutional or instructional contexts. PBL by its very nature is difficult to specify or define in exact terms, as it can be understood and instantiated differently by different individuals and institutions. These differences are often determined by contingent historical, individual and institutional factors. Thus, it is no surprise that problem-based learning implementations are often unique, differing based on individual contexts and existing curricula present at diverse institutions.

Clearly, this complicates a simple study of the effects of PBL on student learning or critical thinking. While this differential implementation may initially be viewed as a corruption of the PBL "ideal", the Situated Perspective (Bruce, 1993) indicates that this hybridization

process actually improves the value of PBL, allowing it to be better contextually adapted. In addition, as Bruce (1993) argues these different implementations allow for a better understanding of the ideal, rather than the other way around (i.e. as a corruption of the ideal). As Bruce (and other situated evaluation theorists argue) the realization of the innovation (PBL in this case) is created through the lens of the "existing goals and practices of institutions and individuals" (Bruce, 1993, p. 17). In other words, these multiple realizations help bring into focus what are the essential elements (so to speak) of PBL as different instructors implement PBL according to their own unique understandings, constraints, historical contingencies and circumstances.

Purpose Statement

The purpose of this qualitative study was to develop a rich description of how PBL was developed and is currently being used in courses within the didactic curriculum at Michigan State University's College of Veterinary Medicine. Course syllabi were analyzed for keywords indicating that PBL was being used in some form during the semester. Using in-depth interviews with instructors, several factors were explored in detail including reasons for implementing PBL, unique contextual factors that influenced the selection and modification of particular forms of PBL, as well as instructors' perceptions of the most significant current issues in veterinary medical education and how PBL could assist in surmounting them.

This study contributes to a better understanding of problem-based learning and the contexts surrounding its implementation and evolution, as veterinary medicine continues to be faced with the challenge of a boundless repository of information to teach, and limited time in which to do so.

CHAPTER 2

REVIEW OF THE LITERATURE

Issues in Veterinary Medical Education

The role of the veterinarian in society continues to change and expand. Often invisible to most, the responsibilities of this skilled profession extend far beyond caring for companion animals, and have grown to include animal welfare, food security, food safety, environmental protection and even global security due to knowledge of diseases that can be used in biological warfare (Edwards, 2004). While the profession has transformed significantly, the underlying educational organization has not expanded and diversified to keep pace (Radostits, 2003). As a result, graduates who would be competent enough to enter any and all of these keys areas are no longer being produced by the system in its current form. Despite this blatant reality, the "romantic image of a single profession that can encompass all the branches of science, agriculture, and medicine" (Eyre (2002), p197) somehow still exists.

The profession is also plagued by an intensive, high credit-load curriculum that results in significant student loan debt for the vast majority of its graduates. Adding additional course content, or further extending the curriculum, is not viewed by most to be a palatable option. Most disturbingly, these problems aren't going away any time soon. They will only become even more pronounced as the knowledge base continues to grow, and the role of the veterinarian is further diversified. Many solutions have been proposed over the last few decades including career tracking, limited licensure and mandatory internships, but none of these approaches have resulted in overall success. Despite the variety of opinions available on the topic, the common underlying themes include the realization that the recent information explosion has resulted in a

body of knowledge that is beyond human capacity to interpret (Pritchard, 1994), and that reforms in the education process are essential for preparing veterinarians for their current (and future) roles.

Redefining the Veterinary Professional

Due to the rapidly evolving nature of the veterinary profession, the Association of American Veterinary Medical Colleges (AAVMC) established the North American Veterinary Medical Education Consortium (NAVMEC) in 2008. This endeavor sought to bring together key stakeholders in order to identify the current needs of the veterinary profession, define the core competencies of graduating veterinarians, and indentify the changes that would be needed in veterinary medical education to realize these goals. Most importantly, the NAVMEC Consortium brought together not only representatives from all veterinary colleges, but also those from accrediting bodies as well as testers/licensers. In order for real change to occur, buy-in from all three of these groups was viewed as essential.

Over the course of three national meetings held in 2010, with more than four hundred stakeholders participating, NAVMEC evaluated every aspect of veterinary medical education in order to arrive at an updated list of core competencies for all graduating veterinarians, along with a number of recommendations for ensuring the future viability of the profession (NAVMEC, 2010). Of notable interest on the revised core competencies list are the elements promoting "critical thinking, problem solving and curiosity, self-directed learning" as well as "collaboration – work within a healthcare team to achieve optimal patient care, client service, or other desirable outcome" and finally "adaptability to changing environments: new technologies; role of animals; societal norms". The desired end product of the professional veterinary program is a graduate

that has “strong comparative medical primary clinical skills, functions as an interdisciplinary problem solver and critical thinker, and is technologically adept”.

In addition, one of the key recommendations in the preliminary report’s section on Admissions and Curricula calls for “clinical skills and SKAs (skills/knowledge/aptitudes) to be taught in an integrated way, using a spectrum of learning techniques, including problem-based learning and case-based methodologies – enabling graduates to hit the ground running on day one”. Obviously, such a vision has the potential to require a massive restructuring of the curriculum, at least at the majority of member colleges. NAVMEC acknowledges this issue, and stated that “this broader curriculum will necessitate a concurrent decrease in curricular depth with greater emphasis on basic principles, critical thinking and problem solving, rather than rote memorization of more facts across the broader scope of topics required for the broad set of competencies”. The most important goal for these reformations is to produce a veterinarian that can effectively and independently seek and integrate information as it becomes available, rather than memorizing ever-increasing number of facts. Emphasis would be placed on developing thinking skills to enable student to locate the content knowledge when it is needed. This method would function well in the current information age, where everything is seemingly a quick Google-search away, as it tasks students with gathering, evaluating, interpreting and assimilating information before arriving at well-reasoned conclusions. Veterinary students with these skills would be better equipped to function as competent practitioners upon graduation. Acquiring said skills would position new graduates closer to the NAVMEC target of being “day one ready.”

Information Overload

We are truly living in the information age. It is estimated that the sum of human knowledge doubles each decade, with the size of the Internet doubling approximately every five years (Zhang, 2008). Clinical knowledge is thought to move at an even more rapid pace, doubling about every eighteen months. Astonishingly, a clinician needs to utilize approximately two million pieces of information in order to practice medicine (Wyatt, 1991). Obviously, the sheer magnitude of this knowledgebase can be more than most students can handle, regardless of their discipline area. As Barrows (1996) described, students, in his experience, often found themselves to be "saturated by the vast amounts of information they had to absorb, much of which was perceived to have little relevance to medical practice". *Relevance* is a key factor indeed, as the transferability of didactic information to the clinical environment is not always apparent to the learner. The passive influx of knowledge has been shown to be ineffective and responsible for inhibiting, or destroying, any clinical reasoning ability (Barrows and Bennett, 1972). This problem is evident in the veterinary field as well, as students are confronted with the challenge of assimilating a continuously growing body of knowledge. Rather than attempting to have students learn everything, educators should assist students in becoming self-directed learners, giving them the ability to *learn how to learn* new materials (Kiley, 2000).

Problem-Based Learning

One approach currently being used by many institutions in the human medical profession, in an attempt to overcome some of the challenges previously described, is the integration of problem-based learning concepts into individual courses, or even the entire curriculum. Problem-based learning challenges students to think deeper, harnessing their analytical and problem-solving skills as they work through real-world problems to become engaged problem

solvers (Torp and Sage, 2002). Broadly, problem-based learning can be defined as a "learning process where students actively work together in teams to achieve a goal" (Busari, 2000). Dolmans et al (2005) view the three essential characteristics of PBL to include using problems as the stimulus for learning, the instructor's role as facilitator, and utilizing group work as the stimulus for interaction. More specifically, Savery (2006) describes the skills gained by the problem-based learning method as including "the ability to think critically, analyze and solve complex, real-world problems, to find, evaluate, and use appropriate learning resources; to work cooperatively, to demonstrate effective communication skills, and to use content knowledge and intellectual skills to become continual learners".

Despite the variations in definition, there are several universal characteristics from the original McMaster model of problem-based learning that are present in all variants. Problem-based learning, as described by Barrows (1996) has the following essential elements: learning is student-centered; learning occurs in small student groups; teachers are facilitators or guides; problems form the organizing focus and stimulus for learning; problems are a vehicle for the development of clinical problem-solving skills; new information is acquired through self-directed learning. PBL is intended to have four primary effects on learning, as described by Charlin et al (1998): learners are active processors of information; prior knowledge is activated and new knowledge is built on it; knowledge is acquired in a meaningful context; learners have opportunities for elaboration and organization of knowledge. The end goal of the process is to develop a self-directed leaner that can deal with ill-defined, real world problems (Torp and Sage, 2002) and realize that most problems do not have a single correct answer (Hmelo-Silver, 2004). In theory, this model appears to fit quite well with medical education, especially the veterinary profession, as students are met with an onslaught of knowledge pertaining to a wide variety of

species. While these lofty goals sound wonderful in theory, how well does problem-bases learning work in reality?

Effectiveness of Problem-based Learning

There has been much research in the medical fields to determine if problem-based learning actually leads to tangible improvements, such as improved problem-solving and critical thinking skills. In Nursing, students' critical thinking skills showed greater improvement with the PBL format as compared to more traditional forms of instruction (Yuan, 2008). Tiwari et al (2006) demonstrated that undergraduate nursing students taught using PBL had significantly higher overall critical thinking disposition scores as compared to students taught using traditional lectures. Cooke (2002) determined that the PBL format in Nursing programs promoted critical thinking, problem solving, self-direction and the integration and synthesis of a variety of knowledge. Simpson (2002) found that PBL improved autonomous learning and problem-solving, and critical thinking skills in both the didactic and clinical practice settings of Nursing education. Research on this topic is also very active in the field of Dentistry (Lum-Peng, 1999; Marshall, 2011). Thammasitboon (2007) found Harvard's Dentistry PBL graduates to have significantly higher scores in critical thinking, patient communication, independent learning, and performance in small group settings, self-assessment and teamwork. Despite this wealth of activity in the human realm, research pertaining to veterinary medicine is very limited. Therefore, this is an ideal area to explore and evaluate further, especially given the recent NAVMEC call to action.

The Many Forms of Problem-Based Learning

Unfortunately, exactly what constitutes "problem-based learning" is still very ill-defined. To complicate matters further, many institutions have created their own special versions of problem-based learning, blending it at will with other elements of their conventional teaching programs (Barrows, 1996). This leads to hybridized implementations, or even alternative curricula, with varying degrees of PBL integration, effectively destroying (in the opinion of some) the true definition of the term (Barrows, 1986). However, this fragmentation effect does not need to be viewed negatively. According to the Situated Perspective theory (Bruce, 1993), the exact realization of an innovation will differ greatly between systems, leading to methods of implementation differing greatly from those originally intended. The innovation of PBL is far from static; it is recreated at each institution as it is modified to fit into existing practices.

As described above, PBL can come in numerous forms. Since PBL is not a specific educational method, it can be integrated into the curriculum in a variety of ways. As Barrows (1986) describes, the four educational objectives more easily accomplished using PBL (as compared to other approaches) include the structuring of knowledge for use in clinical contexts; the development of an effective clinical reasoning process; the development of effective, self-directed learning skills; and increased motivation for learning. Barrows (1986) developed a taxonomy to distinguish the formats of PBL. In his view, students progressively meet the four primary objectives of PBL as they move through this taxonomy (Maudsley, 1999). In *Lecture-based Cases*, students are given traditional lectures then one or two cases to demonstrate a particular issue of relevance. *Case-based Lectures* involve giving cases to students ahead of time that will be covered during the next lecture. With the *Case Method* approach, students are given complete cases ahead of time that will be used in an upcoming class discussion. In the

Modified Case-based method, students are given cases but have more opportunity for self-direction and can make a limited number of choices. In the *Problem-based Learning* approach, students are allowed free inquiry with the cases. Finally, in *Closed-loop or Reiterative Problem-based Learning*, students are given an opportunity after free inquiry to return to the original patient problem for a discussion and reflective phase (Maudsley, 1999).

While all of these approaches can be considered PBL, there are differences between the formats that lead to variations in achievement of the four primary educational objectives of problem-based learning, as described by Barrows. In many ways, the taxonomy can be considered a continuum with the first classification (Lecture-based Cases) allowing for a minimal level of inquiry on the part of the student, while the final classification (Closed-loop or reiterative problem-based learning) allows students a high degree of free inquiry along with a reflective phase.

Charlin et al. (1998) built upon Barrow's work and went one step further to create ten dimensions to further assist in differentiating the many forms of problem-based learning. These dimensions include: the person or group who selects the problem; the purpose of the problem; the nature of the educational objectives and control over their selection; the nature of the task; the presentation of the problem; the format of the problem; the processes that students follow; the resources utilized and how they are identified; the role of the tutor/facilitator; and how learning is demonstrated through product or performance.

Given these criteria, an astounding variety of problem-based learning forms can exist, far beyond what may be considered one individual "ideal". However, the above classification systems are but two interpretations of what is possible. As Bruce (1993) described, the

hybridization process, based on specific local conditions, can lead to the creation of additional forms that are better suited for particular environments. Rather than being seen as corruptions, they can be viewed as improvements to the current, accepted formats. Beyond developing a static list of which instructors are using PBL, as well as which form of it, this study used Situated Perspective theory to better understand the specific circumstances that influenced each instructor regarding their PBL choices and implementation processes. At a higher level, this study also explores the complex variety of factors that influenced each instructor as they developed their course curricula. Using Stark and Lattuca's concept of an "academic plan", several components that impact the development and use of PBL were explored, rather than merely focusing on "singular aspects such as specific content or particular instructional strategies" (Stark & Lattuca, 2009 p. 4). The academic plan model considers multiple elements of a course including purpose, content, sequence, learners, instructional processes, instructional resources, evaluation and adjustment. PBL is not developed in a vacuum; it is influenced by institutional, program and unit factors within the college. Instructor-specific factors, such as background and characteristics, views of their academic fields and beliefs about the purposes of education also play a significant role in curricular development (Stark & Lattuca, 2009 p. 118). By utilizing the academic plan concept, and the role of PBL within this framework, this study resulted in a much deeper understanding of how PBL was instantiated in each course.

Research Questions

As evidenced by the preponderance of existing research on the topic, defining exactly what problem-based learning is can be extremely difficult. A multitude of forms exist, and there is no clear evidence that any one design is universally better than the others. Beyond attempting to merely classify which types of problem-based learning are currently in use at the College of

Veterinary Medicine, this study sought to better understand *why* PBL was chosen by each instructor. The Academic Plan model (Stark & Lattuca, 2009) was utilized to concurrently examine the multiple elements of each course, including content, faculty teaching styles, students' needs, and assessment styles, that lead to the instructor believing that PBL was the best choice for a particular experience. Also addressed was the question of *how* the instructors developed their problem-based learning resources, and if they modified their techniques over time, creating hybrid or even novel formats. Using Situated Perspective Theory (Bruce, 1993), the unique contextual elements within each course were identified. With this information, a better understanding of how PBL usage evolved within each course to better suit local needs was gained. The research questions addressed by this study are as follows:

Research Question 1:

Q1) How do instructors at MSU CVM perceive and use problem-based learning?

- Question 1a: Which instructors are using problem-based learning in their courses?
- Questions 1b: What reasons are given for using problem-based learning?

Research Question 2:

Q2) How are different faculty members developing problem-based learning?

- Question 2a: What forms of problem-based learning are being used, and why?
- Question 2b: What unique elements in each course lead to the selection of particular PBL forms?

Research Question 3:

Q3) What is the future of problem-based learning?

- Question 3a: What benefits, if any, are being seen from the use of problem-based learning?

- Question 3b: How will problem-based learning be used at MSU CVM in the future?

CHAPTER 3

METHODOLOGY

This chapter will focus on the overall design of the study and the reasons for selecting a qualitative approach. Additional information about the College, data sampling and analysis methods will also be supplied.

Purpose of the study

The purpose of this study was to better understand the use and evolution of problem-based learning methods at the College of Veterinary Medicine during the didactic portion of the curriculum. Although problem-based learning has been used in some form or another at the College for decades, there is little guidance from the central administration on implementing PBL in a broad, coordinator manner. Over the years, multiple curricular revisions and constant faculty turnover have resulted in pockets of isolated PBL usage across the curriculum. This study provides a rich, detailed analysis of how PBL is currently being used, how faculty tailored it to meet their instructional needs, as well as discussion on how PBL can be utilized to meet the growing challenges in veterinary medical education.

Research Design

A qualitative design was used to collect the data for this study. This included in-depth analysis of all pre-clinical course syllabi, as well as semi-structured in-person interviews (Appendix A). The syllabi analysis was used to identify instructors that are actively using problem-based learning in their courses in order to invite them to participate in the interviews. Qualitative methods were very useful for this study as it gave the researcher the ability to probe

the unique factors in each course and discover how they differ from one another (Shulman, 1998). The interviews generated detailed, descriptive information, such as instructor attitudes and feelings. The semi-structured format aided in keeping the conversations on track, while allowing latitude for elaboration on topics of particular interest to the participants. Their reasons for using or not using PBL, along with the methods of implementation and in the course, were collected. Each instance of PBL use, as described by the instructor, was recorded and classified according to the taxonomy defined by Barrows (1986), as well as the ten dimensions developed by Charlin et al. (1998). This study resulted in a better understanding of how PBL has been adopted across the courses at MSU CVM, along with the creation of a detailed topology depicting the variety of PBL formats currently being used by the faculty. At a deeper level, it explored the unique elements within each course, subject matter, and instructor preferences that have influenced the adoption and evolution of problem-based learning in the curriculum.

Instruments

Problem-based learning is a complex subject and the details needed for this study to be considered successful could not be collected using a simple survey. For this reason, semi-structured interviews were conducted with instructors to give them an opportunity to express their history with and thoughts on using problem-based learning. An interview guide (Appendix A) was developed in order to ensure a similar experience between participants as several factors of problem-based learning were discussed including implementation, current use and evolution of methods. Each element of the interview guide was designed to align with the primary research questions of this study. At the beginning of each interview, I supplied the participant with background information about the research study and stated the overall goals of the interview process. Next, I asked them to share some information about their background, the

courses they were teaching and their history with the College. Part I of the interview guide asked them to describe how they are using PBL in their course, why they started using it, and the unique course elements that they thought would make PBL a viable solution. This section also gave the participant an opportunity to discuss the challenges of using PBL, its strength and weaknesses, and how student performance was evaluated. Part IIa utilized the taxonomy defined by Barrows (1986), and listed six PBL forms (Lecture-based cases, Case-based lectures, etc.) along with a brief description of each. This taxonomy was distributed to each participant approximately two weeks before the scheduled interview date in order to give them an opportunity to reflect upon their personal use of PBL. It also provided a useful framework for discussion, as several of the terms were unfamiliar to the participants, and the differences between them are subtle. Part IIb explored PBL usage in greater detail, using the dimensions formulated by Charlin et al. (1998). Factors such as the purpose of the problem, the person that controls the educational objectives, the presentation and format of the problem and the role of the moderator were discussed. Finally, Part III gave the participant an opportunity to discuss their view of the most important current issues and challenges in veterinary medical education, and how problem-based learning could be leverages to solve them.

Context for this study

This study focused on how problem-based learning was being used in the professional Doctor of Veterinary Medicine (DVM) program at Michigan State University's College of Veterinary Medicine. The DVM program consists of five semesters of pre-clinical (didactic) study, followed by two years of clinical rotations. There are 112 veterinary students enrolled in the first year class, 113 in the second, and 104 in the third. A detailed list of the courses in the Veterinary curriculum can be found in Appendix B. The pre-clinical portion primarily consists

of traditional lecture and laboratory experiences and was the focus of this study. During these first five semesters of the curriculum, students complete thirty-nine courses, interacting with more than sixty faculty members from a variety of disciplines in the process. The first two semesters of the program focus on the normal structure and function of domestic animals. Semesters three and four address abnormalities, diseases and disorders. The fifth semester teaches intervention and prevention techniques, treatments and surgical procedures. The vast majority of courses are team-taught, typically relying on several instructors with a variety of different teaching styles. As in most medical education programs, many students have difficulty transitioning from the pre-clinical (classroom) environment into the teaching hospital after the fifth semester of instruction. It can be a challenge for students to "think on their feet" while examining a patient in order to recall, synthesis and apply the appropriate information.

The current pattern of problem-based learning usage is very inconsistent across the curriculum, as well as within individual courses. While there appears to be some use of PBL in each semester, it has not been uniformly implemented in a coordinated manner across the entire curriculum as it has been at some other institutions. In 2003, a major curriculum change effectively resulted in a reduction of PBL usage. Prior to that point, each of the five pre-clinical semesters contained a two-credit capstone Veterinary Integrative Problem Solving (VIPS) course, designed to give students the opportunity to integrate what they were learning in their other courses and apply their knowledge to clinically relevant cases. The VIPS courses were implemented in a variety of fashions. In some instances, they were stand-alone courses where students worked together in groups on cases. In other semesters, the time allocated for VIPS was "tacked on" to existing courses such as Physiology or Pathology and students would participate in whole-class activities. Due to various factors, including high credit load, time commitment

needed to properly develop a VIPS course, and faculty lack of interest in the PBL format, the revised curriculum in 2003 greatly reduced the footprint of the VIPS courses. What remained was one two-credit VIPS course during the third semester, a one-credit Large Animal Fundamental Clinical Sciences course during the fourth semester, and a one-credit Small Animal Fundamental Clinical Sciences course during the fifth semester. While this new instantiation of the VIPS course remained true to its roots, the Fundamental Clinical Sciences courses were more designed to ease the transition between the academic and clinical realms. While the courses were useful for increasing student comfort levels in the teaching hospital, the objectives focused on the proficiency of physical skills such as animal handling and examination techniques, rather than on problem-solving skills which were the highlight of the VIPS approach.

Sampling and Participants

The purpose of this study was to interact with instructors who were actively using problem-based learning concepts in their courses. My unique background and position greatly facilitated this process. Being an alumnus of the College, graduating in 2001, I am intimately familiar with the curriculum, in both its present and past forms. My current role as Director of the Center for Academic Technologies (CAT) gives me an opportunity to interact with course moderators and instructors on a daily basis. I have known many of the faculty in the College for more than a decade and have worked closely with them to implement new classroom technologies.

In order to identify the appropriate individuals to interview, all of the syllabi for the pre-clinical courses were collected and analyzed for any keywords that suggested that PBL was being used. I chose this method in order to be inclusive of all instructors and remove any biases that I had regarding who would be the best participants, given my pre-existing knowledge of the

College. The collection of the syllabi in itself was no simple task. Even though each course has a presence on the ANGEL learning management system, not every instructor made their syllabus available for viewing. In many cases, I had to locate the syllabi manually on the College's internal network, or contact the instructor directly and request it. The quality of the syllabi varied immensely. Some merely contained a list of scheduled lecture dates and the topics that would be covered. Others were very well-developed and also included the instructor's teaching philosophy, objectives of the course and even specific classroom activities.

In total, the syllabi from thirty-nine courses were analyzed for keywords that were indicative of the presence of problem-based learning. At the onset of my analysis, my basic list of keywords included: group, case, discussion, problem solving, and critical thinking. All five of these keywords align with the overarching features of problem-based learning. As I continued my analysis, this list of keywords grew to contain related terms including scenarios, application, integrate, simulated and reasoning to name but a few. In the end, I identified fifteen courses that contained one or more of the problem-based learning keywords in their syllabi. The number of keywords varied markedly between the courses. For example, VM 559 - Metabolic and Endocrinological Diseases stated "interactive format, case examples", while VM 532 – Veterinary Integrative Problem Solving included "integrate, problem solving, clinical reasoning, information gathering and processing, interpreting data, applying concepts, teamwork, life-long learning skills, case-based learning format, work in groups, discuss clinical cases, facilitator, student-led learning process, facilitator serves only as a guide, independent study and research of topics". More detailed information regarding the PBL keywords collected from each course can be found in the Results chapter.

After obtaining approval from Michigan State University's Institutional Research Board (IRB), instructors from each of the fifteen courses were contacted via email and invited to participate in this research study. An in-person follow-up request was also made to eight of the instructors, based on existing rapport and physical proximity. A total of eleven instructors, representing twelve courses, agreed to participate. Interviews were scheduled during the summer of 2012 and spanned a two-month period, due to faculty vacation and travel schedules. A total of nine interview sessions were conducted, ranging from 45 to 110 minutes, averaging about 80 minutes. Eight of the interviews involved one instructor only, while the final interview included three instructors, as the course was team-taught.

Data Collection

Eight of the interviews were conducted in my office at the College of Veterinary Medicine. The remaining interview was conducted off-site (Chennai, India) due to the schedule constraints of the moderator of the PDI 518 Comparative Veterinary Gross Anatomy II course. In all cases, the interviews were recorded, with prior permission being obtained from each participant, using a Sony high definition camcorder. The camcorder remained pointed at the wall, rather than at the participant, during the interview process, as the audio was the primary focus of the recording. This also served to put the participants more at ease, since no one was especially excited about appearing on camera. The audio, in MP3 format, was later extracted from each interview recording using Adobe Premiere CS 5.5 video editing software. I then developed transcripts in Microsoft Word by playing the audio files at 40% speed in VLC media player. Three passes were performed on each recording to ensure an accurate word-for-word translation of the interviews. The final versions of the transcription files were then sent to the participants to review for accuracy. Only one instructor replied with changes and additions, but

several others sent additional resources that they believed might be useful to the study, including cases that were previously used in their courses.

Data Analysis

After being recommended by a colleague (Henriksen, 2011), a cross-platform qualitative analysis program called HyperResearch was used to encode and analyze the transcript data. The transcript files were exported into Rich Text Format (RTF) using Microsoft Word, and then loaded into HyperResearch©. Since there was a total of 78 pages of transcript materials, this approach proved to be highly effective for gathering pertinent data and keeping the study organized. This process also facilitated the use of direct quotes from participants.

Keywords called codes were created in HyperResearch© and used to mark key passages of text in the transcripts in order to identify underlying themes. For example, the code "time" was created to identify any segments of text that discussed the time commitment of faculty needed to develop viable problem-based learning experiences, which is commonly cited as one of the primary challenges to widespread PBL adoption. A total of three coding passes were performed on each of the interview transcripts. The number of codes varied significantly between each of the passes. Codes for the first pass were defined by a combination of terms from the Barrows (1986) taxonomy and the Charlin et al. (1998) dimensions, as well as novel terms that were created as the transcripts were analyzed. HyperResearch© was very valuable for capturing additional information from the participants regarding their responses to the Barrows/Charlin classifications. Rather than approach it as a multiple choice question, all of the interviewees elaborated to provide very specific, and useful, details about their individual usage. At times, the Charlin dimensions were even modified to include selections that were not

available in the original version. For example, section 8 of the Charlin dimensions describes "Resources utilized and how they are identified" to include peers knowledge and information given beforehand, textbooks/journals, and subject matter experts. One participant chose to add "video content of physical exams" as a selection, since this was used heavily in her course.

The first iteration of coding resulted in 115 codes, with a majority of the complexity being due to the 56 codes present in the Barrows/Charlin classifications. During subsequent coding passes, codes that had similar meanings were consolidated. The group "benefits of PBL" initially contained several codes including accomplishment, communication skills, deeper level of learning and understanding, immediate feedback, integration, retention of information, self-expression, student enjoyment and taking a history. By the third version of the coding scheme, these terms were consolidated and simplified to include communication skills, critical thinking skills, deeper level of learning and understanding, relevance and integration, and retention of information. Several other coding groups underwent similar reductions such as "challenges of PBL", "current issues in veterinary medical education" and "evaluation of PBL". In the end, the code book contained 56 entries for the Barrows/Charlin typologies and dimensions, as well as 26 codes that addressed the primary research questions of this study. Figure 1, below, shows the groups and codes that were used for the Barrows typologies:

Groups and Codes used for Barrows Typologies

- PBL typology
    - Lecture-based cases
    - Case-based lectures
    - Case method
    - Modified case-based
    - Problem-based
    - Closed-loop or reiterative problem-based

Figure 1: Groups and Codes used for Barrows Typologies

Figure 2, below, shows the groups and codes that were used for the first five Charlin dimensions:

Groups and Codes used for the first five Charlin Dimensions

PBL classification

- 01 – Person who selects the problem/topic
    - Instructor
    - Course moderator
    - Curriculum designer
    - Student
    - Other

- 02 – Purpose of the problem
    - Basic sciences
    - Normal physiology
    - Underlying mechanisms
    - Essential clinical knowledge
    - Solve a patient problem
    - Clinical reasoning
    - Application of clinical knowledge
    - Transferrable skills / communication

- 03 – Nature of the educational objectives and control
    - Instructor-controlled
    - Student-controlled
    - Both instructor and student-controlled

- 04 – Nature of the task
    - Explain / describe a phenomenon
    - Make a diagnosis
    - Plan investigation and treatment
    - Explaining clinical techniques
    - Collect history / perform physical exam / address questions

- 05 – Presentation of the problem
    - Paper case
    - Virtual / computerized case
    - Simulated patient/client

Figure 2: Groups and Codes used for the first five Charlin and Dimensions

Figure 3, below, shows the groups and codes that were used for the last five Charlin dimensions:

Groups and Codes used for the last five Charlin Dimensions

PBL classification

- 06 – Format of the problem
  - One session
  - Two sessions
  - Three sessions
  - Four or more sessions

- 07 – Process that students follow
  - Students work individually
  - Students work in class with moderator
  - Students in group with moderator
  - Students in group without moderators
  -
- 08 – Resources utilized
  - Peers' knowledge and information given beforehand
  - Textbooks / journals / etc.
  - Subject matter experts
  - Video content of exams

- 09 – Role of the moderator
  - Facilitator
  - Content expert
  - Facilitator and content expert
  - Observer
  - Observer and content expert

- 10 – Demonstration of learning
  - Written examination
  - Presentation
  - Discussion
  - Self-evaluation
  - Written assignments
  - Peer evaluation
  - Facilitator evaluation
  - Group questions

*Figure 3***:** Groups and Codes used for the last five Charlin Dimensions

Figure 4, below, shows the final list of the additional groups and codes that were used in this study:

Final List of Groups and Codes Used in Study

- Benefits of PBL
    - Communication skills
    - Deeper level of learning and understanding
    - Relevance and integration
    - Retention of information
- Challenges
    - Limited resources
    - Logistics
    - Pure PBL limitations
    - Time
- Current issues in veterinary medical education
    - Finances
    - Information explosion
- Evaluation of PBL
    - Case assessment
    - Confidence levels and peer evaluation
    - Interviews with facilitator feedback
    - Not sure how to measure benefits
    - Quizzes
    - Writing assignments
- Future of PBL
- Reasons for using PBL
- Unique course elements

Figure 4: Final List of Groups and Codes Used in Study

Summary

Eleven instructors, selected by the presence of terms related to problem-based learning concepts, were invited to participate in this qualitative research study. In-depth interviews were conducted in order to determine how they were using problem-based learning in their courses. The sessions were recorded, transcribed and then coded using HyperResearch © software. Several of the codes were pre-defined before the analysis began in order to address the primary research questions, but many codes emerged as key concepts solidified during the three separate coding passes of the transcript data.

CHAPTER 4

RESULTS

This chapter describes the results obtained from the qualitative analysis of the interviews with instructors that were actively using problem-based learning methods in their courses. Instructors were invited to participate in this study based upon the presence of keywords related to problem-based learning concepts in their course syllabi. Instructors were asked to discuss their reasons for using PBL, the specific form(s) of PBL they had attempted, as well as how PBL could be used to overcome existing challenges in veterinary medical education.

Description of Participants

A total of eleven instructors, representing a wide variety of disciplines, were interviewed for this study. While each instructor was a veterinarian by training, they also brought with them perspective and experience from many of the specialty areas including pathology, nutrition, epidemiology and anatomy. In order to keep their identities anonymous, the participants have been renamed as Annette, Cheryl, Elizabeth, Jaime, Jason, Louise, Matt, Nathalie, Raj, Samantha and Steve. The table, below, illustrates each participant's rank, specialty area and the courses they teach.

Name	Rank	Specialty	Courses
Annette	Associate Professor	Epidemiology	VM 533 Veterinary Epidemiology
Cheryl	Associate Professor	Food Animal	VM 532 Veterinary Integrative Problem Solving
Elizabeth	Associate Professor	Clinical Pathology	PDI 554 Veterinary Clinical Pathology
Jaime	Assistant Professor	Endocrinology	VM 559 Metabolic and Endocrinological Diseases
Jason	Professor	Pathology	PDI 551 General Pathology
Louise	Associate Professor	Clinical Pathology	PDI 554 Veterinary Clinical Pathology
Matt	Professor	Food Animal	LCS 560 Fundamental Clinical Skills for Large Animals
Nathalie	Associate Professor	Anatomy	VM 524 Basic Science in Clinical Medicine
Raj	Professor	Anatomy	PDI 519 Comparative Veterinary Gross Anatomy II
Samantha	Associate Professor	Nutrition	VM 513 Ethical and Animal Welfare Issues in the Veterinary Profession; VM 514 Comparative Lifestage Nutrition
Steve	Associate Professor	Clinical Pathology	PDI 554 Veterinary Clinical Pathology

Table 1: Participant information

Annette. Annette is a veterinary epidemiologist and teaches several in-person and online courses. She received her DVM degree from MSU in 1991 and then worked in clinical practice for about two years. She attended the University of Illinois and earned a Masters degree in Population Medicine and Epidemiology. Next, Annette completed her Ph.D. in Population Medicine and Epidemiology at North Carolina State University. Her research focus is pre-harvest epidemiology of foodborne pathogens. She is also very interested in online learning. Annette is very technically savvy and realizes the impact that distance education, multimedia and other tools can have on veterinary medical education. Annette strives to help

students realize that epidemiology is relevant to their future careers as clinicians. This can be challenging, as Annette described,

> For epidemiology, they can't see where it would apply in their clinical life, and the way they envision themselves as clinicians. I show how epidemiology applies for what their ultimate career goal will be. For depth of learning and understanding, it's a deeper way of learning the material.

Epidemiology can be a difficult subject to teach, since there often are not simple black and white solutions to problems. For many students, this is their first time dealing with things that fall into "the gray area". However, this is very useful for preparing them for the clinical world, as Annette noted,

> For the second year students, it takes them to a place with gray answers, a lot of things they're going to be faced with in practice, where the answer is not necessarily clear. It's the first time they've faced some uncertainty in their clinical practice. All is not known. Making clinical decisions is an area of uncertainty. You have to be a little careful, because sometimes they freeze up. What do you mean we don't really know that?

Annette believes that relevance and retention are two of the key strengths of the problem-based learning format, as she described,

> It puts them in the scenario in which they want to envision themselves. They want to be a clinician. Putting it in a clinical setting makes it meaningful to them. Or, that's what I hope anyway. They can see that, even in simple things they've done in practice, what's really going on in the background? They can put themselves in that setting. If I can put them in the setting that they envision themselves being in, and show the relevance to their

career path, then it will help them to retain that knowledge and they can use it on their day job.

Cheryl. Cheryl is a large animal practitioner, specializing in equine medicine and surgery. She teaches the current Veterinary Integrative Problem Solving (VIPS) course, which is offered during the second year of the DVM curriculum. Cheryl has many years of experience using problem-based learning, and taught courses at Mississippi State University using these methods before coming to Michigan, as she described,

> I taught using only PBL for seven years in Mississippi. The whole curriculum was PBL only. I would teach equine, food animal, small animal. I have a big background in PBL. Then a new dean came in and they stopped doing PBL. Seven years with, and eight years without.

Cheryl sees problem-based learning as a useful tool that can help students become better critical thinkers, rather than relying on the rote memorization of information. As she noted,

> The goal is to teach them to think. And the sooner you teach them to think the better. That's the point of PBL. Teaching students how to think constructively and critically.

Beyond developing critical thinking skills, Cheryl also wants her students to have fun while learning, as well as develop their "soft skills", such as the ability to work effectively with group members. Students overall find her course to be a rewarding experience, as she described,

> I got hired to teach the PBL course. I already had the experience, and that's what they wanted. It's the most hardcore PBL that they get. They like it quite a bit. The goal of the class is that it's the funnest class that you have this semester. It's fun to work in

groups, and interact with your colleagues. It needs to be random collegial. Overall, the SIRS were positive. Students overall really liked it. But they're enthused about it.

Teaching VIPS can be challenging for Cheryl. In addition to the hectic logistics of the course, there is added pressure of knowing that this is the only VIPS experience students have in the current curriculum, compared to a total of five VIPS courses that were present in the previous version of the curriculum. Cheryl understands the value of VIPS, and how it offers students a unique experience, compared to other courses,

I'm not teaching diseases. I'm teaching them to think about diseases.

Elizabeth, Steve and Louise. Elizabeth, Steve and Louise together teach the Veterinary Clinical Pathology course during the second year of the DVM curriculum. They also teach the Pathology clinical rotation (PDI 630) and a graduate course called Advanced Clinical Pathology. Clinical Pathology is a complex topic that lends itself well to using problem-based learning techniques. As Louise stated,

Clinical Pathology is always about solving a series of problems. You have to take a lot of information, a lot of basic data. Even before problem-based learning was talked about as problem-based learning, it's been used in cases, and that sort of thing to start about Clinical Pathology. It's part of the discipline, at least the way we practice it. We're pretty committed to interactive, active learning formats.

Elizabeth believes that context is especially important. Rather than giving students an assortment of unrelated facts that they cannot directly relate to, she designs cases that utilize this information. This improves student reception, understanding, and retention, as she stated,

> To give them a series of facts isn't going to help them, when they ultimately go into their career. They have to learn to problem solve and supply that knowledge. It's also a nice hook to engage them and catch their interest, and I think you put it in the context of a case they're more likely to remember the material. And so they have a place to put it, and they understand where it fits, and I think it helps them remember it.

Steve also agrees that one of the strengths of their course is that it uses realistic data and processes that are reflective of what students actually use in practice. As he stated,

> I think that maybe, they said this too, the materials that we provide for clinical pathology, data, interpretation, understanding, are the same materials that they get when they're in practice, so it's just, it's reflective of what they will be doing, exactly what they will be doing to some extent. So they're going to get those case profiles, and they're going to have to think about them, and work through them, and that's basically how we organize most of our problem-based learning activities.

The Veterinary Clinical Pathology course takes place during the fourth semester, which tends to be the most stressful for students due to the high credit load (21 credits, along with several laboratory sessions) and the nature of the courses offered at that time. The instructors' first attempt at problem-based learning was more "traditional" and didn't supply any foundational knowledge that students really needed to be functional. As Elizabeth described, this did not have positive results,

> I would say when we first started with PDI 554, we tried to do the more traditional PBL, where they got a case, and we expected them to look at the case, and come in ready to discuss the material. And that didn't go over well, would be a nice way to say it. They

> weren't coming to class prepared. In my sense, they were not doing the reading they needed to do to prepare themselves to discuss the cases. So when we went through the cases, they didn't understand them. And, it was very difficult to keep them on task, and I think it's competition with everything else they have during a semester. So, I think that exercise didn't' work terribly well.

Steve agreed with the student stress level during the fourth semester being an impetus for them to develop a "hybrid" teaching method that utilized mini lectures in addition to cases,

> Semester 4 is a notoriously difficult semester. There are some instructors in other courses that really hold their feet to the fire and make them worry a lot. So, they have great concerns about success that semester. And they just felt like they didn't have the time to prepare in advance, or they felt they didn't, they needed a little more foundation from which to prepare, so maybe that was another aspect of the way it was done the first time around. They didn't have that little mini lecture or foundation to give them preparatory information from which they could learn.

Overall, Elizabeth, Steve and Louise believed their methods were very effective for preparing students for the clinical environment, as it is a much more active process of learning as Elizabeth described,

> I think it helps them learn to apply it, to use it, to understand it, to problem solve, so I think it's, in my book, I can't imagine teaching without doing case-based teaching.

Steve also believed that their design was much richer than a standard lecture, as it allowed them to build on their knowledge over time,

> I think the engagement and the application parts are really important at all of the levels that we do it, but thinking back to 554, where it's more preliminary, we could just lecture and give them base information, but they would miss out on the applied nature of what it is that we're doing, and seeing how these things unfold as panels, and profiles. We build from the beginning, towards the end, when you do those labs that are case-based labs, it's synthesizing, it's covering the large amount of materials from the whole class, whereas at the beginning we would just have data from the CBC. So, it allows them to build and apply in a way that they will be doing it in the clinic. That's the big strength that I see, at that level.

Jaime. Jaime is a veterinary endocrinologist and teaches the Metabolic and Endocrinological Diseases course during the third year of the DVM program. She also teaches an Endocrinology clerkship during the clinical portion of the curriculum. Jaime prefers to teach students basic concepts, rather than having them try to memorize voluminous amount of data, as she described,

> I'm a very practical person, and I never saw the value in having to memorize pages of worthless trivia that I was never going to trust my memory for anyway, I was always going to look it up anyways. It's more important to be able to do the basic stuff, and be able to interpret it without having to look everything up.

To her, problem-based learning embodies veterinary medicine. It is very useful for helping students learn to integrate information. After they graduate and enter clinical practice, students will need to determine what is wrong with their patients, as she noted,

> Problem-based learning? That's what veterinary medicine is. If you can't evaluate cases, you're not going to be much of a veterinarian. For Endocrinology, it's really all about evaluating patients. I always said animals did not come in the door with multiple choices on their side! That's the real strength, it's much more practical, and it's much more integrated. And that's the thing too, I see with some students who really struggle with being able to take the stuff that they're being taught in terms of lecture, and being able to integrate it, and put A and B together and make C out of it. I think that's the strength of PBL, because you have to form those connections, but you have to really know your background.

Jaime feels particularly challenged by the time constraints that are imposed on her course. She only has two credit-hours to teach the very complex subject of Endocrinology. As she stated,

> I feel like I'm always so limited by the amount of time I have. The VM 559 class is only a two credit-hour class. You have to cram all of Endocrinology into that. That is the problem, the time. There's so many cool things you can do, but where… Whatever I put in, I have to give up something else.

Jason. Jason teaches the General Pathology course, which is offered during the second year of the DVM curriculum. In addition to Pathology, he has a wealth of experience in teaching and learning strategies and student assessment. He has also received the CVM Distinguished Faculty Award on multiple occasions. Jason was heavily involved in the Veterinary Integrative Problem Solving (VIPS) courses and has been using problem-based learning methods for many years. He was very supportive of the teaching methods used in the VIPS courses in the previous

version of the curriculum and believed they were of great benefit to students. He described the reason for the original VIPS courses,

> When we were laying out the new curriculum, just an overall theme, was to have these so-called capstone courses, the VIPS courses, in the pre-clinical semesters. Their goals in general were going to be to integrate what the students were learning in the other courses, and to demonstrate it in a clinical way, demonstrate those basic science concepts in a clinical way, whether they used problem-based learning or not. Do something that was going to tie everything together. The VIPS course was meant to be that capstone course.

Jason believed the VIPS courses served to link didactic materials to the clinical environment, and improved students' retention of basic concepts, as he described,

> Well, I think the students do appreciate seeing the clinical applications of what they're learning, in the basic sciences courses. And, I've had many comments on the SIRS forms, where they tell me when they're third and fourth students that, you know, I saw a case of such and such in the clinics, and I remembered that we had a case of that in VIPS, and they remembered the VIPS case, so it helped them in the clinics. So, that makes me feel good. I think they remember those cases, and they remember what they got out of those cases, so I think there's maybe a longer term retention of the basic concepts, in addition to seeing the clinical application of those basic concepts.

Jason has been an advocate and user of problem-based learning techniques for about sixteen years, and has studied what instructors have done at various other veterinary institutions, including Mississippi, Cornell and Purdue. One of his motivators for using PBL in VIPS, and in Pathology, was to increase student enjoyment in the process, as he stated,

> I guess from what I had learned from reading, and from Purdue… I got kind of excited about it [PBL], and it seemed like a fun way to learn.

Jason is a dedicated educator and has been involved in multiple initiatives including the NAVMEC conference series, the College's Veterinary Scholarship of Teaching and Learning group, as well as the annual CVM Education Day event, which is designed to explore innovative instructional methods.

Matt. Matt is a food animal veterinarian and has received numerous teaching awards including the Norden Distinguished Teacher Award and the CVM Distinguished Faculty Award. Despite his prominence in the field, Matt is extremely personable and approachable. Students are especially comfortable with the way he uses cases and stories to illustrate key concepts, as Matt described,

> One of the reasons I was popular as a faculty, was that I always told stories. I had stories for all cases, that would support what we were talking about. I had a case that… I'd give them a little case-based kind of thing. It was a type of problem-based, but more case-based. I've been doing it really since I've been teaching.

Matt has been using PBL techniques for many years and was a VIPS moderator back in the 1990's. He believes relevance and retention to be the major strengths of PBL, as he noted,

> The major strength of PBL is that it does add the relevance into learning. It presents you, puts you in a situation where you recognize what's important, and what may be less important. It's extremely situational. It puts it all into perspective. That's the major strength of it. Rather than rote memory, it gives you relevance. And it gives you a feeling of accomplishment, because you feel like I'm learning something that I'm going

to use. I can understand, I'm going to remember this. I think they do. One of the major advantages is retention of information because of relevance.

Matt's teaching style is notable different from most other instructors. Rather than rely on a PowerPoint presentation with a few dozen slides, which seems to be commonplace, he oftentimes will project an image of a cow and use that as the focal point for the entire lecture. He then asks the students to describe what they see, develop a list of possible diagnoses and formulate treatment plans. While this format at first shocks most students, they quickly recognize its usefulness and become active participants in the process.

Nathalie. Nathalie is a veterinary anatomist and teaches Comparative Veterinary Gross Anatomy, as well as Basic Science in Clinical Medicine in the first year of the curriculum. She has been using problem-based learning for several years and believes that it helps students to apply their knowledge, as well as develop better communication skills by working with their groups. As she described,

> The students can apply, they're better, by having to apply their knowledge, they actually gain a better understanding of it. By working in a group, they can learn from each other. They can fill in gaps in their own understanding, or catch errors sometimes. They gain a better feel for what it's used for. They start to apply, it's a tool that they need to know. I've had several students that say that they learned more in this class, than they do in the other courses. They actually have to think their way through the case. They also, there's some process skills there. Working in a group, listen to each other in a group, communicating their ideas to others in a group. There are process skills that are integrated into working in a group that are very important too.

Nathalie uses PBL heavily in the Basic Science in Clinical Medicine course. This is often challenging to students, as it is a format with which they are not initially comfortable, and it usually requires more effort than their other courses. Despite these factors, she believes the course is very well-received by students, as Nathalie stated,

> They absolutely love it. In VM 524, they really like the course. I get pretty favorable reviews. This year, I made it a bit harder. They need to submit answers to quiz questions as a group. That made it more work for them, so they're a bit more, this is hard work. They still really like the course. They have to work a lot harder, and try to meet as a group afterwards. They like the course. The format. They feel it engages them.

Raj. Raj is a Neuroendocrinologist and teaches the Gross Anatomy course during the first year of the DVM program. He is a very dynamic speaker and likes to use several forms of multimedia in his lectures, as he described,

> In my class, I make sure that I give a little bit of visual, auditory and reading experience. It happens naturally, because this is Anatomy. They get to see it, feel it, dissect it, and I also lecture. All a combination of it. Video demonstrations. Virtual dissections. We create models. They can listen to it. All sorts of ways are incorporated into the course. I apply the same method to endocrinology also.

Raj is also very careful not to overwhelm his students during lecture. Rather than attempting to give them every possible detail, as many instructors do, he prefers to use his slides as a guide, making the class more of an interactive experience with discussion, as he detailed,

> Some people try to put too much into the curriculum. If you look at any of my lectures, none of my lectures will have more than 25 slides. If I put more than 25 slides, I cannot

finish in the lecture. I do not just verbatim say what is on the slide, it's more extempore. I use the slide as a crutch, but more interactivity. Ask questions. If you get that, this is what's going on. That's another reason why they come to my lecture. They do not get a whole lot just by looking at my slides. They believe that they get more by staying in the class and listening to me directly. Teachers try to give too much within that one hour time. Us, as a whole, the curriculum, trying to teach them too many things, in that 2.5 years. In terms on Anatomy, we have cut back a lot. We have cut back so much consciously. Details. So many details. Do we have to make them memorize all 25 branches of the axillary artery? Every unit we have an important list of structures, to reinforce the important ones. If you feel like dissection more, we'll give you instructions for that. But don't kill yourself trying to pick out the other branches. We don't go into really details, only the major important ones, and comparative. I constantly change what I want to talk about. I'm very fluid, really flexible. I don't rehearse. My lectures are not etched in stone. I'm more on the fly.

Raj also uses classroom response technologies to help keep students engaged. Rather than passively delivering a typical fifty-minute lecture, this approach allows him to actively gain feedback from students every few minutes, as he described,

It's kind of like a hybrid kind of model. I will bring in a couple of cases related to what I was talking about, make the students answer it, and then clarify if they answered the questions wrong or things like that. This goes very well with iClickers. Also, it gives me an opportunity to take them out of the monotony of lecture. Every ten minutes, make them think, and bring them back to the lecture.

Samantha. Samantha is a clinical nutritionist and teaches in the Comparative Lifestage Nutrition course, as well as the Ethical and Animal Welfare Issues in the Veterinary Profession course, both of which are taught during the first year of the program. Even though Samantha's courses are taught during the didactic portion of the curriculum, she utilizes many clinical techniques including taking a history from a client and performing a physical exam. These activities are carried out in a simulated environment in the Learning and Assessment Center (LAC) as Samantha described,

> The one thing the students like the most about the nutrition course is the chance to go to the LAC. To me, this is the problem-based learning approach. It's problem-based and it's case-based, but they don't do it in a group. Each student goes on two different occasions to the LAC to meet with a client and their healthy dog or cat. The students have to take a diet history from that person and perform an abbreviated physical exam on the dog or cat. Students are expected to assign a body condition score to the animal and answer any questions the client-actor might have related to food or feeding their pet. In the years when I first did this, I had client actors bring their own animals and give their own diet history. But after a couple years of that approach, I decided I'd better give each actor a similar type of diet history and 'plant' some specific questions for them to ask the students. I don't know if it was fair, but I think I was able to give some more structured questions and along the way I've also gotten better at helping the actors. My instructions to the client actors now say in the diet history, "only tell the student about the treats you feed if they ask". Students get videotaped in-action and they get feedback from the client-actor. Each student also has to complete a self-evaluation form within one week of their scheduled event.

The near-immediate feedback that students receive from this process is one of the main advantages of this method, as Samantha stated,

> They get some feedback fairly quicky because they can look at an electronic report with what the actors said about them. Also, each student has to spend some time thinking about their own performance. They can go through the motions and do nothing, or they can actually really think about it. Sometimes, their reflection or summary is quite thoughtful, which is good. One of things I will do in the future is provide feedback in the form of a clinician or technician reviewing their tapes and sharing constructive feedback. This has been optional in the past but I want to incorporate it so I can say every student is getting feedback from someone on our teaching staff about their performance.

Samantha believe that self-reflection also plays a major role in the learning process, as she commented,

> So, I think for the student, it's being in the moment to practice, and then they get some immediate feedback from the client-actor on what they did well. It's also their opportunity to practice self-reflection. You have to watch your tape and you have to be able to say, "Here's where I did this…" or "Here's where thought I was effective…" or "Here's where I thought I wasn't as effective and I can work on it." What I know is that for students who spend time doing it and doing it well, it shows up on what they write in their self-reflection. If they hardly do anything, the bare minimum, that shows too.

In the Ethics course, Samantha believed her written assignments and group discussions gave students an opportunity to learn from each other, as well as express themselves in ways that are not possible with multiple choice questions. Samantha's courses are unique in this

perspective as, unlike other disciplines, ethics and nutrition are difficult to both teach and assess without these methods. As Samantha stated,

> From my perspective, the most valuable aspect of the Ethics course is the chance for students to hear each other and to hear their own voice; for them to be able to express themselves out loud. And in my course they have to have done a little bit of pre-thought or pre-work, so that they come (not just spouting out a lot of hot air but) having thought about the topic beforehand. And being able to listen to other peoples' opinions, that can really influence them. So, for the Ethics class, that interaction and "testing" of one's opinion has great benefit.

Research Questions and Results

The following sections will focus on a detailed analysis of the research questions for this study. The courses that are currently using problem-based learning, and the instructors' reasons for doing so, will first be explored.

Research Question 1 Analysis: Perception and Use of Problem-based Learning

Q1) How do instructors at MSU CVM perceive and use problem-based learning?

- Question 1a: Which instructors are using problem-based learning in their courses?
- Questions 1b: What reasons are given for using problem-based learning?

The findings for this first research question, based on the analysis of course syllabi for presence of keywords related to problem-based learning, indicate that PBL in some form is used in many courses across the curriculum. It is also used in each of the five semesters of the DVM didactic program, but to varied degrees. Problem-based learning appears to be especially

prevalent in the second year of study (Phase II), with six courses including multiple PBL-related terms in their syllabi. Semester five (Phase III), the semester immediately before students enter clinics, has the lowest occurrence of PBL-related terms. A total of three course syllabi in semester five include relevant terms, but two of these were quite minimal. As for the reasons that instructors use problem-based learning in their courses, the participants' responses focused on several key themes. Instructors believed that PBL helps to improve students' critical thinking and improves their ability to integrate information that they previously learned. They viewed the ability to evaluate a clinical situation and make decisions as more important than having students memorize endless facts. Contextualizing information, and relating it to what students will be doing when they graduate, makes it more relevant, and enjoyable, for them. These concepts are discussed in more detail in the following sections.

Instructors Using Problem-based Learning in Their Courses. As previously mentioned, all of the course syllabi in the pre-clinical curriculum were analyzed for the presence of keywords related to problem-based learning. This included terms related to cases, group work, discussions, critical thinking and active learning.

Semester 1. Table 2 (below) shows the findings of the syllabi analysis for Semester 1 of the curriculum. Only one course, VM 513 Ethical and Animal Welfare Issues in the Veterinary Profession, included PBL-related keywords in its syllabus. VM 513 made mention of several PBL terms, focusing on small group work and cases. None of the syllabi from the other courses in Semester 1 included PBL-related keywords. I did not anticipate encountering PBL in most of the courses in Semester 1, as it has traditionally been very lecture-intensive, delivering foundational knowledge to students in their first semester of the program. Courses such as

MMG 559, PDI 518 and PDI 520 consist primarily of lecture and laboratory sessions, with little to no time allotted for discussions or group work. Similarly, VM 511, Veterinary Clinical Examination and Techniques, is a hands-on course, focusing on the handling, restraint and palpation of several animal species including dogs, cats, horses, poultry, cows and sheep. I was somewhat surprised that PBL terms were not encountered in the syllabus for PDI 514 Veterinary Neurosciences. I believe this particular topic would lend itself well to PBL with the use of cases, as the goal for the student is to learn how to localize lesions in the brain and spinal cord that are causing clinical signs of disease. It may be that students at this early phase in their academic career, do not have the knowledgebase they need in areas such as anatomy, physiology and diagnostic imaging, to effectively work through cases in neuroscience.

Semester	Course	Problem-based learning keywords
1	ANS 511 Animal Science for Veterinarians	None
1	MMG 559 Veterinary Microbiology and Immunology	None
1	PDI 514 Veterinary Neurosciences	None
1	PDI 518 Comparative Veterinary Gross Anatomy I	None
1	PDI 520 Veterinary Tissue Structure and Function	None
1	VM 511 Veterinary Clinical Examination and Techniques	None
1	VM 513 Ethical and Animal Welfare Issues in the Veterinary Profession	Small group case discussions, small group session, small group cases based on scenarios, small group meetings, discussion hour, contributions you made to the discussion

Table 2: Problem-based learning keywords in Semester 1

Semester 2. Table 3 (below) shows the findings of the syllabi analysis for Semester 2 of the curriculum. Four courses (PDI 519, PSL 513, VM 514 and VM 524) mentioned PBL-related keywords in their syllabi. PDI 519 Comparative Veterinary Gross Anatomy II and VM 524

Basic Science in Clinical Medicine included an abundance of PBL terms and stressed the clinical aspects of what was being taught in the course. Some examples of this in PDI 519 include "clinically relevant details of anatomy", "application…to relevant clinical situations", "clinical modules", "clinical cases", and "clinical quizzes". Likewise, VM 524 mentioned "interacting with clinicians and faculty", "simulated clients" and "client interviews".

Semester	Course	Problem-based learning keywords
2	MMG 571 Veterinary Pathogenic Microbiology Parasites	None
2	PDI 519 Comparative Veterinary Gross Anatomy II	Clinically relevant details of anatomy, application of the material learned in anatomy to relevant clinical situations, better application of the learned material, clinical modules, clinical cases, without rote memorization, assigned to specific groups that consist of 7 or 8 of your classmates, clinical correlations, clickers quizzes
2	PDI 521 Veterinary Organ Microanatomy	None
2	PHM 552 Veterinary Pharmacology 1 Principles and Neuropharmacology	None
2	PSL 513 Animal Physiology for Veterinarians	Work in groups to integrate information, actively participate in VM 524
2	VM 514 Comparative Lifestage Nutrition	Hands-on activities, skills used in daily practice, scheduled interviews in LAC with simulated client-actors
2	VM 524 Basic Science in Clinical Medicine	Construct their own understanding, case-based format, team-based approach, critical thinking skills, small group work and learning, small group discussions and assignments, interacting with clinicians and faculty during question and answer sessions, interacting with simulated clients, solve clinical problems as a team, this course is case-based, client interviews
2	VM 541 Veterinary Career Development and Practice Management	None
2	VM 548 Principals of Diagnostic Imaging	None

Table 3: Problem-based learning keywords in Semester 2

Semester 3. Table 4 (below) shows the findings of the syllabi analysis for Semester 3 of the curriculum. Three courses (PDI 551, VM 532 and VM 533) contained PBL-related keywords in their syllabi. Not surprisingly, VM 532 Veterinary Integrative Problem Solving (VIPS) mentions many PBL terms. As described earlier, VM 532 is a capstone course that is specifically designed to help students integrate what they are learning across the rest of the curriculum using cases in a student-led small group environment. PDI 551 General Pathology and VM 533 Veterinary Epidemiology are also represented and focus mainly on clinical relevance and case discussion.

Semester	Course	Problem-based learning keywords
3	MMG 563 Veterinary Pathogenic Microbiology Bacteria and Fungi	None
3	PDI 551 General Pathology	Gross Necropsy Rounds, cases are presented and discussed
3	PHM 553 Veterinary Pharmacology 2 Systems and Infectious Diseases	None
3	PHM 557 Veterinary Toxicology	None
3	VM 532 Veterinary Integrative Problem Solving	Integrate, problem solving, clinical reasoning, information gathering and processing, interpreting data, applying concepts, teamwork, life-long learning skills, case-based learning format, work in groups, discuss clinical cases, facilitator, student-led learning process, facilitator serves only as a guide, independent study and research of topics
3	VM 533 Veterinary Epidemiology	Clinical decision making skills, case study work, multiple learning methods, application (case studies)
3	VM 544 Veterinary Public Health	None
3	VM 547 Respiratory Diseases	None

Table 4: Problem-based learning keywords in Semester 3

Semester 4. Table 5 (below) shows the findings of the syllabi analysis for Semester 4 of the curriculum. Three courses (LCS 560, PDI 553 and PDI 554) contained PBL-related keywords in their syllabi. PDI 554 Veterinary Clinical Pathology contained a multitude of terms including active learning, problem solving, group work and clinical relevance. The other two courses, LCS 560 Fundamental Clinical Skills for Large Animals and PDI 553 Systemic Pathology, focused on clinical cases.

Semester	Course	Problem-based learning keywords
4	LCS 560 Fundamental Clinical Skills for Large Animals	Scenarios, hypothetical case studies, clinical situations
4	MMG 565 Veterinary Pathogenic Microbiology Viruses	None
4	PDI 553 Systemic Pathology	Grand Necropsy Rounds, necropsy cases
4	PDI 554 Veterinary Clinical Pathology	Active learning, apply and extend content material, integration of course material in a problem solving format, group assignments, understand and use information in clinically relevant situations, actively engaged in class discussions, confidence and lasting learning, actual cases from clinical experience, collectively discussed/debated/argued, group assignments, case scenarios
4	VM 543 Cardiovascular Diseases	None
4	VM 545 Principles of Anesthesia and Surgery	None
4	VM 546 Musculoskeletal Diseases	None

Table 5: Problem-based learning keywords in Semester 4

Semester 5. Table 6 (below) shows the findings of the syllabi analysis for Semester 5 of the curriculum. Three courses (SCS 561, VM549 and VM 559) contained PBL-related keywords in their syllabi. Compared to previous semesters, the keywords were not especially prevalent in Semester 5. SCS 561 Fundamental Clinical Skills for Small Animals and VM 559 Metabolic

and Endocrinological Diseases were both quite vague, including only “clinical problem solving” and “interactive format, case examples”, respectively. VM 549 Applied Diagnostic Imaging was slightly more detailed and included mention of interpretation, application to clinical cases and group work.

Semester	Course	Problem-based learning keywords
5	SCS 561 Fundamental Clinical Skills for Small Animals	Clinical problem solving
5	VM 549 Applied Diagnostic Imaging	Interpreting clinical imaging studies, apply principles to clinical cases, groups of two students
5	VM 553 Theriogenology and Urinary Diseases	None
5	VM 554 Hematological, Oncological and Dermatological Diseases	None
5	VM 555 Neurological and Ophthalmological Diseases	None
5	VM 557 Operative Surgery	None
5	VM 558 Digestive Diseases of Domestic Animals	None
5	VM 559 Metabolic and Endocrinological Diseases	Interactive format, case examples

Table 6: Problem-based learning keywords in Semester 5

In summary, a total of 14 courses included some type of PBL-related keywords in their syllabi. The breakdown of courses by semester is as follow: Semester 1:1; Semester 2:4; Semester 3:3; Semester 4:3; and Semester 5:3. Based on this information, problem-based learning use is highest in Phase II (Semesters 3 and 4) of study, which focuses on the study of Abnormality and Disease. This may be due to the fact that, by this point, students have obtained enough foundational knowledge in key subjects such as anatomy, physiology, microbiology, pharmacology and diagnostic imaging that they can benefit from cases and discussions that

require basic functionality in these areas. Problem-based learning use appears lowest in the final semester (Semester 5) of the didactic portion of the curriculum. While the curriculum is structured with an intention of utilizing Semester 5 (also called Phase III) for "Intervention and Prevention", the majority of the courses are similar in structure to those in Phase II and focus on Abnormality and Disease. For example, five of the eight courses in Phase III address some form of disease (theriogenological and urinary, hematological, oncological and dermatological, neurological and ophthalmological, digestive, metabolic and endocrinological). With the exception of VM 559 Metabolic and Endocrinological Diseases, these courses are lecture-intensive and do not utilize problem-based learning tools such as cases and discussions.

Reasons for Using Problem-based Learning. Understanding *why* instructors are using problem-based learning in their courses was a crucial factor in this study. To facilitate the exploration and analysis of the participants' responses, a code named "Reasons for using PBL" was defined in HyperResearch© before the interview transcripts were coded. Several common themes emerged as this topic was discussed with the instructors. The instructors indicated that they believed PBL helped their students to integrate previous knowledge and improve critical thinking. They also believed that PBL helped them to evaluate clinical situations more effectively. Using PBL, the information presented to students is contextualized and may be perceived as more relevant to their future careers.

Jason felt that the reason for using problem-based learning was to integrate all of the information that was being taught across the curriculum, as he described,

> The goals in general were to integrate what the students were learning in the other courses, and to demonstrate it in a clinical way, demonstrate those basic science concepts in a clinical way. Do something that was going to tie everything together.

Nathalie also felt that the integration and application of previous knowledge was the primary reason for using problem-based learning. Rather than memorizing information only for an exam, PBL requires students to have an on-going ability to recall and utilize knowledge from other areas, including communication skills. As Nathalie noted,

> They gain a better feel for what it's used for. They tend to understand, this is intangible. They learn the physiology, but it's in one ear out the other. They learn it for the exam, then it's gone. They start to apply, it's a tool that they need to know. I've had several students that say that they learned more in this class, than they do in the other courses. I'm using it. They actually have to think their way through the case. They learn, they get a lot. They also, there's some process skills there. Working in a group, listen to each other in a group, communicating their ideas to others in a group. There are process skills that are integrated into working in a group that are very important too.

Cheryl also felt that problem solving and critical thinking skills development were vital abilities that problem-based learning helped to reinforce,

> I really think it helps their critical thinking. People that couldn't really walk the line are now able to do that. That's problem solving, critical thinking, all those names that I love about veterinary medicine, beyond memorizing things. Especially now days, there's access to everything. If you can teach them to think, that's everything. Teaching them to think, that's my job.

Jaime indicated that the ability to interpret information was essential,

> It's more important to be able to do the basic stuff, and be able to interpret it without having to look everything up.

The link to, and preparation for, the clinical environment was another common theme that emerged in the discussions with the instructors. Even though they spend five semesters in a classroom environment, veterinary students are expected to apply their knowledge to patients during their clinical rotations during their last three semesters of study. As several instructors indicated, they use problem-based learning in an attempt to help prepare students for the clinical environment. For most, this is viewed as the nature of veterinary medicine. As Jaime described,

> That's what veterinary medicine is. If you can't evaluate cases, you're not going to be much of a veterinarian. If I was teaching straight physiology, but even there, there's case-based approaches. But, for Endocrinology, it's really all about evaluating patients.

Louise felt similarly regarding her specialty, Clinical Pathology,

> Clinical Pathology is always about solving a series of problems. You have to take a lot of information, a lot of basic data. Even before PBL was talked about as PBL, it's been used in cases, and that sort of thing to start about Clin Path. It's part of the discipline, at least the way we practice it. We're pretty committed to interactive, active learning formats.

For Samantha, one of the reasons for using problem-based learning was her perception that it gives students an opportunity to be "hands on" in a clinical setting, rather than passively listening to lectures,

> I think it's that they actually get to practice the skill of taking the diet history, communicating with the client, putting their hands on an animal and practicing the physical exam.

Similarly, several instructors felt that the *relevance* of problem-based learning activities was especially useful. They believed that students were more interested in these types of exercises, as compared to stand-and-deliver lectures, and they may have viewed them as better preparation for the clinical world after they graduated. As Matt described,

> The major strength of PBL is that it does add the relevance into learning. It presents you, puts you in a situation where you recognize what's important, and what may be less important. Because, when you go into a straight lecture class, we could teach all of the anatomy that you wanted with straight lecture, but we recognize that the look and see and feel, and put relevance as to why you need to know the anatomy… It's extremely situational. That's the major strength. Most students will learn from recognizing, this is a case, this is the reason we're learning this. It puts it all into perspective. That's the major strength of it. Rather than rote memory, it gives you relevance. And it gives you a feeling of accomplishment, because you feel like I'm learning something that I'm going to use. I can understand, I'm going to remember this. I think they do. One of the major advantages is retention of information because of relevance.

Annette had a similar perspective, and used problem-based learning to help students prepare for their lives as clinicians out in practice,

> For Epidemiology, they can't see where it would apply in their clinical life, and the way they envision themselves as clinicians. Show how Epidemiology applies for what their ultimate career goal will be.

Elizabeth agreed, emphasizing that she believed context helped to improve students' understanding and the relevance of the material she was teaching,

> In my mind what it does is, it creates active learning, but it helps students supply the knowledge. To give them a series of facts isn't going to help them, when they ultimately go into their career. They have to learn to problem solve and supply that knowledge. It's also a nice hook to engage them and catch their interest, and I think you put it in the context of a case they're more likely to remember the material. And so they have a place to put it, and they understand where it fits, and I think it helps them remember it.

Steve, who co-teaches the Clinical Pathology course with Elizabeth, had a similar feeling and stressed the fact that he believed what the students experienced with their problem-based learning activities was similar to what they will encounter in clinical practice,

> The materials that we provide for clinical pathology, data, interpretation, understanding, are the same materials that they get when they're in practice, so it's just, it's reflective of what they will be doing, exactly what they will be doing to some extent. So they're going to get those case profiles, and they're going to have to think about them, and work through them, and that's basically how we organize most of our PBL activities.

In summary, some form of problem-based learning was present in each of the five pre-clinical semesters of the curriculum. It was most prevalent in the second year of study (Phase II), which focuses on Abnormality. It was least prevalent in semester five (Phase III), which

teaches Intervention and Prevention. Instructors cited a variety of reasons for why they used PBL, including an effort to integrate information from previous courses, development of critical thinking skills, improved evaluation of clinical situations, and contextualization of information to make it more relevant to students' future careers.

Research Question 2 Analysis: Problem-based Learning Development

Q2) How are different faculty members developing problem-based learning?

- Question 2a: What forms of problem-based learning are being used, and why?
- Question 2b: What unique elements in each course lead to the selection of particular PBL forms?

The findings for the second research question indicate that many different forms of problem-based learning, based on the typologies developed by Barrows (1986) and the ten descriptive dimensions formulated by Charlin et al. (1998), are being used by instructors in the College. In the majority of courses, instructors are using two or more typologies, with Lecture-based Cases being the most common. The most advanced typology, Closed-loop or Reiterative Problem-based Learning, is the least common and is only used by instructors that have significant experience with problem-based learning and teach the VIPS-like courses.

As for Charlin's dimensions, the discussions indicated that most PBL encounters focused on topics and objectives that were selected by the instructor, were delivered as a computerized case, and were completed in one session. The purpose of the problem most commonly focused on teaching basic sciences, physiology, clinical reasoning and communication, with a task of explaining or defining a phenomenon and making a diagnosis. Students worked in class with moderators and were allowed to use any type of resource they desired. Instructors were

facilitators/guides in the PBL process, but also functioned as content experts when needed. Written examinations were the most common form of demonstration of learning, but some instructors also used discussions, presentations, written group assignments and simulated client interviews.

The instructors believed PBL was especially useful when their courses involved teaching critical thinking and problem-solving skills, if they wanted their students to integrate and apply what they already knew - rather than learn new factual information, and when their course content required discussion, analysis and interpretation. The process of implementing and using PBL involved several challenges. Developing and using PBL took more time and effort, as compared to traditional lectures. Students required more time to work through the PBL exercises. Locating space in the College for small group discussions and other PBL activities was difficult. Instructors had to put additional efforts into overcoming the restrictions of what they termed "pure PBL", as they believed it did not provide enough guidance for their students. These issues are discussed in more detail in the following sections.

Forms of Problem-based Learning Being Used at the College

Lecture-based cases. Lecture-based cases were, by far, the most commonly mentioned typology in the instructor interviews. Each of the eleven participants reported using this format at some point in their courses. In Lecture-based cases, students are given traditional lectures, then one or two cases to demonstrate a particular issue of relevance. Given that most instruction at MSU CVM occurs in a large classroom environment, utilizing this format is fairly simple for the instructor and does not typically lead to any logistical challenges. Samantha has used this form in both of her classes, as she described,

> In our Ethics class, with the large group sessions, I might sometimes use a Lecture-based case. And, in the Nutrition course, it would not be uncommon for the guest instructor covering canine, equine, bovine, or avian species to present a vignette or two, and then walk the students through the relevance of the information and how it might apply to the clinical setting. So lecture-based cases are definitely used in both courses.

Matt also uses Lecture-based cases in his course. He prefers it to other approaches that require students to review materials ahead of time, since they often come to class unprepared. The use of classroom response technologies are a valuable addition to this format, as he described,

> Lecture-based cases. I definitely do, it emphasizes importance, it gives relevance, it takes a topic and turns it clinical. I guess, most of what I'm doing, I'm doing in class, give them the information, right then, as a directed kind of a lesson, in a specific topic. What I find is…to have students do it out of class, it doesn't get done to the level… You walk into a class of 100, and maybe 20% of them have looked at it. That's the reason I do the Lecture-based cases. I don't use iClickers. I used to us, in G-150, when we had it, I used to use, we built that one program Q&A, if I could get in and get the questions presented. What I liked about that, I felt what was so revealing, was the immediate feedback, how many people got it right, and how many people did not. I like that format. I can guide the discussion much better than if I just give them information and tell them to do this case.

Raj uses a similar approach, with several cases covered during each lecture. He also emphasized the value of using classroom response systems, in this case iClickers,

> I would say Lecture-based cases, pretty much every lecture. I'm using… maybe three or more (cases) per lecture. They use iClickers a lot. This goes very well with iClickers. Also, it gives me an opportunity to take them out of the monotony of lecture. Every ten minutes, make them think, and bring them back to the lecture.

Jaime follows the Lecture-based case format for each of her lectures. Foundational information is delivered first, followed by cases related to that topic. Time is always an issue, since she only has fifty minutes to cover all of the material, as she noted,

> For VM 559, I use mostly lecture-based cases. We have to present the information first. I'll have my whole lecture, and then at the end, I'll do clinic cases. And so, we'll just go through a number of cases step-by-step and figure out treatments. Every lecture is set up this way, so there's information and then... You get to the end and there's the dog cases, and cat cases, for hyperthyroidism. That's the way all of my lectures are. The lectures are 50 minutes. It's gotta go really fast. For VM 559, that's probably what I use the most.

Case-based Lectures. The case-based lecture format is used by a few instructors, but is far less popular than the Lecture-based case approach. Case-based lectures involve giving cases to students ahead of time that will be covered during the next lecture. Because of their high credit loads each semester and hectic schedules, students rarely find time to review these cases before they are presented in class. Matt, Cheryl and Annette reported using this format on occasion. Jaime is planning on trying the Case-based lecture format this year, giving students more of her cases in advance. Louise uses multiple PBL formats in her course, depending on what she would like to accomplish, as she described,

> So we're really using PBL cases in four different places in different ways there. It gets kind of complex and messy. I think that they have different purposes and different places in the course. I considered the class as more of a combination of Lecture-based and Case-based lectures, we kind of hybridized them.

Case Method. With the Case Method approach, students are given complete cases ahead of time that will be used in an upcoming class discussion. This format is more interactive than the previous two described, and involves a greater degree of discussion. Samantha reported using this format in her Ethics and Welfare course,

> This format (case method) is the one I would say is used primarily during the middle six weeks of the Ethics and Welfare course. Students are given a case scenario or vignette, and then required to prepare an outline that includes a statement framing the ethical dilemma, listing 5 key stakeholders, two opposing approaches to the dilemma, and they are expected to come to the discussion with that outline ready to go.

The Case Method is also used for a portion of the Clinical Pathology course, as Louise described. Her approach, however, has changed over time and the assignment is now much more focused, as she described,

> Case Method is more typical for the assignment, and that has morphed, over the three of four years we've done that case. The first year we really gave them big chunks of stuff and said go swim in the deep end. And it didn't work out so well. And we've gotten more and more directed in the assignments and the questions we ask, and the way we approach it. It's becoming less of an open-ended question used in cases, and more directed over the years.

Modified Case-based Method. In the Modified Case-based method, students are given cases but have more opportunity for self-direction and can make a limited number of choices regarding diagnostics and treatments. None of the instructors interviewed indicated that they were using this method in any of the courses they taught in the pre-clinical curriculum. Jaime did mention that she was using the Modified Case-based Method in her clinical rotation (PDI 634), with a series of cases that she constructed. These are best used for self-study or in small groups, as she described,

> These are cases that I've collected over the years. With the interpretation on the back. It's a very, it's a nice self-study tool for them. I've had a number of the Residents come over and sit with these. I have online, I have case sets like this, where these are all online, where, similar to this, but online, where they'll have the case here, but the next slide will have the results and the interpretation on it. I have it in multiple formats for them, so they can work in groups like doing this, where they can actually… I encourage them to do that, and they work over here in the conference room here. They can ask me questions if they have questions. They're in groups of two for the clerkship, and the idea is that they work together, and discuss the cases together. If the students have questions, they'll come, but I don't specifically discuss them, because there's so many of them. It's the repetition. I don't expect them to get through every single case, but to do as many as they can, and they're always there, and they can come in and work on them.

Problem-based Learning. In the Problem-based Learning approach, students are allowed free inquiry with the cases. Cheryl, Nathalie, Elizabeth, Steve and Louise all indicated that they use this method in their courses. Elizabeth described the experience in Clinical Pathology in greater detail,

> I would say it's much more like the traditional Problem-based Learning. We give them a case, divide them into groups, they sit and work through the case, then there's a discussion period at the end that can delve into where ever they want to go with the case. They're given a set of case data, then they divide into small groups. Supposed to be using their notes, internet, come with books and things like that. They're talking about it, working their way through the case. Then, it comes to a discussion, and then we kind of go through the case, step by step, I ask directive questions, get responses. Can they explain the lab abnormalities, can they come up with a mechanism for this, and then at the end it's a summary of, what are the major problems? What are you thinking and what else might you want to do in terms of diagnostic tests? Then I usually give them a conclusion of what was done in the clinic, what happened to the animal, so they find out in real life what happened to that particular animal.

Closed-loop or Reiterative Problem-based Learning. In Closed-loop or Reiterative Problem-based Learning, students are given an opportunity, after free inquiry, to return to the original patient problem for a discussion and reflective phase. Cheryl and Nathalie both indicated that they use this method in their courses. In both instances, the entire class will gather at the end of the week, often with a content expert present, and discuss what was learned on that particular case. Based on Elizabeth's description for the process in Clinical Pathology, in appears as though Closed-loop or Reiterative Problem-based Learning is used in that course as well.

In summary, all of the typologies developed by Barrows (1986) were represented in the pre-clinical curriculum, but to varying degrees. Instructors tended to use two or more typologies in their courses, and in some cases they developed their own hybridized formats. Lecture-based

Cases was the most commonly used typology, and was frequently selected by instructors that taught disease processes. Closed-loop or Reiterative Problem-based Learning was the least common typology and was used by instructors that had significant experience using PBL, and by those that taught the capstone (VIPS) courses.

Dimensions of Problem-based Learning

In addition to the Barrows typologies described above, the ten Charlin dimensions were also discussed during the instructor interviews in order to develop a more detailed account of their problem-based learning encounters. As described by the instructors, the majority of PBL exercises at the College focused on a topic selected by the instructor, were delivered as computerized cases, and were completed in one session. The purpose of the problem varied, but most commonly focused on teaching basic sciences, physiology, clinical reasoning and communication, with a task of explaining or defining a phenomenon and making a diagnosis. Most frequently, students worked in class with moderators and were allowed to use any type of resource they desired. The instructors acted as facilitators and guides in the PBL process, but at times were required to function as content experts. Demonstration of learning usually occurred by written examination, but some instructors used more elaborate methods such as discussions, presentations, written group assignments and simulated client interviews. The Charlin dimensions are explored in further detail in the following sections.

Person who selects the problem or topic. In all of the interviews, the participants indicated that either the instructor or the moderator selected the topics that would be used for the cases and discussions. There were no examples of students being given this option. The College currently does not have a Curriculum Designer, so this choice was also never mentioned. The

course moderators were quite flexible and tended to give other instructors in the course, and guest lecturers, the freedom to select cases that fit their lectures, as Samantha described,

> The person who selects the topic? For Ethics, that would be me as the course moderator. The one caveat to that is when Dr. Siegford or one of the faculty from the Center for Ethics is giving their presentations; they have case scenarios that are specific to their presentation material and I don't dictate what that should be. The same thing is true in the Nutrition course; when I had guest instructors (Drs. Marteniuk or Raphael), I would let them select their own cases and that makes sense because they are pulling case material directly from their clinical experiences. The one thing that I do dictate is not so much the problem, but the format (I want them to make sure they include the same elements of animal, diet and feeding management assessment as I do).

For Cheryl's Veterinary Integrative Problem Solving (VIPS) course, it's more of a joint effort between her and the instructors that teach the other courses that semester. She designs her cases to align with what the students are learning elsewhere, as she detailed,

> It's preset by the courses that are offered in the same semester. I stick to what they're taught that semester. I would try to line up that closely. I try to get it so that it coincides pretty carefully.

This team approach was also encountered in PDI 554 Veterinary Clinical Pathology, where Elizabeth, Louise and Steve at times selected the topics together, as Louise noted,

> It would be instructor I think, in all of those categories. Either instructor, or instructors, some time we choose things together. Primarily the individual moderator, or the person teaching it, the instructor. When you give them the assignment, especially some of the

later things, then it's kind of more of a group effort between the three of us, as far as who is selecting these cases.

Purpose of the problem. The majority of the instructors interviewed believed that problem-based learning was useful for many different purposes including teaching basic sciences, physiology, clinical reasoning and communication. Matt preferred the flexibility of PBL as students progressed through his course, as well as a mix-and-match approach that could encompass multiple purposes in a single case,

> To some extent, it depends on where they are in their education. We might have one, where we emphasize the communication skills and what you're going to tell them, or how you're going to handle the situation. I love to show them a slide of a down cow. And then, start by what are the possibilities? Then we can get into basic sciences, we talk about physiology and calcium metabolism, underlying mechanisms about diet, obviously getting her up in solving a patient problem, why we're giving her calcium, etc. All of these things, you can just go down the list.

Jaime also designed her cases to include several purposes. Since the topic of Endocrinology is very integrative, it requires the students to have skills in multiple areas, as she described,

> For the Endocrinology stuff, it's all of them. To really understand the cases, you need to know the basic sciences, you've got to know the normal, the mechanisms, the pathology. You're going to solve a patient problem, you've got to go through reasoning apply it and be able to communicate.

Louise also believed that the cases used in her course touched upon several of these areas. As she detailed,

> I think mechanisms, problem solving, reasoning, application. You could throw some of the others in there too. I think we're reviewing normal physiology, I think we're also trying to provide essential clinical knowledge, so I have B thru F (normal physiology, underlying mechanisms, essential clinical knowledge, solving a patient problem, clinical reasoning), and G (application of clinical knowledge) I guess.

Samantha's experiences focused more on communications aspects and clinical reasoning skills. She also added a new category called "moral reasoning" to better describe what students do in the Ethics and Welfare course, as she described,

> Absolutely transferrable skills and communication for both of my courses. How do we talk about this? Well, in Ethics and Welfare we start by talking to each other and figuring out how individuals identify and evaluate ethical (or welfare) problems. Students also explore and discuss how they, as professionals, are going to deal with animal owners, staff, the public and the media. Communication skills are critical here as well as in the nutrition course, where students practice getting a diet history from client actors. Those videotaped interviews are also valuable for students to practice conveying how and what they understand in terms of an animal's diet and feeding management, so that they can put it altogether in a recommendation.. I would say that clinical reasoning is something that I'm trying to convey; that has to do with the structure and the format that we use. Clinical reasoning in Nutrition, and I guess "moral reasoning" in the Ethics and Welfare course, that's really what the Ethics and Welfare course is all about.

Likewise, Cheryl's use of problem-based learning in her VIPS course focuses more on the use of clinical knowledge, rather than on foundational knowledge,

> Solve a patient problem. Clinical reasoning. Application of clinical knowledge. Transferrable skills, and client Communications. It's not my job to teach them the pharmacokinetics of a drug. It might be my job to teach them the appropriate time to use that drug.

Nature of the educational objectives and control. In nearly all of the courses, the objectives were instructor-controlled. As Raj, a first-year instructor, stated, the students are still too early in their academic careers to have this level of control,

> This is first year. They really don't want to. They are still getting the hang of the system. It's difficult for them to go beyond that.

Cheryl does allow some level of student control in her VIPS course by giving her class the opportunity to submit questions/topics ahead of time for the content experts to cover during the Friday wrap-up sessions,

> Mostly instructor-controller. I also pass out SIRS forms regularly, what case did you like, do you don't like. They have to fill out questions they still have before the expert comes at the end of the week. They filled out those and I actually gave those to the expert.

Nature of the task. The most common responses for this dimension included explain/define a phenomenon and make a diagnosis. Nathalie saw this as an opportunity for students to integrate their existing knowledge while working through her cases, as she detailed,

> It's mainly A (explain/define a phenomenon). I will ask them to describe something that's going on. They'll have a case. It's more directed than pure PBL, where you throw them a case and they figure it out. I ask them to describe what happens. What normal fetal circulation is. What would happen if… Then they're integration their knowledge, applying their knowledge. Making a diagnosis is a small part. I do end giving them the diagnosis. That's not where they're at. That's a challenge for them, what keeps them going. They work on it very hard, so they can figure it out before I give it to them. Try to deepen their understanding of the Physiology. Their task is to try and integrate other stuff. There's a reason for learning about villi. Some of them get it, but a lot of them do not make that correlation.

Similarly, Steve focuses on the pathogenesis and diagnosis of disease in his Clinical Pathology course, as he described,

> Mostly, we're focused on explaining the pathogenesis of the laboratory abnormalities, so the phenomenon, describing it, in terms of magnitude of change and things like that. We also focus on interpretation, which is making a diagnosis, but we try to make the interpretation more apparent, what they're interpreting in terms of the overall diagnosis. They're interpreting each lab abnormality sometimes, and what it might mean, but not focused a great deal on the final diagnosis of a patient.

Explaining clinical techniques is also an important element of Clinical Pathology, especially the laboratory portion of the courses, as Elizabeth detailed,

> We do have a laboratory portion of that course, and I don't know what you meant by explaining clinical technique, but that's very hands-on and they learn to do some of the

> laboratory work like look at blood smears, and how to do a urinalysis, so we do have some hands-on skills. They do learn to look at blood smears, they learn to do a urinalysis, they learn to spin down blood and get serum, use the refractometer, some basic lab skills. We have incorporated a couple of techniques into evaluation of a case on an assignment. Here's a urine sample and it's been spiked with something, and they do a dipstick as part of evaluating the, generating the data to help them evaluate the case. So, that's the only place that's come in. It's a similar situation where we give them a glass slide to evaluate, blood or something. That's more common even. They need to evaluate the blood and that, along with the analyzer data, will be used to answer the directed questions.

Jaime and Samantha included several other task types in their experiences. As Jaime mentioned, "That is Endocrinology. You're going to have to do it all.". Samantha described the experiences in her Ethics and Welfare courses in greater detail, which are different in many ways, compared to other courses in the curriculum,

> When I think about the Ethics and the Welfare course, the primary nature of that task in those six weeks is to be able explain or describe the ethical dilemma. And then, instead of making a diagnosis, students need to be able to identify two opposing approaches to the dilemma.. Then, rather than developing a treatment plan (as you would with an Internal Medicine case), students work at identifying and exploring the advantages and disadvantages of the two opposing approaches as they relate to five key stakeholders. That's the nature of "the task" in the Ethics and Welfare course. The nature of "the task" in the Nutrition course is to collect a diet history from a pet owner, perform a physical

examination on a healthy dog or cat, be able to assign a body condition score, and address nutrition-related questions.

Presentation of the problem. Most of the instructors used virtual/computerized cases, usually presented as PowerPoint files. While they typically only used text and perhaps a few images, some instructors such as Nathalie were more advanced and included radiographs and audio files in their PowerPoint-based cases. Elizabeth mentioned embedding actual lab report data into her PowerPoint files to make the cases even more realistic. Simulated clients were also used by a few instructors. Nathalie described using client actors at the Learning and Assessment Center (LAC) for her VM 524 Basic Science in Clinical Medicine course,

> There's also a simulated client at the LAC. It's part of the communication aspect. It relates, they need to explain that one case to a client, who pretends to be an animal's owner. It's not part of the problem-solving aspect. It's a result of them having worked on a case, rather than an integral component of working on the case.

Samantha also utilized simulated clients in her Ethics and Welfare course. She uses a hybrid approach by having students watch and discuss video clips of simulated client-doctor interactions, rather than having students interact directly with the live actors,

> The one place where I have virtual cases is in a few large class sessions; these seem to work well as exercises that get students thinking early-on about the nature of ethical dilemmas across the veterinary profession. I start by tell everyone that "we're going to watch this little video clip and I want you to be thinking about X, Y or Z." The way that I know that those short video clips have been impactful is when students are talking about them later in small group discussions or writing about them in their assignments at

different points in the course. More than a few students reflect on what they saw in the video clips by recognizing a situation ("that happened at our practice back home") or recognizing the approach a doctor took with a client, or vice versa. When you can see or hear the tension projected on a big screen in the classroom, even though they are actors, it can feel and look quite real. Some students comment that the video vignettes are "made up" but I tell students that the scripts these actors are working from really came from some veterinarian's personal experience, word for word. That can have quite a bit of impact for many students, rather than just reading a case scenario or vignette on paper.

Matt and Cheryl also used simulated clients in the courses. Matt described one of the exercises in his course, in which students interacted with the simulated client,

I do one case, one class a year using a client. It's done here. A brought a client in VIPS. You had to get a history from him, had to educate him, you worked in groups. Then you had to talk to him about therapy. The whole setup was this guy had spent time in prison for having illegal drugs on his farm.

Format of the problem. Most of the instructors interviewed used a one-session format, completing their cases before the class session ended. Typically, multiple cases could be covered during each lecture. The primary reason for this design was time, or lack of it. Also, some instructors believed that the immediate feedback given when a case was covered in one session was more helpful to students, as Matt described,

I like one session. One problem, one case. The time for them to learn is that immediate feedback. That was one thing I never liked about straight PBL. They tried to work on it

a couple days, then we tried to go over it later, and it just lost it in the transition. I like to get it, do it one session.

The exceptions were Cheryl and Nathalie, who usually used two sessions to cover their cases. For VM 532 Veterinary Integrative Problem Solving (VIPS) and VM 524 Basic Science in Clinical Medicine, the class would meet for a second session (question and answer period) at the end of the week with a content expert to discuss the case.

Processes that students follow. Most frequently, students would work in class with moderators. This was most common in courses that used the Lecture-based case typology, during which the instructor would present cases to the class in a whole-group setting. Courses such as Cheryl's VIPS, Samantha's Nutrition and Ethics, and Nathalie's Clinical Medicine used a variety of techniques throughout the semester. Cheryl described starting with whole-class activities at the beginning of the semester, then progressing to groups with moderators, and finally groups without moderators once the students become more comfortable with the format.

Matt also used small groups in his course, preferring it to individual work since students often "got lost". He alone often functioned as the moderator, floating between small groups as he described,

> The one that I like the best is students work in group without moderators. They work without moderators, but I'm in class. What I like to do is, I give them the case, and some questions to do, then I say get it done. I'm in the room, so they can ask any questions. I'll spend the whole time from group to group. I like relatively small groups, I don't like more than 3 or 4 per group, even down to 2. I don't particularly like individuals, they get lost. Individuals will not ask enough questions, they're just lost and they're trying to get

> out of there because they're some uncomfortable. I literally go around to them and ask if they have any questions. It helps with communication. I feel like they're not afraid to ask me. I'm fairly open, and I'll ask them questions. That's just a style that I use… You're a floating moderator for the whole group.

Similarly, Nathalie uses both individual and group structures in her course, also acting as the moderator for several small groups,

> In VM 524, they work a bit individually ahead of time, then they work in groups with and without moderators. It's not one group, one moderator. I have ten groups, one moderator, which is me. Thirty groups really, but not thirty at one time. They work a bit individually ahead of time.

Resources utilized. All of the instructors interviewed allowed their students to utilize any type of resource needed, including course packs, textbooks and journals. Content experts, if available, were another source of information and students were encouraged to interact with them. Several instructors also commented that most students would attempt to find information on the internet first. They didn't discourage this practice, but they were concerned about the quality and potential inaccuracy of the information that students encountered, compared to what they would find in textbooks and peer-reviewed journals. For her Nutrition course, Samantha felt that video resources were especially important as she described,

> You should really have an "other" (category). I mean, rather than textbooks, journals, etc. I would suggest "video". For example, in the Nutrition course I utilize a wonderful video of Dr. Merrils performing a body condition score and performing a physical exam on her cat, Hobbs. Additionally, I provide as a resource a video-taped interview of a

former student conducting a diet history and physical exam. I got that student's permission and I tell students in my course, "If you've never done this before, you should access the video of the former student and watch how he introduces himself to the client, how he establishes an agenda for the interview and how he interacts with the animal. It is especially helpful to have "role modeling" by peers in the form of short videos they can access anytime during the course.

Role of the moderator. In all cases, the instructors acted as facilitators for the problem-based learning exercises they used in the courses. Most of the time, they also acted as content experts, even if only at a basic level if the topic covered was not their specialty area. Of course, the primary goal was to *guide* the discussion and not provide all of the answers, as Jason stated,

I guess I'm facilitator and content Expert. I'm trying to get them to give me answers, but then I embellish.

Nathalie is careful not to provide too many answers, in order to keep her students motivated and find the information on their own, as she noted,

It's a bit of everything. Content expert, a bit, but not always. They need to realize that they can actually look it up, and not just give up!

Demonstration of learning. In the majority of the courses, students are assessed by written examination. The cases covered are used as practice for what will be on the exams. In some instances, the formats are nearly identical, so it is in the students' best interest to participate in the problem-based learning exercises, as Jason noted,

> Then they'll have a written examination. The (practice) sheets are all for their own… I just try to stress to them that, these questions are in the same format you're going to see on the exam, so that's why it behooves you to do them. It's practice for you. I'm honest with them, to say that you're even going to see the exact same questions, just a different case. Learn these questions!

Time is the main reason why other assessment types aren't used by most instructors. As Matt described,

> We do have some examinations. In LCS 560, we have to give them exams. When you have half the class, 50 students in there, it's difficult to assess individuals, to evaluate their effectiveness, it's just too difficult. I do 50 at a time, over here in A213. It's pretty labor intensive.

Cheryl, Nathalie and Samantha were the exceptions and use several different assessment techniques in their VIPS, Clinical Medicine and Nutrition courses, respectively. In addition to written examinations, Cheryl also utilizes discussions, presentations and self-evaluations. Nathalie uses written exams, online quizzes, written group assignments and facilitator evaluations of video recordings of students interviewing simulated clients. In her view, the client interview was the ultimate test of whether or not the understand the materials,

> Written exam, online quizzes. They also have the group questions that they have to answer as a group, two questions per group. They do have to demonstrate some understanding. Performance. They interview with the client. If they can't explain it to the client, then they don't understand it very well. They're all recorded, and examined by

a facilitator. For the process, and for the content. A few errors, if they get nervous. Fifteen minutes of footage per student.

Samantha also uses more elaborate methods, beyond written examinations, to assess her students. Her methods include written assignments, discussions and self-evaluations. The topics discussed in her Ethics and Welfare course are particularly useful, as she described,

> As I mentioned before, self-evaluation does happen in the Nutrition course, but it also is able to take place in the Ethics and Welfare course. There's one particular writing assignment that is both instructive and eye-opening; it occurs in the week when students sit around the table and talk about the potential dilemmas associated with receiving free gifts. We ask them to consider if it's okay to accept free gifts as students but not as a practitioner? And we ask them to consider whether or not accepting free gifts will influence them in any way? There are a few articles in the literature and students are expected to read them (some do; others don't). I find that particular discussion to always be so wonderful. Some students, whose parents are veterinarians and have taken gifts, see no problem with this practice. And students, who come at it completely fresh, get really disturbed and ask "why haven't we had this topic earlier in the semester?" Think about this for a minute, though. If we were to have this kind of conversation early on in the semester, before students got all those "freebies", would students really think about this issue in the same way? I don't think so.

In summary, the ten dimensions developed by Charlin et al were used as a framework to develop a more detailed account of PBL use at the College. The discussions found that most PBL exercises were on topics and objectives selected by the instructor. They were delivered as

computerized cases and were completed in one session. The most common purpose was to teach basic sciences, physiology, clinical reasoning and communication, with a task of explaining or defining a phenomenon and making a diagnosis. Typically, students worked in class with moderators and were allowed to use any type of resource (textbooks, internet, etc.) they needed. Instructors took on the role of facilitators, but were also content experts if needed. Demonstration of learning was usually by written examination, but some instructors also used discussions, presentations, written group assignments and simulated client interviews.

PBL Exercise Examples

As discussed previously, the instructors implemented PBL in a wide variety of ways, often using more than one typology, or creating their own hybridized versions. Several PBL example exercises are listed below in order to illustrate the variety of methods that are used in the College.

Raj described using Lecture-based cases during his Comparative Veterinary Gross Anatomy course. During the last ten to fifteen minutes of each of his fifty-minute lectures, he would present a case to the class for discussion. The interactions took place in the primary lecture hall (G-150), and involved the entire class. The exercises were designed to reinforce the concepts that Raj had just covered during lectures. Students contributed to the discussion through the use of iClickers technology, which enabled the entire class to participate anonymously. Raj indicated that student participation was typically very high, since he believed that using iClickers helped to reduce the stress associated with responding with an incorrect answer. By using this technology, Raj received immediate feedback, and could instantly share this information with the entire class.

Matt described using a modified Closed-loop approach when he taught the Veterinary Integrated Problem Solving (VIPS) course. These exercises took place in A-213 (the cafeteria) and involved half of the class per session (approximately 55 students). Cases were based on an individual animal, or on a herd issue. Students were given some background information about the case, including a patient signalment, history and presenting complaint. The case contained information the students needed regarding findings from physical examination, diagnostic tests, treatments and prevention strategies. Students work in groups of four, with one class member assigned to function as the moderator and manage the answers to the case, distributing them to the other three students as they worked through the case. Students earned points if they asked appropriate questions, but they would lose points if they asked unnecessary questions or ran inappropriate diagnostic tests. Matt functioned as the overall moderator for the exercise, floating between all of the groups, often playing the role of content expert if needed. At the beginning of the semester, the students were given one hour to work through one case. As the semester progressed, they addressed two or sometimes three cases during a two-hour class session. When the student group completed their case, they brought it directly to Matt for scoring and feedback, while the class was still in session. Matt also went through the entire case at the end of the class session, leading a discussion if any aspects needed clarification. Matt preferred to review the case at the end of the session, rather than waiting until the next session, which is a more common approach with Closed-loop PBL.

Matt also mentioned using a Case-method approach in his Fundamental Clinical Skills for Large Animals course to discuss two or three cases in detail. The exercises took place in A-213 (the cafeteria) and involved half of the class per session. The format was very flexible, and students could work individually, or form pairs or small groups at their discretion. Students were

given basic background information about each case ahead of time and then discussed them during the class sessions. Matt usually relied on volunteers, but would call on students if needed to keep the case discussion moving.

During two different class sessions, Matt would invite a simulated client into the classroom so that students could practice their communication skills, such as taking a history, and work through example cases. The format of this exercise best fits the Problem-based typology. Half of the class (approximately 55 students) would be involved per session and would meet in A-213 (the cafeteria). The students were divided into small groups of four or five individuals. Each group would work with the simulated client on a specific task, such as taking a history or discussing diagnostic tests or treatment options. After each group completed their exercise, they would receive immediate feedback from the simulated client, the other students in the class, as well as from Matt. They would also self-critique their own performance and give suggestions for improvement. This exercise resembles a Modified Case-based approach.

Nathalie described using Closed-loop exercises in her Basic Sciences in Clinical Medicine course. Students were given basic background information about the case on Friday, including patient information, history and basic test results. They also received suggested readings and a few questions about the case. The following week, one-third of the class (approximately thirty-seven students) would then meet in A-213 (the cafeteria) for a two-hour session on either Monday, Wednesday or Friday morning, with a rotating schedule. Students were divided into groups of three or four individuals and were then assigned rotating roles of Manager and Recorder. Each morning, they completed a brief web-based quiz that was based on the assigned readings. The group would then work through the case together, answering all of the questions Nathalie designed. They had to make decisions regarding what diagnostic tests to

run, and which treatment options to select. During the discussion, Nathalie functioned as facilitator and content expert. Students were encouraged to use any and all resources, including books, journals and the internet. At the end of the class session, Nathalie would reveal the actual diagnosis and discuss follow-up information about the case. On Friday afternoon, the entire class would meet in the primary lecture hall (G-150) for a two-hour session to discuss the case in further detail with a content expert.

Samantha indicated that she used a Modified case-based approach in her Ethical and Animal Welfare Issues course. Students were given case information ahead of time and were expected to review it and prepare an outline to bring to the class discussion. In the outline, they described the ethical dilemma of the situation and proposed two opposing approaches to resolving the dilemma. They also listed the pros and cons for each approach, and how they related to the five different stakeholder groups: the animals, the owners/caretakers, the veterinarian, society, and the veterinary profession. Each student brought their work to the discussion and shared any questions or concerns that they had. Half of the class (approximately fifty-five students) would meet in A-213 (the cafeteria) and were divided into small groups consisting of nine or ten students. Each small group had an external facilitator that was responsible for taking attendance and recording the contributions that each students made to the discussion. Contributions included a question, a statement of opinion, sharing details about an article the student read, or sharing an experience from sometime in their past. Students documented their contributions and submitted them to Samantha for grading. Samantha reviewed all of the submitted materials and returned them to the students with comments within twenty-four hours.

Finally, Cheryl described using a series of Closed-loop exercises in her Veterinary Integrative Problem Solving course. On each Thursday, students were given introductory information about a case. Students were divided into groups of seven or eight individuals and would meet for one hour, twice each week (Monday and Wednesday), to work through the case. They then reviewed the case information (history, physical exam findings, diagnostic test results, treatments, follow-up information) to answer a series of "task questions". External facilitators assisted with keeping the discussion on track, but were not treated as content experts. Students were encouraged to use all types of resources, including books, notes and the internet. During the Monday session, each group completed an assignment, such as writing up the patient's current problem list, filling out a problem-oriented medical record form, or developing a treatment plan. This assignment was submitted to Cheryl at the end of the session for grading and feedback. During the second (Wednesday) session, the group discussed the case with the facilitator and assessed each other's performance. This Group Report was then submitted to Cheryl for grading and feedback. On Thursday, the whole group would meet for a case summary discussion led by a content expert. This was typically the clinician that saw the patient, as many of the cases were based on actual patients from the College's teaching hospital.

As described above, there was a high degree of variation in how PBL was used in the College. Even within a single course, PBL was implemented in several different ways. Each instantiation was shaped by several factors, including the background of the instructor, the content area and the specific objectives of the exercise. There was also a great deal of hybridization, with several instructors modifying or combining typologies to better suit their own needs. In short, there was no apparent "typical" form of PBL being used in the College.

Unique Course Elements

Problem-based learning is a very flexible construct that can accommodate a wide variety of needs. The instructors that were interviewed for this study described several unique course objectives, for which they felt using PBL was well-suited. PBL was perceived to be effective in courses that involved problem-solving and critical thinking skills, challenging students to work through and discuss information, rather than just relying on memorization. This is similar to the rounds sessions approach typically used in clinical rotations. PBL was also common in capstone courses, such as VM 524 Basic Science in Clinical Medicine, which sought to help students integrate and apply previously-learned concepts through the use of hands-on activities, discussions, and communication exercises, rather than teaching new factual information. Finally, PBL was perceived to be useful in courses, such as Epidemiology, Nutrition, and Animal Welfare, that often didn't have clearly defined correct answers and instead relied on case examples and discussions to further explore concepts. Logistically, the instructors in this study believed that each of the objectives previously described would have been very difficult to achieve using a traditional lecture format.

Rather than the rapid-fire 50-minute lecture approach, Nathalie believed that students need some time for it to "sink in", and also opportunities to integrate, practice and reinforce what they are learning. She described these limitations of the current curriculum in more detail,

> And, it's the lack of time for students to actually absorb and integrate it. Time and occasion. The way for them to learn something is to actually do it, and there's not enough time for that. Work their way through problems. A lot of didactic teaching that is stand up and deliver. They still need time to digest it. They digest it better if they're

exercising their brain while they're digesting. The application, and the time. They have only seven lectures for Endocrinology, and that's ridiculous. So, not enough time to process. There is some redundancy, a chance to view it from different angles, and integrate it a little better.

For Matt, problem-based learning aligned with his tendency to use stories as cases in his lectures. He would initially simplify them to stress important factors, and then increase their complexity as the class progressed. Matt preferred lecture-based cases over other options that were more student-directed, as he explained,

I was never a big fan of the straight PBL. The typical form, here's a case, go do your own thing. Students tended to lose relevance. They didn't (know) what was important and what wasn't important. They would miss major chunks of information because they just didn't have the background. All of a sudden, there would be a case that they would be working on. There would be a very, very important part of that case that they would need to recognize, and they'd go right over the top of it and didn't know it was there. They'd dismiss it.

Matt's style was very interactive. He preferred to use a single image as a focal point for a discussion, delving deeper into possible diagnoses, treatments, etc. and the discussion develops. While this approach is quite common in the clinic during a typical rounds session, it can be much more difficult to successfully implement in a lecture environment. As Matt noted,

I like visual. And so, commonly what I'll do is show them a slide, or a picture of a cow, or a calf with scours, or ask questions to them. I use a lot of verbal, what would you do? One slide or two slides then ask all that. On a slide, now I'll ask some questions about it.

Annette also mentioned challenges with using traditional lectures to teach her subject matter, Epidemiology. In her course, they will, possibly for the first time in the DVM curriculum, encounter situations where the correct answer cannot be clearly defined. Conveying this concept requires case examples and discussion to clarify. As Annette explained,

> For the second year students, (it) takes them to a place with gray answers, a lot of things they're going to be faced with in practice, where the answer is not necessarily clear. It's the first time they've faced some uncertainty in their clinical practice. All is not known. Making clinical decisions in an area of uncertainty. You have to be a little careful, because sometimes they freeze up. What do you mean we don't really know that?

In his Anatomy course, Raj sought to help his students connect what they're currently learning back to the clinical environment, through actual clinical encounters. This was radically different from how Anatomy was taught in previous iterations of the curriculum, where clinical relevancy was often overlooked. As Raj stated,

> How is all of this applied in a clinical situation? By nature, Anatomy is very detailed. A lot of information. They're left in a sea of details, and they cannot really remember. I need to pick the important ones that they really need to remember that will help them in the clinics. So really focus on that, and drive it in. This is what I really want you to remember. And how do I achieve that using a clinical approach?

Samantha believed that her subject matter of Ethics and Welfare couldn't effectively be taught or assessed using a unidirectional method such as the lecture, so she felt that problem-based learning methods provided her with additional tools to overcome these limitations. As she described,

> To me, the thing about Ethics is to talk about it, listen to other peoples' opinions, get educated, read about it, and write about it. I've haven't found a way yet to assign a reading from a book chapter, and then adequately and fairly evaluate if the student read the assign and got something out of it.. There's isn't a clear way to get people to be able to weigh in with their opinion in a multiple choice format. Multiple choice immediately smacks of a "right or wrong", or a "you don't know" answer—but that's not appropriate for the subject matter of ethics and welfare.

As Samantha stated, the Nutrition class is still a work-in-progress as she continues to explore hybridized methods for an ideal solution. Time continues to be a major obstacle, as she described,

> My attempt has always been to provide practice information regarding comparative Nutrition. Two contact hours each for the dog, cat, horse, cow, and one exotic species like birds or reptiles. The other contact hours in the course are designed to allow students to go to the LAC to practice taking diet histories and performing physical exams. The way that I setup the formal didactic contact hours is one half of the class at a time, each week, for two hours. It's my attempt at modified case-based instruction. I have done several different things over the years, and none of them really seems to work; I think part of the problem is there's just not enough time. Perhaps another part of the problem is that I'm trying to do too much!

Cheryl believed that her course objectives could not be achieved using a traditional lecture format. Her goal was to develop her students' problem-solving abilities and teach them how to think critically, rather than to deliver more didactic materials. As she stated,

> The goal is to teach them to think. And the sooner you teach them to think the better. That's the point of problem-based learning. Teaching students how to think constructively and critically… It's much quicker to do didactic teaching. But, it teaches something different. You can't teach problem solving by here's what you're reading, take the test on it.

Likewise, rather than just adding to the list of things that they need to know or memorize, Cheryl sought to teach her students how to utilize the information they already have in order to make logical, informed decisions. As she put it,

> Especially now days, there's access to everything. If you can teach them to think, that's everything. Teaching them to think, that's my job. It takes time to find information. These guys get so much information. I'm sure they love the ease of getting that information. I would feel the same way. I'm not teaching information like that. I'm teaching them how to think. How to get from A to B to C, in a logical way, with the tools that you have now. My idea is, I'm making them problem-solving veterinarians. My task is different, thankfully.

Cheryl also wanted to make the experience enjoyable and give her students the opportunity to interact with one another in small groups. She felt this could not be achieved in a typical large classroom lecture format, as she described,

> The goal of the class is that it's the funnest class that you have this semester. It's fun to work in groups, and interact with your colleagues. It needs to be random collegial. Overall, the SIRS were positive. Students overall really liked it. But they're enthused about it.

Elizabeth, Louise and Steve also wanted to improve problem-solving skills in their course (Clinical Pathology) rather than just give students more facts to memorize, as Elizabeth stated,

> To give them a series of facts isn't going to help them, when they ultimately go into their career. They have to learn to problem solve and supply that knowledge.

The *application* of knowledge is what Elizabeth, Louise and Steve were trying to achieve in their course. This was more reflective of what students would soon be doing in the clinic, and having them participate in these activities would prepare them for that environment. Steve believed the standard lecture approach was too passive and didn't allow students to actively participate in the process, nor could he gauge their comprehension at any particular moment. As Steve commented,

> I think the engagement and the application parts are really important at all of the levels that we do it, but thinking back to 554, where it's more preliminary, we could just lecture and give them base information, but they would miss out on the applied nature of what it is that we're doing, and seeing how these things unfold as panels, and profiles. We build from the beginning, towards the end, when you do those labs that are case-based labs, it's synthesizing, it's covering the large amount of materials from the whole class, whereas at the beginning we would just have data from the CBC. So, it allows them to build and apply in a way that they will be doing it in the clinic. That's the big strength that I see, at that level... If I just stand there and talk, I don't know where they are.

In summary, problem-based learning was perceived to be particularly useful in courses that sought to teach critical thinking and problem-solving skills, those with an objective of integrating and applying existing knowledge, and courses that relied heavily on discussion and

interpretation, as the content they taught existed in the “gray area”, and didn’t typically have just one correct answer.

Challenges with Using Problem-based Learning

While the instructors I interviewed believe there were many advantages to using problem-based learning techniques in their courses, as they described many unique course issues that could not be accomplished using the traditional lecture format, they did acknowledge that there were several major challenges involved with implementing and using PBL on a regular basis. When I first started coding the interview transcripts, I started with a general code called "challenges". After refining my results through the process of multiple coding passes, three major theme areas of challenges emerged: logistics, time and pure PBL limitations. From the perspective of the instructors, PBL took much more time and effort to plan and carry out, as compared to traditional lectures. Time also had an impact on the students, as the PBL exercises tended to take longer to work through and often required considerable mental effort. The instructors also found it difficult to locate and schedule space in the College that could be used for discussion groups and other activities. Finally, instructors had to work around the limitations of what they called "pure" or traditional PBL. This led them to modify their techniques in order to ensure that students were benefitting from the process. Each of these themes will be described in detail in the following sections.

Logistics. Logistics were an especially important concern for instructors that used small group discussions and facilitators in their courses. The participants indicated that the process of scheduling facilitators and meeting rooms was at times overwhelming. Physical space at the College is very limited, and locating a large number of break-out rooms for small groups wasn't always possible. As Samantha described,

> The time commitment is big, and the logistics… If you want to do problem-based learning, with facilitators, the logistics of the space, finding the space, recruiting the people, scheduling the time for ten different groups, multiple times per week…

In addition, Samantha found the process of actually running the events to be challenging as well. Luckily, the Learning and Assessment Center (LAC), which Samantha utilized to host and record her simulated client encounters, relieved some of that pressure. However, she still needs to schedule at the LAC well ahead of time, if it is even available, and coordinate the CVM events with those from the other health colleges. As she described,

> It's a strength that we can rely on the Learning and Assessment Center (LAC) to hire, schedule, and train client-actors. I simply could not coordinate those kinds of events if we didn't have a relationship with the LAC that we have. Even if we had video cameras in four different rooms in the hospital, I would need someone to help me with the logistics. The space is so sought-after that Nathalie and Cheryl and I have to schedule our events a whole year in advance. And, we have to do that before we really know what the academic calendar going to look like. That's especially a problem for me, because I want to use animals. At the LAC, they're not going to let me schedule an event with animals on a day where there's another event already planned because we have to be aware of allergies that some people have to animals.

Cheryl dealt with similar issues. For her VIPS course, the class was broken into fifteen small groups, each with a facilitator. The facilitator was typically a clinician from the Veterinary Teaching Hospital, but can be a private practitioner not affiliated with the College. Regardless,

scheduling that many people, along with the rooms for the small groups, can be a daunting task, as she described,

> It's a lot more work. Getting fifteen people organized every Monday and Wednesday. The man hours involved in a two-credit course, are not reflective. It's much quicker to do didactic teaching. But, it teaches something different. You can't teach problem solving by here's what you're reading, take the test on it.

Time. The second factor that many of the instructors found to be a challenge with problem-based learning was time. The veterinary curriculum is already packed full, so increasing students' credit load is not an option at this time. In addition, the credits allocated to several courses, such as Samantha's Nutrition course, were reduced in the last revision of the curriculum. This makes it very difficult to cover all of the required materials, especially when using a more time-intensive approach such as problem-based learning, as Samantha noted,

> I've given up a lot, but I still can't meet the timeframe. So, I'm having conversations with our Associate Dean about revisiting the curriculum, or taking the Nutrition course (up) to two credits, or considering another place where's the best fit? Maybe I have to give up more, but I don't want to create something that's only going to evaluate or assess student learning by multiple choice tests.

Annette also felt that the structure of the current curriculum is very rigid, and doesn't give her much opportunity to explore new teaching options,

> Packed curriculum, there's not a lot of flexibility in time. The curriculum is much more structured, so that makes it difficult. Try to do some things within the construct of the one-hour lecture period…

For Cheryl, she felt that she needed more time to develop additional cases and keep them "fresh". However, developing a detailed case is no easy task. If the same cases (and the answers) are passed down between classes each year, the student won't bother working through them, which defeats the whole purpose of the exercises. As Cheryl described,

> If you don't change the cases, it becomes passed down from generation to generation and it misses the point. They know the answers so they don't need to do the thinking. It's something you have to keep current on the cases. So, it misses the point. I have some cases from Jason. I developed three or four of my own the first time. I've written two more cases for next semester. I want to write another two this Summer. I have a high turnover of cases. I'm a firm believer in keeping cases fresh. You can almost use the exact same setup, but you can changes things a little bit. Sometimes, I just tweak a case. My goal is to have a bank of thirty cases. I have about twenty. I keep the same type of cases from year to year.

Jaime also found time to be a challenge as she struggled to teach students the foundational information they needed to know, while still finding time for cases that would reinforce these concepts. Without the basic information, students won't progress too far with the cases, however. While Jaime may find some topics in Endocrinology particularly interesting, she was careful not to go off on tangents that aren't clinically relevant for a "practice ready" graduate, as she described,

> The biggest challenge there always is, is TIME. That's the biggest constraint. There's a certain amount of information you have to learn and go through, before you can get to cases. The cases are what's really important. Try to figure the balance to fit as many

> cases as you can, but you always have to present the basic information too. Trying to figure out, what's the best way of doing it, especially if you have a classroom of 100+ students, it's a lot different if you have a small group... I feel like I'm always so limited by the amount of time I have. The VM 559 class is only a two-credit hour class. You have to cram all of Endocrinology into that. That is the problem, the time. There's so many cool things you can do, but where… Whatever I put in, I have to give up something else.

In addition to the time constraints on the instructors, time is also an important issue for the *students*. Participating in problem-based learning exercises often required additional effort before and after the actual class meeting time. It could be challenging for students to find time to do this, especially if they are in lecture all day, and studying for exams in the evening. As Elizabeth described,

> I think I get lots of positives of doing the cases. I get lots of negatives about the amount of time required to do the work that we require in that rotation. I think the process they love.

Louise had similar thoughts regarding the time issues. The second year of study is particularly difficult for students, as she noted,

> PDI 554. This course is so damn different. I think they, for the most part, again, I think it's a time/energy factor to them. It's just such a miserable semester.

Elizabeth also felt that the hectic pace of the semester made it difficult for students to pause and integrate the information they've learned. In second year, students have a tendency to live from one exam to the next, as she described,

> And, it was very difficult to keep them on task, and I think it's competition with everything else they have during a semester… I think that Elizabeth touched on one of the big problems we've had, they're just so overloaded in the curriculum, with information, credit hours, etc. And by doing problem-based learning, you're including not only the knowledge and the information factor in there, but you're expecting them to stop and think about it a bit, and they don't stop and think about anything in that semester.

Nathalie also found time to be a challenge, both from her perspective to plan and conduct the events, and for the students to work through the exercises. In her view, the students end up working much harder than they would in a typical lecture class, but she believed their efforts help them to actually understand the information at a level not possible with other approaches. She described the challenges for her as well as her students,

> One is, the time it takes for me. I cannot take the whole class in small groups in one go. So, I repeat the small group sessions three times, in the cafeteria. And, the other drawback is just the time it takes, if you want them to work through something. I don't think it's a drawback. The time it takes is worth it. By working their way through, they understand it better. Better than reading, and regurgitating… Actually integrating stuff takes time. They need to be able to work on something, think it through, argue it back and forth, talk to each other about it, then they can put it together mentally much better… Then they have to work a lot harder, and try to meet as a group afterwards. They like the course, the format. They feel it engages them.

Pure PBL limitations. Several instructors were quite vocal about what they felt were the limitations of "pure PBL" and why this format was not a good fit for their class. These impressions caused them to select alternative approaches, or develop their own hybrid techniques. Matt felt that traditional PBL models didn't give his students enough background information or guidance, which often lead them to go off on irrelevant, frustrating tangents, as he described,

> I was never a big big fan of the straight PBL. The typical form, here's a case, go do your own thing. Students tended to lose relevance. They didn't what was important and what wasn't important. They would miss major chunks of information because they just didn't have the background. All of a sudden, there would be a case that they would be working on. There would be a very, very important part of that case that they would need to recognize, and they'd go right over the top of it and didn't know it was there. They'd dismiss it. I think the biggest disadvantages, in traditional PBLs, they've lost some of that relevance, just because of lack of knowledge, lack of ability to recognize relevance. They would tend to flounder a little bit, they didn't know quite which direction to go. If you're working in a small group, they'd get into the situation where they would get off on tangents that were unimportant.

Nathalie and Jaime also mentioned using a more "directed" approach, rather than merely giving the students a case and hope that they are able to work through it successfully. Jaime gives her cases after lecturing on a related topic, so the students have most of the information they'll need to successfully work through it.

The instructors in PDI 554 have worked through several iterations of PBL over the years, beginning with a traditional approach that they believed didn't provide enough structure for the students. As Elizabeth described, the students never found the time to the preparatory work needed before class,

> I would say when we first started with PDI 554, we tried to do the more traditional PBL, where they got a case, and we expected them to look at the case, and come in ready to discuss the material. And that didn't go over well, would be a nice way to say it. They weren't coming to class prepared. In my sense, they were not doing the reading they needed to do to prepare themselves to discuss the cases. So when we went through the cases, they didn't understand them. And, it was very difficult to keep them on task, and I think it's competition with everything else they have during a semester. So, I think that exercise didn't' work terribly well.

Steve expanded on this topic, indicating that these results prompted them to develop "mini lectures" that would introduce the topic to students and give them the basic concepts,

> And they just felt like they didn't have the time to prepare in advance, or they felt they didn't, they needed a little more foundation from which to prepare, so maybe that was another aspect of the way it was done the first time around. They didn't have that little mini lecture or foundation to give them preparatory information from which they could learn.

In summary, my discussions with the instructors indicated that their use of problem-based learning evolved over time. In addition to using multiple PBL typologies, they also modified their approaches from year to year, and even at times created their own hybridized solutions.

They believed PBL to be particularly useful when their objectives included teaching critical thinking and problem-solving skills, integrating and applying knowledge, and when their content required discussion and interpretation. Using PBL was not without its challenges. PBL tended to take more time and effort to plan and carry out, as compared to traditional lectures. Time was also an issue for students, as it usually took longer to work through the PBL exercises. Instructors also found it difficult to locate space in the College that could be used for PBL activities, such as small group discussions. Many of the instructors had to put effort into working around what they perceiving as the limitations of traditional, or "pure" PBL, since they believed it did not provide enough guidance for their students.

Research Question 3 Analysis: The Future of Problem-based Learning

Q3) What is the future of problem-based learning?

- Question 3a: What benefits, if any, are being seen from the use of problem-based learning?
- Question 3b: How will problem-based learning be used at MSU CVM in the future?

The findings for the third research question indicated that instructors believed the use the problem-based learning lead to many tangible benefits for their students. The benefits they perceived included improved communication skills, achievement of a deeper level of learning and understanding, the ability to integrate information and relate it to real-life clinical applications, and increased retention of information. However, the instructors were not sure what the best way was to measure the benefits of PBL. Most were still using written examinations that were testing on facts, rather than on the processes that PBL was teaching. They were aware of this misalignment and were exploring other evaluation methods including case assessments, confidence level and peer evaluation, interviews with facilitator feedback, and

quizzes. The instructors advocated for the continued use of PBL and felt that it was useful for addressing some of the current issues in veterinary medical education, the greatest of which they perceived to be information explosion and the ever-expanding curriculum. In general, they felt that PBL has a bright future, and could even see a rapid increase in use amongst younger instructors, but only if the College provided the time and training needed for faculty to properly develop such resources.

Benefits of using Problem-based Learning

In the first coding pass, a general term called "benefits of PBL" was used to code the interview transcripts. Several common themes emerged, so this information was re-coded on the second and third passes with the addition of the following codes: communication skills, deeper level of learning and understanding, relevance and integration, and retention of information.

Communication skills. Improved communication skills were perceived as a particularly useful benefit of problem-based learning by multiple instructors. Not surprisingly, this theme emerged most frequently with instructors that utilized small group discussions and client interviews in their courses. As Samantha described in her Ethics and Welfare class, PBL gave students an opportunity to both verbalize their thoughts and learn how to respond to what others are saying,

> From my perspective, the most valuable aspect of the Ethics course is the chance for students to hear each other; for them to be able to express themselves out loud and be able to listen to other peoples' opinions. This approach has a direct impact on the majority of students in each new class.

In Samantha's Nutrition course, students have the opportunity to develop their communication skills by interacting with simulated clients and taking a diet history on two different occasions. This process, along with the immediate feedback that they receive, helped them to develop interpersonal communication skills that will be vital in the clinical environment. This is something that can be difficult to replicate in a typical classroom environment. As Samantha stated,

> Most students conclude that the value of the Nutrition course is that they actually get to practice the skill of taking the diet history, communicating with the client, putting their hands on an animal and practicing the physical exam. I didn't mention this, but students are given a ten-point checklist for ten communication skills and ten different physical exam skills. These checklists are posted in ANGEL early in the course and they are given to every client actor, who reviews the checklists as soon as the student walks out of the examination room. . Did the student shake the client's hand? Did the student greet the animal by name? Did they greet the client by name? Did they talk using every-day language? So, for students the value is in being in the moment to practice all of those skills, and then to get some immediate feedback from the client actor on what they did well.

Cheryl had similar thoughts regarding her Veterinary Integrative Problem Solving (VIPS) course. Her students also interacted with simulated clients multiple times at the Learning and Assessment Center (LAC) to develop their communication skills. Interestingly, the students also had a debriefing session afterwards in their small groups to learn from one another. As she described,

> We do go to the Learning and Assessment Center. They actually have to get the history from the client. Not all the time. Practice getting the history. One time. They meet in groups to see who did the better job getting the history. Learn how to ask better questions to get the history. They would get history, take blood from the animal, from simulators. They had to give bad news that their animal had cancer, and explain that to them. They don't have to die from it, but it's going to be sort of a near ending life sort of thing that happens. Each student goes twice to the LAC.

Nathalie, who used small group discussions in her Basic Science in Clinical Medicine course, believed that PBL was useful for students to develop their "process skills" that arose from interacting with their classmates. This also helped them to fill in their knowledge gaps, as she described,

> By working in a group, they can learn from each other. They can fill in gaps in their own understanding, or catch errors sometimes... They improve their communication skills. Party because of the PBL, but also from the communication aspects of the course... They actually have to think their way through the case. They learn, they get a lot. They also, there's some process skills there. Working in a group, listen to each other in a group, communicating their ideas to others in a group. There are process skills that are integrated into working in a group that are very important too.

Deeper level of learning and understanding. Several instructors believed that using problem-based learning helped students to develop their critical thinking skills and achieve better understanding, rather than just knowing enough to pass the exam. For Cheryl, PBL was a tool she used in an effort to help her with her goal of developing students as critical thinkers and

problem solvers, which are essential skills for any veterinarian. Instead of teaching a particular subject such as anatomy or physiology, she perceived her role as aiding students to utilize what they already knew. As she described,

> I really think it helps their critical thinking. People that couldn't really walk the line are now able to do that. That's problem solving, critical thinking, all those names that I love about veterinary medicine, beyond memorizing things. Especially now days, there's access to everything. If you can teach them to think, that's everything. Teaching them to think, that's my job... I'm teaching them how to think. How to get from A to B to C, in a logical way, with the tools that you have now. My idea is, I'm making, them problem-solving veterinarians. My task is different, thankfully.

Cheryl believed that using PBL changed the way students perceived, processed and connected information, making them more efficient when they reach clinics. As she commented,

> The really sharp ones, it'll change the way they store information. The ones that are really clinically-oriented. You start categorizing things, so much better recall. If you start putting them in order. This is a possibility for GI, etc. it's much easier for long-term recall. You're getting information in, and you're seeing how you're going to use it eventually. A lot of vet students have had no clinical experience. Teach them an organized way to work up a case, before they actually get the cases for real, before they actually store all of that information they're going to need to work up the case. You start aligning the way they think early on.

Elizabeth commented on how problem solving skills were essential in the field of Clinical Pathology. Just knowing a set of facts, within having the ability to connect them together and see the big picture of a case, isn't enough, as she stated,

> In my mind what it does is, it creates active learning, but it helps students supply the knowledge. To give them a series of facts isn't going to help them, when they ultimately go into their career. They have to learn to problem solve and supply that knowledge.

Relevance and integration. Instructors believed that using problem-based learning helped students to integrate what they were learning in all of their courses and relate it back to a clinical perspective. Without this connection to a patient, even a theoretical one, the students often perceived that they were just learning a series of unrelated facts. Matt felt that this sense of relevance changed students' perspectives and increased their motivation to learn the materials, since they're actually going to use it later in their careers, as he stated,

> The major strength of PBL is that it does add the relevance into learning. It presents you, puts you in a situation where you recognize what's important, and what may be less important. Because, when you go into a straight lecture class, we could teach all of the anatomy that you wanted with straight lecture, but we recognize that the look and see and feel, and put relevance as to why you need to know the anatomy… It's extremely situational. That's the major strength. Most students will learn from recognizing, this is a case, this is the reason we're learning this. It puts it all into perspective. That's the major strength of it. Rather than rote memory, it gives you relevance. And it gives you a feeling of accomplishment, because you feel like I'm learning something that I'm going to use. I can understand, I'm going to remember this. I think they do.

Annette shared this view and tailored her course (Epidemiology) to have a clinical relevancy, since students viewed themselves as "clinicians in the making", as she described,

> For Epidemiology, they can't see where it would apply in their clinical life, and the way they envision themselves as clinicians. I show how Epidemiology applies for what their ultimate career goal will be… It puts them in the scenario in which they want to envision themselves. They want to be a clinician. Putting it in a clinical setting makes it meaningful to them. Or, that's what I hope anyway. They can see that, even in simple things they've done in practice, what's really going on in the background? They can put themselves in that setting. If I can put them in the setting that they envision themselves being in, and show the relevance to their career path, then it will help them to retain that knowledge and they can use it on their day job.

One of Annette's ultimate goals was to have more clinical experts involved in delivering the case vignettes she uses in her course. Even though she's an expert in Epidemiology, she believed that her students would be more receptive if the information was coming directly from a practicing clinician, using "clinical speak", as she described,

> I'm not a Cardiology expert. My dream for the course, I would have these cases, then have the Cardiologist give a case vignette. They *believe* clinicians. It's put them in the mode of what they seem themselves being. If they could just come in and get this brief vignette. Do clinicians really use these words? What I'm telling you know is what's behind the intuitive decision making that you'll make as a clinician. It'll become almost automatic. They didn't say "positive predictive value". It's the *interpretation* of "positive predictive value". It's a translation into clinical speak.

Jaime believed that the ability to integrate information from other courses was the key benefit that students gleaned from problem-based learning. However, this can be challenging for a course like Endocrinology since it requires working knowledge in several other subjects including anatomy, physiology and pathology. In Jaime's case, she needed to stay well-apprised of what her students have learned in their previous and concurrent courses in order to effectively design her exercises. As she stated,

> That's the real strength, it's much more practical, and it's much more integrated. And that's the thing too, I see with some students really struggle with being able to take the stuff that they're being taught in terms of lecture, and being able to integrate it, and put A and B together and make C out of it. I think that's the strength of PBL, because you have to form those connections, but you have to really know your background. It's one thing if you're giving them all the material they need to know, that's one thing. But if your stuff is dependent on them, and in Endocrinology, they need to have a good knowledge of Physiology, they need to know Pathology, and they need to integrate all of that. And that's the challenge with it, to try to get them to integrate that. You can't just rely on the information in this course alone. You've got to put together everything you've learned so far. Sometimes you don't quite know what they've really been taught in previous classes either.

In Clinical Pathology, having the ability to evaluate a clinical finding within the context of others is especially important. Students need to look at the patient as a whole and determine which findings really are important at that point in time. Some instructors felt that the use of PBL cases can aid in this process, as Elizabeth stated,

> I think they do actually start to learn to problem solve in that they can apply data to real situations, and you know, you can memorize that an enzyme will go up with liver damage, but to be able to look at it in the context of other data, and say yeah, this is an insignificant increase, or this truly does suggest there's liver damage, because these other things are abnormal as well, and if it's the history and the other findings in the animal. So I think it does help them apply the data, the information. I think that's really important. Some people are really good with facts and do really well in an earlier course, but when I see them in 630, they may struggle with the integration and what's more, in this context, with this constellation of findings, is that really important now or not. It's hard for some of them to judge that that one really is minor compared to these other things, that are major. They remember each fact that they're all important, they're in the same plane. I think by doing the cases, we could spend more time, because that's something…

The lectures and cases in Clinical Pathology are designed to be applied to what students will be doing in the clinic. It's an iterative process, one blood panel or profile at a time. But, the elements are not taught in isolation. Just as a patient in the clinic can have multiple concurrent issues that interrelate, Steve uses a layering approach, as he described,

> I think the engagement and the application parts are really important at all of the levels that we do it, but thinking back to 554, where it's more preliminary, we could just lecture and give them base information, but they would miss out on the applied nature of what it is that we're doing, and seeing how these things unfold as panels, and profiles. We build from the beginning, towards the end, when you do those labs that are case-based labs, it's synthesizing, it's covering the large amount of materials from the whole class, whereas at

> the beginning we would just have data from the CBC. So, it allows them to build and apply in a way that they will be doing it in the clinic. That's the big strength that I see, at that level.

Steve also felt that relevance was of particular importance. He's teaching real-life skills; the exercises his students are working through in their PBL activities are reflective of what they will encounter in the clinic, and eventually in practice. As he stated,

> The materials that we provide for clinical pathology, data, interpretation, understanding, are the same materials that they get when they're in practice, so it's just, it's reflective of what they will be doing, exactly what they will be doing to some extent. So they're going to get those case profiles, and they're going to have to think about them, and work through them, and that's basically how we organize most of our problem-based learning activities.

Retention of information. Retention of information can be challenging in the DVM curriculum. Students are presented with an abundance of information, oftentimes only focusing on what they need to know for the next exam. The instructors in this study believed that problem-based learning can help to improve retention in a variety of ways. Matt believed that relevance to real-time situations was particularly effective, as he stated,

> Rather than rote memory, it gives you relevance. And it gives you a feeling of accomplishment, because you feel like I'm learning something that I'm going to use. I can understand, I'm going to remember this. I think they do. One of the major advantages is retention of information because of relevance.

Jason felt that students perform better, and retain more knowledge, if they actually enjoy the process. As he noted,

> I would like to think that, since they, enjoy the format, you're going to learn it better. You're only going to learn what you enjoy learning, so… And it sticks a little bit better. Just like to think that!

Students do appear to like the clinical perspective, and many students have told Jason that they tend to vividly remember the cases he taught them in VIPS and even apply those concepts to cases they've encountered in the Veterinary Teaching Hospital.

> Well, I think the students do appreciate seeing the clinical applications of what they're learning, in the basic sciences courses. And, I've had many comments on the SIRS forms, where they tell me when they're third and fourth students that, you know, I saw a case of such and such in the clinics, and I remembered that we had a case of that in VIPS, and they remembered the VIPS case, so it helped them in the clinics. So, that makes me feel good. I think they remember those cases, and they remember what they got out of those cases, so I think there's maybe a longer term retention of the basic concepts, in addition to seeing the clinical application of those basic concepts.

As Cheryl stated, she believed that using PBL changed the way student stored, and later accessed, information. She felt this lead to improved connection and recall, as she stated,

> You start categorizing things, so much better recall. If you start putting them in order. This is a possibility for GI, etc. it's much easier for long-term recall. You're getting information in, and you're seeing how you're going to use it eventually. A lot of vet students have had no clinical experience. Teach them an organized way to work up a

case, before they actually get the cases for real, before they actually store all of that information they're going to need to work up the case. You start aligning the way they think early on.

In summary, the instructors perceived that using problem-based learning lead to many benefits for students including enhanced communication skills, superior critical thinking skills, a deeper level of learning and understanding, the ability to apply what they were learning to clinical scenarios, and improved retention of knowledge.

Evaluation of Problem-based Learning

While all of the instructors in this study stated that they believed the use of problem-based learning to be beneficial, only a few dabbled with methods other than written examinations. In most cases, they focused on how well students were performing on individual PBL exercises; they did not extend their evaluations beyond the didactic curriculum to determine if students are able to apply these skills during their clinical years. There was a sharp division between the pre-clinical and clinical curriculum as most instructors did not teach in both settings. Also, students were not allowed to select whether or not they want to participate in PBL, as they are at some institutions. So, there was no control group in place to which the PBL students could be compared. After multiple passes, the transcripts were coded to include several different methods that a few of the instructors used to evaluate the effectiveness of their PBL approaches including case assessment, writing assignments, confidence levels and peer evaluation, interviews with facilitator feedback, and quizzes. However, by far the most common response from instructors was that they were not sure how to measure the benefits of using PBL. So, it was impossible to determine if PBL was in fact effective, since none of the instructors had a way

to actually evaluate it. Each of the approaches the instructors used will be discussed in further detail in the following sections.

Case assessment. For her Clinical Pathology course, Steve used a "midway case" written assignment to determine how students were performing. This was compared to a similar case at the end of the course. This approach did not assess their performance in clinics, however.

> So, we haven't done a pre-post assessment, exactly, to see that, but subjectively, we give them a midway case, that they have to write up, we've only been doing this since the competencies got put into place. So, to be standardized now, they're getting a pretty broad case at the midway point of the three week rotation, and they write it up and evaluate it, so we can compare the midway and final performance on those, but they're different cases, but you can see how they're attacking it basically. That's the only opportunity I can think of where we can really look at that.

Writing assignments. Several other instructors used written assignments in their courses to evaluate student performance. For Samantha, this was an essential component for both her Ethics and Nutrition courses. In addition to content, Samantha also evaluated the overall effort that the students put into their writing assignments in terms of grammar and spelling. As she stated,

> Since I'm the person who reads all of the student papers each week, I have an overall sense of when or where people struggle. And when there is some "struggling", I think that there's learning taking place. Part of the grading rubric requires that some attention must be paid to grammar, spelling, and punctuation. I think this is critical to developing excellent communication skills (and minimizing errors). When students rush or don't pay

close enough attention to grammar and spelling, it is in some respects an indirect measure of one's effort and willingness to seek excellence in how they express themselves. Most students are either good or very good in their efforts to communicate, and the rubric is helpful in distinguishing among written work or performances that earn 4.0 versus 3.5 versus 3.0 grades. The written assignments in Ethics are particular useful for Samantha as they allow her to discover, in greater detail, how (and why) students' perceptions and opinions changed as they worked their way through the course. This level of assessment would be difficult to obtain from a multiple choice test, so Samantha is comfortable that her approach is worth repeating in future offerings of her course.

Being able to listen to conversation or read what students have written is a useful method for me to evaluate this PBL, especially in the Ethics class. When students actually write, "I came in knowing just what my opinion was going to be and which position I was going to take during our small group decision, but then I did a '180' after listening to my classmates. I never thought about X and Y before." In one fashion or another, I see or hear this kind of statement every year. This is the kind of feedback that tells me the exercise or approach is worth repeating.

Cheryl also used written assignments in her Veterinary Integrative Problem Solving (VIPS) course. Students participated in multiple group assignments. One of these assignments was to develop a report, as group, on a case using the SOAP format. This included a subjective summary of the patient, objective data obtained from physical examination and diagnostic tests, an assessment of the patient's status based on all available data, and finally a plan for the patient's care. This is an essential skill for students to develop before they reach clinics, as it will be used daily.

Quizzes. Cheryl, Jason and Nathalie reported using quizzes to evaluate student performance of PBL exercises. For Cheryl, the quizzes only accounted for a small percentage of students' grades, as she used a wide variety of assessments, as she described,

> The get points for attendance, 30%. They need to show up, and be engaged. Group assignments. They turn in something. I might make them SOAP the case. All seven or eight of them will SOAP the case together. So they turn that in and I grade it. Group reports. What were some of the frustrations with the case? They just need to turn it in for group credit. Group assignments are one person turns it in. I do have quizzes, 21% is based on quizzes. Here's a dog, here's what it looks like. Flea bite sensitivity, but it also has a murmur. But you need to SOAP every problem. They get graded on self-performance. Then there were assignments…

Jason didn't mention using quizzes in the Pathology course that he currently teaches, but he did use them frequently when he taught VIPS several years ago. However, the quizzes focused on case content rather than what students should have been learning with the PBL process. In Jason's view, this was far from ideal, as he mentioned,

> I did do some things that, again, this kind of evolved over the years. We would have a quiz at the end of the week when we'd have that case summary session, the Q&A with the content expert. We'd start that day with a quiz, a 3-5 multiple choice question quiz, initially it was on ANGEL when we did it, I think. And, so, it was on, it was on unfortunately, it was mostly on case content, kind of against PBL, more on facts, than on process, but eventually we tried to work some questions in that were more thought provoking kind of questions. They did center around the learning objectives, so you'll

> see there's some questions I've got in here that are labeled as to this is an objective that comes from the Microbiology course, or the Pharmacology course. So when I wrote the quiz questions, they were about these questions. So these were the questions that we really wanted the students to target in on. Those are the key things they should have gotten out of the case.

Nathalie used web-base quizzes to evaluate how students were performing on her cases. While she relies on the honor system to ensure that students are doing their own work, she has no way of being sure, as she noted,

> The formal evaluations are quizzes, online quizzes. And the students have done well on them. For all I know, they're open-book, and they could be doing them as a group. I can't forbid that, so I don't even try. They're going to learn more about themselves if they do it on their own.

Interviews with facilitator feedback. Samantha's Nutrition course was unique in the respect that she used the Learning and Assessment Center (LAC) to give her students an opportunity to interact with simulated clients in order to take a diet history and perform a brief physical exam. In addition to receiving immediate feedback from the simulated client, students also had the option to receive feedback from clinical facilitators who reviewed videotaped encounters or interviews. While many of the students were interested in obtaining this extra level of feedback, the large class size and limited availability of clinical facilitators made this logistically challenging. The lack of complete follow-through resulted in negative feedback for Samantha. As she noted,

> One-quarter to one-third of each class always said that they would like some optional feedback on their videotaped performance. And while I could get some clinical faculty and technicians to agree to help look at the tapes and offer constructive feedback to the students, it always ended up being "hit or miss". These events are happening during the second half of the semester and everyone is always so busy. I would set a deadline and most everyone could meet the deadline, but there were times when one or more evaluators (including me) could not stay caught up. This year, we did not get the feedback to students in time for their 2nd exercise in the LAC, and there were some frustrated people as a result.

Confidence levels and peer evaluation. Only one instructor (Jason) mentioned using confidence levels to evaluate the effectiveness of problem-base learning methods in his course. However, his methods were quite interesting and deserve mention. Jason used data from three years of his course to construct a study, which was published in the Journal of Veterinary Medical Education. Jason described the study in more detail,

> I also, actually did a study that got published in JVME, about students' self confidence levels, so I measured that as to what was their confidence in… Something like clinical skills, making a problem list, making a differential diagnosis.. Anyway, there were three things that I measured, their self confidence at the beginning, and at the end of the semester. So, I gave them this little survey on their confidence in doing various things. They were mostly clinical type skills, like making a problem list was in there too. It went up in all three things. And I had three years of data, I used three years of classes to do that, so I had a good enough N. So, that was good, and they went up. I can't remember

which one went up much more significantly that the other two. I think it was the differential diagnosis one, which is probably the one I was expected to go up the most.

Similarly, Jason developed a study that compared student self-assessment to what their facilitators and peers thought of their performance. This study is still in development and has not yet been published.

Not sure how to measure benefits. The most common response from the instructors indicated that they were unsure of how to measure the benefits of using problem-based learning. While they all believed that PBL was useful, they have yet to find a direct way of measuring this assumption. Also, several instructors mentioned the difficulty of trying to tease out the role that PBL played, in comparison to the multitude of other factors that affected student performance. Since the students are not separated into PBL and non-PBL groups, the exact impact of PBL that PBL had, if any, could not be determined.

As Matt stated, student performance can be measured when they take their board exams near the end of the curriculum, but it's impossible to determine exactly what role PBL would have played.

That's one of the issues, how do you evaluate it? I don't think there is a real effective way to evaluate it. Other than, take the students when they graduate, or when they're taking the NAVLE, and see how they perform, etc. I think it is difficult. We all recognize that you can't test knowledge. You can test facts and figures and stuff, and you can test responses to certain questions, but to really overall say is this system better than this system, it's incredibly difficult. I think it is difficult to evaluate, because you can always, you can ask questions on an exam, but does it, is it really reflective?

Annette was also unsure how to evaluate PBL. She relied on student feedback regarding the exercises she used in her class, but acknowledged that this was not very accurate. Also, she had no way of determining if the concepts she taught actually carried through to clinics, as she described,

> I'm not really sure how well it's working. I haven't really assessed it in anyway. Students who say anything about it say that they like it... It's hard to gather. I can put some anecdotal thing together. I don't know. I would really love to know if by the clinical year, students bring up any of these things. If we had the faculty and staff, and have an epidemiologist go to rounds. Some things from an epidemiology standpoint. In our spare time!

Similarly, Jaime felt frustrated by the pre-clinical / clinical separation and stated that she had no way of knowing how her students were performing once they reached clinics. She did have some anecdotal information that indicated that the students who took her advanced course were performing better than their counterparts. The merits of her course were spreading by word of mouth, as she noted,

> I don't really have a good way of evaluating it down the line, since I'm not over in clinics. It would have to come from the Internal Medicine people… I'll have students come back from rounds, and they can just answer all the questions and the residents didn't even though. They can tell that they've learned a lot. I've heard that from some of the clinicians over there too. The Endocrine students do much better than the regular students do. They've had more practice just going over cases. That's how I know, I guess, but I don't really know for sure, I don't have any way of measuring it. I always

> ask the students, how do you feel about Endocrine now? The end, vs. the beginning. And everybody feels that it's a worthwhile experience, and the clerkship is always full, and there's a waiting list to get it, and there's people that can't get in. I just can't offer it more than one time. To me, that's people view it as being worthwhile. People recommend it to other classes.

Elizabeth also heard back from students, on occasion, about how the Clinical Pathology course prepared them for some of the more intensive clinical clerkships, especially Internal Medicine. While this isn't an ideal form of evaluation, it did give her confidence that the course is of some benefit to them, as she noted,

> It's a backwards way of assessing does it help, comments from students I hear frequently. I'm so glad that I've had this before Internal Medicine, because I heard this helps tremendously. And I've had ones that have gone through Internal Medicine and then gone through Clinical Pathology, and then said oh boy, I wish I would have had this before I had Internal medicine. So, that gives me a warm fuzzy feeling that we're doing something right, that it does help them when they get to the Medicine clerkships. They basically apply what we're telling them.

In summary, most instructors indicated that they were not sure how to accurately measure the benefits of problem-based learning. Many still relied on written examinations, but were not satisfied with this format as it tended to test on memorized factual information, rather than the clinical thinking processes they were trying to convey by using PBL. Several instructors were experimenting with alternative evaluation methods including case assessments and interviews, but they found the time commitment involved with using such techniques to be much higher.

Overall, my conversations with the instructors indicated that none of them have found an accurate method for measure the impact and effectiveness of using PBL.

Current Issues in Veterinary Medical Education

Initially, a code named "current issues" was used in HyperResearch classify what the instructors considered to be the most pressing issues in veterinary medical education. Through subsequent coding passes, two major themes emerged and the findings were reclassified using the codes called "finances" and "information explosion".

Finances. The issue of finances was mentioned frequently in my discussions with the instructors. The cost for earning a DVM degree has been increasing much more rapidly than the average starting salary for new graduates. In 2011, the average starting salary was approximately $47,000 while the average educational debt was over $140,000. The debt level for out-of-state students is even higher, and oftentimes approaches $250,000. Several of the instructors were concerned that these figures are impacting the profession's ability to recruit the best and brightest, as Annette stated,

> The cost of education vs. current salary is a big issue. It has impacts. I have some concerns about being able to recruit. I want to recruit the people we *want* in our profession. It sets us up for wonderful opportunities to do things in veterinary medicine.

Cheryl felt that the curriculum doesn't teach enough about basic business concepts. She believed that students didn't have a firm understanding of how the decisions they made while in college would impact their future lives. For example, taking out an extra few thousand dollars in loans will end up costing them much more with interest over the course of a twenty-year repayment program. Also, she believed that students aren't taught as many "real world" skills as

they should be. She felt that they need to be taught basic, although most times less glamorous, skills such as equine dentistry, as she described,

> Obviously, financials. Does that go without saying? Training for all phases of the career. The recruitment of the best students. Being the most successful practitioners. We need to do some more business. Put in some more business. Business should start on day one. There gets to be a disconnect between academia and real world. That can be reflected in the students' education. They need to know basic skills that are going to make them money. It would be great if they could float teeth. Teach them the day to day. They need that to live.

Information explosion. The most actively discussed theme in this section was the concept of information explosion. All of the instructors believed that what veterinarians needed to know in order to be practice-ready upon graduation was increasing almost exponentially. However, many instructors also felt that what was being taught in the curriculum didn't always align with what students really needed to know. Also, they believed there was a fair amount of disconnect among the instructors; they were oftentimes unaware of what was being taught in the other courses, especially in courses that were in different semesters than when they were teaching. For example, there is no easily accessible, common repository for course syllabi and lecture topics that faculty can access. This had a tendency to lead to information being unnecessarily duplicated between courses. Samantha commented on the lack of communication between instructors,

> The most important issue in our MSU-CVM training program is "getting the curriculum right"....by this, I mean that we need to focus much more attention on regular revisions,

> streamlining course content, and working harder to get moderators to understand where and how their courses overlap (or don't). As a group of faculty instructors and administrators, we should work toward the goal of making sure that each instructor (and eventually the students) knows exactly why we teach what we do and when, and how each course builds on the courses from the previous semester.

Matt felt that, at times, students were being taught exotic procedures that they probably wouldn't even use in private practice, rather than the basic procedures that they could use every day. In his view, the curriculum is expanding, and "drifting", to accommodate this new information that isn't necessarily very useful to the student upon graduation,

> The explosion of information is an issue. We're trying to teach everybody everything, and you can't do it. I think we need to get back to more basics… One of the major issues we have in dairy cattle is lameness. In the Musculoskeletal class, I get two lectures to cover *all* lameness in all cattle, sheep, goats and pigs. In two 50-minute lectures. And you wonder why they're not ready for clinics? And so, I think that, part of that is "curricular drift", part of that is the fact that we shortened up the pre-clinical for more clinical time, but it's… I get 2-3 lectures to do all issues with the digestive system of the cow... I had five hours of lecture on *all* of the problems in lameness. Terry Braden had five lectures on the fractured femur. Orthopedics. They try to teach them every procedure. They need to teach them basics. They try to make everyone an expert. We need to give them experience. They go into surgery and they *watch* somebody. The stuff that we're teaching in equine is stuff that they will rarely use.

Raj also felt that the curriculum was "uncoordinated". He believed that instructors within the same semester seem to work well together, but there is still a disconnect between each year of the curriculum, as he described,

> Coordinating what is happening to different courses in the same semester. They've worked hard to improve that, in the first year. There's still a lot that needs to be done, in terms of second and third year, and graduate. All the first year course moderators sat for six months to talk about the whole thing. Sometimes it's not exactly happening at the same time. There might be some lag in terms of how the learn physiology or anatomy, but it happens within two or three weeks. So in that sense, I think, I've heard, that lots of complaints about other semesters and years that are not as coordinated.

Raj also stated that he believed many instructors didn't know what was important to include in the curriculum, and what could be omitted. In his view, they try to pack as much into their 50-minute lecture as possible, rather than trying to identify what students really need to know. His approach for teaching Anatomy was quite different, as he tried to convey only the relevant details, instead of teaching his students every fact that he knows. As he commented,

> Some people try to put too much into the curriculum. They do not know, or they do not understand. "I need to let them know everything that I know about a particular subject in the curriculum". If you look at any of *my* lectures, none of my lectures will have more than 25 slides. If I put more than 25 slides, I cannot finish in the lecture. I do not just verbatim say what is on the slide, it's more extempore. I use the slide as a crutch, but more interactivity... Teachers try to give too much within that one hour time. Us, as a whole, the curriculum, trying to teach them too many things, in that 2.5 years. Without

thinking about consciously, cutting back things. We talk about business and entrepreneurship in first year. I think that's a little too much in my opinion. You can teach them financial management, and that's helpful. This is at least skills that they really need to have to pass the boards. I think we should focus more on that, and maybe like a selective, or an online type of course, that the students can still get the information, and they can still take it.

Jason also saw the curriculum as "fragmented". He felt that instructors want students to learn more and more information, but they're not paying attention to what they're being taught in other courses and semesters. Jason also advocated for better communication between instructors across all semesters to help redundancy and improve consistency. As he stated,

I think we really need to, to integrate the whole curriculum better. Integrate basic sciences, and clinical sciences better. We need to have better communication, I think, across the board, among instructors too, to know what's taught before us, what comes after us, so we have just a tighter kind of a curriculum overall. It's so fragmented, that's how I see it really now… I still try with some courses, for example, Martha Mulks who now teaches the Bacteriology course in semester III. I ask her for her topics list. What are her lectures? What's the order of her topics, and her schedule, and I give her mine. Especially, it's pertinent when I'm covering inflammation, and some of the case examples that I might use when I'm talking about inflammation. I'm going to say hey you guys, you already learned about Staph or Strep from Dr. Mulks, so here's my case. And then she wants to know what I covered in inflammation, so she knows how much she has to talk about, chemical mediators, or something like that, if she knows that they've had that lectures from me… I would really like to see that more… So, you can

> plan your lectures accordingly, you don't have to dwell on such and such, because they already do it. I do think that all of us should have access to every other coursepack. Why not? We can identify the gaps, we can see where the redundancies are. To me, the main thing is *consistency*; you don't want to be teaching something one way, when what they learned last semester was different for that same topic… I think here, a lot of our faculty are just learning about learning objectives! They're frustrating, when it's taught differently in different courses. That's what I see as the main issue. You need to get more consistency and better integration.

Jaime also viewed the curriculum as bloated, and not very reflective of what students really need to know. She believed there is a tendency for instructors to include the "really cool stuff" rather than the basic information that students actually need. What it boils down to, in her opinion, is too much information and not enough time to teach it. She also felt that the assessment techniques used by some instructors were not always appropriate, and tended to test on irrelevant minutiae rather than useful facts. As she described,

> To me, there's so much material! I think the biggest challenge for instructors is, you need to boil it down. You need to be able to pick out what the students *really need to know* to be passable in practice... It's hard, because this is the area that you love… When you're so involved with the material, the stuff to me that's cool is the minutiae. It's the stuff you're only going to see once in a lifetime. When I sat down and thought about it, you're right, and that has served me very well. If it's really cool, it goes out. There's not time to cover all of the little cool things. You wish you did. But, they've gotta get the basics. That to me is the biggest challenge as an instructor. *You gotta be willing to let it go*. Sure, you can make harder questions. But, people that give an hour

> lecture, and give somebody 30 pages of notes, and put on their exam, some one little statement out of the… who cares! That's one of the biggest challenges. There's just way too much information. And the students have to get the basics. If they don't get the basics, they need a good foundation, so they can later get stuff more that they're interested in. And that's a real challenge for me for the Endocrine stuff. I have to keep it to the… so that they can diagnosis stuff, diagnose patients when they come in the door… That's what I think is the biggest challenge, the information overload. We have an incredibly difficult task. I would love to be able to include research papers, etc. but I just don't have time. I have a finite number of lectures, and I gotta get the more important stuff in.

Louise also commented on the idea of "baseline knowledge" – the information that students really need to know in order to be functional. Students seem to barely be surviving the ever-expanding curriculum, as she described,

> To me, the core issues, and it's been, for a long time, is how much do they really need, what's the knowledge base, what's really "baseline knowledge"? What do they have to have in order to function? The curriculum just keeps getting denser, and denser, and denser, as far as content, information that they're expected to know, and the credit loads. I think we feel that it's a tremendous amount, because we're in semester four, the course PDI 554. If you contrast the students that are coming into veterinary medicine, and they're all bright and they're all energetic, and they're all ready to go, and by the time to you kick them out, they're just so *wasted*…

Elizabeth has changed her approach to teaching over time, and actually delivers less facts to her students, even in the face of information explosion. Her goal has always been to help students learn how to find information, as she described,

> It's a time issue for how much information can you give them. The longer I've been teaching, the less facts I give them, because I think that they… I want to them to be able to learn how to look up that material when they need it, and understand it. I'm more interested that they learn the basic concepts of how to apply them, because then they can build upon that as they go through their career. I can remember when I was in practice, going back and pulling out my medicine book, and then going back and talking to the client. I thought I knew, but I wasn't quite sure. So, I think they need to learn *how to learn,* is what they, what I hope they develop, is how to develop and build on what we're doing. I can't tell them everything!

Steve agreed that what's taught in the curriculum needs to be reduced and made more relevant, but commented that the process for determining exactly what information is truly needed for a new graduate would be very difficult. Trying to reach a consensus among instructors across the entire curriculum would be a daunting task, as he described,

> I think it's really difficult to reach a consensus, on what is a "core piece of knowledge", even in the case of the three of us in our discipline. Then you open it up and say Internal Medicine and Clinical Pathology. They you open it up further… It's really hard to find the balance amongst all the disciplines, what is needed and what isn't. Then you get into the discussion of, what's the product of a veterinary school? Is the product a practicing clinician? Or is the product all possible things that veterinary students can become,

> which is very diverse. If that's what you're looking at, then you want some more basic science, and you want exposure to some things that you wouldn't do if it was just all of technical clinicians kind of stream. I think it's really hard to define that, but I think that most people *can* trim down what they teach.

Nathalie also believed that there is too much information in the curriculum and that faculty have not been able to determine what is truly important. She also commented that the curriculum is lop-sided in some subject areas, allocating inadequate time and number of lectures for very important, complex topics, such as Endocrinology. Also, this structure does not give students adequate time to absorb the materials, as she described,

> The excess of information and the inability of faculty to decide what's important and what is not. The students can't decide that. And, it's the lack of time for students to actually absorb and integrate it. Time and occasion. The way for them to learn something is to actually *do it*, and there's not enough time for that. Work their way through problems. A lot of didactic teaching that is stand up and deliver. They still need time to digest it. They digest it better if they're exercising their brain while they're digesting. The application, and the time. They have only seven lectures for Endocrinology, and that's ridiculous. So, not enough time to process...

In summary, the issues that the instructors were most concerned with included finances, along with what they termed to be an explosion of information. The two concepts were heavily intertwined. The instructors believed that students were not receiving the proper information they needed to make sound financial decisions while they were in college. This included how they handled student loans and the impact it would have on their future budgets. They also

stated that they felt they were not being taught real-world, "bread and butter" skills that could be used daily once they were in practice to generate revenue. Part of this issue was due to lack of time in the curriculum. The other major factor was a perceived misalignment between what the students really *needed* to know, and what faculty *wanted* them to know. The instructors felt there was a tendency for faculty to teach more and more every year, without evaluating the necessity of what they were including in their courses. As an example, students received multiple lectures on orthopedic surgical procedures, but the majority of the class would never use these skills in practice. However, they were taught little to nothing about equine dentistry, which is a valuable money-making skill. In their view, students needed to be taught less exotic information, in favor of more knowledge that's applicable to real-life. Several instructors believed that many individual faculty appear to be unable to differentiate between the two.

Future Use of Problem-based Learning

The instructors were very optimistic about the future of problem-based learning at the College. In general, they felt that its level of use would either remain stable or increase in the near future. The participants believed that the primary factors influencing PBL adoption included instructor buy-in, faculty development to educate instructors on innovative teaching methods (such as PBL), and College support of instructors that go above and beyond to engage in these activities. Samantha reinforced the notion that this is a complex issue, relying on many interrelated factors, as she noted,

> The future of PBL is very strong IF we pay attention to the curriculum *and* faculty development *and* competencies! I see each one following the other and fitting in nicely with the objectives of training (or retraining) faculty instructors on the best ways to

deliver course content *and* get students to build critical skills, such as communication, leadership, problem-solving, independent investigation, self-directed learning, etc.

Raj believed the future of PBL was bright, and use would most likely increase, but only if faculty could use a form of PBL that worked for them, instead of being restricted to a set format that doesn't mesh well with their particular course and teaching style. He also felt that PBL use was "infectious" and would spread across team-taught courses (which did occur in Clinical Pathology), as he stated,

> I think it will only increase. Maybe in different formats, and not be the traditional format. I think if the teachers know, if you get a format that is convenient for them, it is not etched in stone, no one is committed to a specific format, you can use it whatever, the way you like it, I think they will use it more, that's my opinion. There are some that regularly think that you need to do it like the SOAP method, or the VIPS method, or something like that, that's what they think in the head… Fear of the unknown. I've never done it before, what if I do it and students don't like it?... It's also infectious. If it is a team-taught course and there are a couple of people teaching, and one person uses it, the other person uses it. You are compelled.

Jaime believed that PBL should be made more "practical", giving the instructors the latitude they need to customize it to their own needs. In her view, that would increase adoption, as she described,

> Certainly, it could be incorporated at every single level... The challenge is to make it more "practical". I'd like to see things go more case-based... I think that's fine if the students have background information. But, to give them a whole topic, I think it doesn't

direct the students enough. I think with the amount of information that's out there, students need a little more direction than that. Maybe I haven't been around it enough where it's been really effective. Instead of having an instructor that incorporates both, it's all lecture, or all case-based. If you don't have any basis, it doesn't work very well either. I like some structure.

Elizabeth commented on the importance of faculty buy-in, but acknowledged the extra effort that PBL takes. Without a core group of faculty members using and advocating for PBL, she believed its use will eventually diminish,

> It's going to be driven by the instructors that are here. If you have a core people that find it valuable, it will continue. If you have core people that don't find it valuable, it won't. I think it probably takes more time to teach that way. I think it would be easier for me to just put together a lecture of facts, as opposed to teaching in a case-based approach. So I would like to think that we select key faculty that are on board to continue to work that way.

Nathalie also commented on the importance of instructor buy-in, and how she believed that future PBL use would depend on their comfort level and available time for development. She didn't see the current status quo changing until the College experiences an influx of new faculty,

> The future of problem-based learning? It's going to depend on the instructors. I like it, it's very useful, but it depends a lot on whether instructors are willing to use it, have comfort with it and time to use it. Probably not changing until you get a change of

personnel. You get new people in, that might change. Haven't seen enough new people coming in.

Many of the instructors viewed faculty development and training as key to the continued use of problem-based learning. Without making faculty aware of innovations in education, they will most likely teach their students using methods similar to how they themselves learned. To complicate matters further, the vast majority of instructors at the College are clinicians or researchers, not trained educators. Matt believed that the current methods being used by the College to educate instructors need to be expanded to reach more clinicians, not just the "same old crowd", as he stated,

> One of the things that I think veterinary medicine needs to do is put more emphasis on educational training, that's what you do, is train the teachers. If you polled every faculty member in our college, less than 10% of them have any educational training. They're very good content experts, the best there is. But they're not trained in education… I think the College has made efforts to try to train. But, you go to one of those educational things, and there's the same 10-15 people. Those aren't the people you need. How do you get the clinicians that really need to be there?

Annette commented that development was crucial, and that the College needs to provide the resources and support faculty needed to pursue these types of endeavors. She also stated that it would be useful to have some faculty assigned to teaching duties only, rather than having them try to juggle clinical and research responsibilities as well. In her view, the teaching responsibilities always manage to somehow become the lowest priority item, leading instructors to find the least time-consuming solution to fulfill their teaching obligations. As she described,

> My other bias is that I really think we should have people that are entirely or primarily teaching faculty… There has to be investment in the College on the personnel we really need to make engaging online courses. We need people to help do them. We're also not trained at that… This goes back to how we assign people. If you're going to do it well, you need time to plan it and develop it. The quickest thing for a faculty member to do is to develop a straight up lecture…

Equally important, several instructors commented on the importance of the College giving credit, such as promotion and tenure, to faculty members that are more actively engaged in innovative teaching methods. They believed that efforts in teaching tend to get overlooked and research, grants and clinical performance take precedence. Jason commented on his previous experience faculty volunteers in the VIPS course,

> They were excited initially, and then it waned, because they realized they weren't really getting any reward for this, just like anything related to teaching! It was all voluntary, they'd put in their time and do it.

Cheryl was also concerned about how faculty viewed the value of putting extra effort into something like PBL. As she stated, "What do they get for it? It gives them nothing."

The instructors also felt that the College needs to be consistent in its support of innovations such as PBL, rather than waning and sending mixed messages to the faculty. As Jason stated, the College's interest in NAVMEC-related endeavors were "back-burnered" for about two years while all attention was focused on accreditation,

> I don't know what the future is going to be, at least NAVMEC is promoting the better integration, and also are promoting more kind of clinically-based instruction to

> demonstrate the applications on concepts. Maybe that'll be some impetus for us to get more PBL… Now that the accreditation site visit is over! I thought our Education Day was excellent, but then we just kind of dropped it… That got put to the back burner.

The future of problem-based learning use at the College is a complicated issue. While the instructors that I interviewed were very positive about it, its continued use will depend heavily upon faculty buy-in. More faculty members can be made aware of PBL, and other teaching innovations, if the College expands its development and training to include more individuals. At this point, efforts are primarily focused on a core group of faculty that have already been using PBL for some time now, rather than attempting to branch out and reach new instructors. The College is, in many ways, "preaching to the choir" rather than trying to find new converts. The participants also stressed that instructors need to be recognized for their efforts in teaching, in a similar way to those that pursue clinical and research paths. Without some form of support and recognition from the College, the motivation to expend additional efforts on teaching will be greatly reduced.

In summary, the findings for the third research question showed that instructors were supportive of problem-based learning and believed that using it had many benefits for their students. These perceived benefits included improved communication skills, achievement of a deeper level of understanding, the ability to integrate information and relate it to the clinical environment, and increased retention of information. Most instructors were still searching for the best way to accurately evaluate the effectiveness of PBL, and at this point none of them had an accurate method for measuring the true impact of PBL. They tended to rely on written examinations, but were using some other methods including case assessments, interviews and quizzes. The instructors were supportive of using more PBL in the future to address some of the

current issues in veterinary medicine, including finances and the explosion of information in the profession. Their overall view of the current curriculum showed that they believed there was misalignment between what was being taught, and what students really needed to know to be successful in practice once they graduated. The instructors believed that PBL would continue to be relevant in the future, perhaps being used even more, but this would be dependent upon the College providing the proper training and support to faculty.

Summary of Results

Problem-based learning is used, in some form, in each of the five pre-clinical semesters in the DVM curriculum. It is especially prevalent in the second year of the program, Phase II, which focuses on the study of abnormality. Most commonly, instructors used cases presented at the end of their lectures to reinforce the topic by giving students an opportunity to actively apply their knowledge. These cases were presented to the entire cohort of students at once in a large classroom setting. The majority of PBL exercises were on topics and objectives selected by the instructor, and were delivered as computerized cases that were completed in one session. Only a few instructors used what they described as more "traditional" problem-based learning, which involved small group discussions that usually spanned over multiple class sessions. This format was most common in the capstone courses that replaced the Veterinary Integrative Problem Solving (VIPS) courses that were present in each semester in the previous version of the curriculum. Overall, the instructors were not locked into one specific method of PBL; most used two or more of the PBL typologies and even created their own hybrid approaches.

Instructors believed that using PBL had a wide variety of benefits. From their perspective, it helped to improve students' critical thinking skills and their ability to integrate

information previously learned. This prepared them for the clinical environment, where they needed to have the ability to quickly recall and utilize knowledge from many other areas in order to evaluate a situation and make a sound decision. Instructors also felt that PBL contextualized what was being taught, making information more relevant to what students will be doing in practice once they graduate. PBL was perceived to be of particular benefit in courses involving the development of critical thinking and problem-solving skills, the integration and application of existing knowledge, and in situations where the course content required discussion, analysis and interpretation.

Implementing and using PBL was not without its challenges. Logistically, the instructors felt that it required much more effort to design cases and coordinate group exercises than it did to prepare traditional lectures. Time was another factor that the participants mentioned; PBL activities did not always fit neatly into the fifty-minute lecture blocks that most faculty were allotted. Instructors were generally unsure how to evaluate the effectiveness of PBL. Most still used written examinations, but were experimenting with other formats including case assessments, writing assignments, confidence levels and peer evaluation, interviews with facilitator feedback, and quizzes. None of the instructors I interviewed had an accurate way to measure the true impact that PBL was having on students.

PBL is being used by a core group of faculty at the College, but its prevalence has remained relatively unchanged over the last decade or two. Those using PBL believed it helped address the two greatest current issues in veterinary medical education, which they perceived to be finances and the explosion of information. Overall, the participants felt that PBL had a bright future and could even see a surge in use. Instructors indicated that efforts to further educate faculty on innovative teaching practices tended to target this same core group, rather than

branching out to include more clinicians and new faculty members that could make an even greater impact. They also indicated that the College will need to provide further incentives, such as promotion and tenure, to encourage faculty to expend additional efforts on teaching innovations, such as PBL.

CHAPTER 5

CONCLUSIONS

Today's veterinary students face many challenges as they work through an intensive four-year program to join the ranks of the profession. In addition to constantly increasing tuition rates and static starting salaries, they must master an ever-increasing repository of knowledge in order to be a "career-ready veterinarian". Rather than teaching students to memorize only facts, modern veterinary medical education seeks to develop the critical thinker, capable of analyzing the situation and making informed, logical decisions based on prior knowledge and experience. Such skills are vital for functioning in a clinical environment. Problem-based learning (PBL) is an alternate pedagogical approach, sporadically implemented across veterinary colleges, that may be able to help solve the profession's current educational crisis. As Torp and Sage (2002) described, problem-based learning challenges students to think deeper, harnessing their analytical and problem-solving skills as they work through real-world problems to become engaged problem solvers.

The goal of this study was to develop a rich description of how instructors were using PBL in their courses. It also sought to explore *why* they chose to use PBL, how it benefited students, how they assessed its effectiveness and how they perceived the future of PBL at the College. Based on the presence of PBL-related keywords in their syllabi, eleven instructors, representing twelve different veterinary courses, were invited to participate in interviews to explore their thoughts on PBL. The interviews were recorded, transcribed and analyzed for underlying themes using HyperResearch software and an initial set of codes. After multiple coding sessions, the code list was modified as additional themes emerged. While the reasons for

and methods of using PBL varied between instructors, there are several commonalities that are useful for exploring how PBL can be further leveraged to address current issues in veterinary medical education.

Discussion of Finding

Problem-based learning exists in many forms and is implemented differently at each institution. How PBL is integrated into the curriculum is determined by a combination of historical, individual and institutional factors. The Academic Plan concept (Stark & Lattuca, 2009) was utilized in this study to develop a deeper understanding of what influenced the evolution of PBL at the College, simultaneously considering a host of factors such as instructor background and teaching style, course content, instructional resources and evaluation methods. In essence, each PBL instantiation is unique, as it is based on individual contexts along with the curriculum that is already in place (Bruce, 1993). Despite the many interpretations in existence, the four primary reasons for using PBL include the structuring of knowledge for use in clinical contexts; the development of an effective clinical reasoning process; the development of effective, self-directed learning skills; and increased motivation for learning. This study utilized the taxonomy developed by Barrows (1986) along with the dimensions developed by Charlin et al. (1998) as a framework to discuss PBL use with instructors. The concepts of Situated Perspective Theory (Bruce, 1993) and Academic Plans (Stark & Lattuca, 2009) were leveraged to better understand the contextual, historical, and contingent reasons for the specific manner in which PBL was used. This study explored problem-based learning at multiple levels including how instructors were using PBL in their courses, the specific forms of PBL that instructors chose to use and their reasons for doing so, as well as the future of PBL at the College and how it could

be used to overcome current issues in veterinary medical education, as identified by the instructors.

Perception and Use of Problem-based Learning

Based on syllabi analysis and instructor interviews, it is clear that problem-based learning is being used in a variety of ways across all five semesters of the didactic veterinary curriculum. There are also indications that PBL may play a role in clinical rotations as well, but that portion of the curriculum was not specifically addressed by this study. Students experience many different class styles as they progress through the curriculum. Over the course of two and one-half years, they complete thirty-nine courses that are taught by about sixty different faculty members. The faculty of the College are an eclectic group, having clinical or research backgrounds, with expertise in diverse fields such as physiology, microbiology and parasitology. Their experience levels with teaching range from a few months to a few decades, and their instructional philosophies are just as varied. Many of the courses are traditional, having a lecture-based structure. Some are lab-based, while others are "hands-on" and designed to teach clinical skills. Such a diverse environment has influenced the adoption and evolution of problem-based learning.

Despite the variations between courses, two key findings regarding the instructors' reasons for using problem-based learning emerged. The first finding was *clinical preparation*; the instructors sought to prepare their students for life as clinical veterinarians. While they all recognized that learning individual facts is important, they kept the broader goals of the veterinary curriculum in mind as they taught their courses. The end product of the professional DVM program is a veterinarian that can gather, analyze and synthesize information in order to

make informed decisions about clinical patients. The ability to integrate information from different subject areas to enhance problem-solving skills is one of the primary strengths of PBL (Maudsley, 1999). Several participants even stated specifically that a veterinarian is a clinical problem solver with well-developed critical thinking skills. The instructors used PBL in an effort to give their students opportunities to practice and refine these skills before they started their clinical rotations, and their future careers. This was done in a variety of ways, depending on the nature of the course they were teaching. For most of the courses, instructors developed cases that were used at the end of each lecture to reinforce a particular topic that was being presented. Other courses were capstone in nature, designed to help students integrate knowledge at a much broader scale, encompassing multiple courses and semesters. In some instances, instructors embraced PBL for its ability to deal with ill-defined real-world problems (Torp and Sage, 2002) along with those that do not have a single correct answer (Hmelo-Silver, 2004). Regardless of the scope and the timeframe, the overall objectives of the instructors were to help students integrate what was being taught into their existing knowledge base and demonstrate how this could be used in their future careers. The instructors in this study believed that PBL assisted with the overall goal of the DVM program to develop graduates that could think critically, analyze complex real-world problems and independently seek resources to become lifelong learners (Savery, 2006).

The concept of *relevance* was the other key finding of this study. The instructors believed that problem-based learning helped to convey how the concepts they taught were relevant to clinical practice, which can be difficult to do using a standard lecture format in a classroom. Rather than teaching facts in isolation, instructors felt that PBL gave them a way to tie everything together. This had the tendency to increase student interest and participation, as

they perceived the PBL exercises as valuable for their upcoming careers, rather than as extraneous information that they would only need to know for the exam, and would never actually use in real life. As Matt stated, PBL "puts it all into perspective". Students appeared to agree with this notion, as several instructors reported students recalling PBL cases that they used for reference during their clinical rotations.

Problem-based Learning Development

The participants in this study were instructors with diverse backgrounds and varied teaching styles. Most had already been using problem-based learning for several years and were familiar with its advantages and disadvantages. Another major finding of this study is that many different PBL typologies are actively being used in the College. The Lecture-based cases typology was found to be the most common and involves the inclusion of topic-relevant cases at the end of the traditional lecture period. This approach was the simplest to implement and required the least amount of time to develop. It was not very intrusive on students, and required little to no modification of the existing curricular structure. Students already receive the majority of their didactic instruction in a large classroom environment, so including Lecture-based cases was fairly simple. Many instructors, especially those with clinical experience, have used what they generically called "cases" in teaching for quite some time, oftentimes without even knowing they were a form of PBL, so additional training is usually not required. The more advanced PBL typologies, Problem-based Learning and Closed-loop or Reiterative Problem-based Learning, were much less common in the College, but were still used in some instances. These formats were used by instructors that have more experience with PBL, and by those that have been teaching longer in general. This typology occurred in the capstone courses, which included Veterinary Integrative Problem Solving (VIPS) and the clinical competencies courses. Rather

than teaching very specific factual details, as would be encountered in Anatomy, Pathology, etc., these courses had a broader focus, and involved the application of knowledge learned in previous semesters from a variety of disciplinary areas.

Another major finding of this study was that individual instructors have experience with more than one typology, rather than being locked into a specific form. They may actively use multiple typologies in their course, or they may change what they use over time through trial and error. Most of the instructors involved in this study viewed their courses as "works in progress". They are constantly changing their techniques in an attempt to improve their teaching. Every course is unique, and PBL is perceived as being malleable enough to help meet a wide range of course objectives. Whether it's taking an accurate dietary history from a client, or developing a list of differential diagnoses for a down cow, the instructors in this study have indeed *adapted* PBL to suit their own specific needs. As Bruce (1993) described, the "local conditions" in each course did, in fact, lead to innovation and the creation of additional forms of PBL that were better suited for those particular environments. Regardless of their preferred typologies, there was an underlying theme that instructors were proud of how they have modified "traditional" PBL to make it a better experience for students. In no sense was this "corruption of the PBL ideal" seen as a detriment. Many times, the conversation with the instructors would turn to discuss the limitations of what they called "pure PBL" and what they did to overcome those issues. While they embraced the general concepts of PBL, they didn't see this tool as being set in stone. They have taken ownership and have modified PBL to make it their own. In alignment with the Situated Perspective Theory (Bruce, 1993), the contextual adaptations and hybridization processes have resulted in altered methods of implementation that have improved the value of PBL in the College.

Finally, the findings of this study indicate that time and logistics are the primary challenges regarding PBL implementation and use. This explains why the Lecture-based cases typology was the most common, as it involved considerably less time to plan and use, comparatively, than the more advanced PBL formats. Logistically, using Lecture-based cases required no change in venue, since the primary lecture hall, which accommodates the entire veterinary cohort, could still be used. Several instructors expressed interest in using other PBL typologies, but there were issues to be addressed before they could accomplish that goal. The time commitment for developing exercises using the Problem-based Learning and Closed-loop or Reiterative Problem-based Learning typologies is much higher, and this can be a challenge if they have other obligations due to their clinical and research appointments. This is often the fact, as having a 100% teaching appointment is a rarity. Also, physically, there are a very limited number of break-out rooms in the College that can be used for small group discussions and activities. Until the proper space can be located (or created) to accommodate it, the use of advanced PBL typologies will be severely limited.

The Future of Problem-based Learning

The findings of this study showed that the instructors perceived problem-based learning to be very beneficial to students and they plan to continue using it in the future. In their words, they believed that PBL helped students to improve their communication skills, achieve a deeper level of understanding, better integrate what they were learning, and attain better knowledge retention. Instructors dabbled in many types of assessments in order to evaluate the effectiveness of PBL. These included case assessments, writing assignments, quizzes, interviews and research studies to measure confidence levels and peer evaluation. However, another major finding of this study is that the instructors weren't quite sure *how* to evaluate PBL's benefits. The majority

relied on multiple-choice exams that focused on factual data, even emphasizing the importance of applying what they were teaching using Lecture-based cases. Several instructors commented on this mismatch, but were unaware of a solution to the problem. Even though they perceived PBL to be useful and effective, none of the instructors currently have a method to measure the impact that PBL use is having on students.

The findings also indicate that faculty believe what students are being taught is not necessarily reflective of what they need to know to be functional veterinarians in the future. This is, in part, due to the recent information explosion, which has caused many instructors to simply give students more bulk information, rather than focusing on relevant underlying concepts. The result is a curriculum that feels even more packed, as instructors struggle to fit in every bit of knowledge that students "need to know". Although it has improved, communication between course moderators, especially between semesters, needs to improve. Information is still unnecessarily duplicated between courses, or presented in a less than optimal order. Improved coordination could minimize student stress and help them to develop a deeper understanding of concepts, as they would be presented from multiple perspectives.

Another major finding of this study is that the College needs to provide additional training and incentives if they would like more faculty members to embrace innovative teaching strategies such as problem-based learning. The instructors in this study believed that training activities thus far have been focused on the same small group of faculty that has already been ahead of the curve for quite some time. There is a strong desire to bring training "mainstream" in order to reach a broader audience and make more of an impact. This will help to ensure the long-term viability of PBL at the College, since the current "champions" have been teaching using PBL for decades and are approaching retirement. Without such an expansion, there will

not be an opportunity to transition from one generation to the next. The history of, and lessons learned from, PBL may end up becoming lost in the process.

Finally, this study found that the College needs to examine its position on faculty that are involved with instruction. Many of the participants in this study felt that teaching obligations were oftentimes added as an afterthought to an instructor's duties and were not regarded as highly as clinical and research activities. This caused them to feel under-valued, despite the amount of effort that they put into their courses, including developing time-consuming PBL activities. The instructors that were interviewed for this study as noted that very few faculty have any kind of formal training in education, so there is a tendency for instructors to teach as they have been taught. This can have the side effect of perpetuating questionable practices, rather than introducing new advances. Given the fact that no faculty member holds a full-time teaching appointment, many participants questioned whether instruction was truly one of the College's top priorities.

Conclusions

This study yielded several important findings from which these conclusions were formulated. Regarding the first research question, it is evident that problem-based learning, in some form, is being used in each of the five pre-clinical semesters. There may be significant use of PBL in the clinical portion of the curriculum as well, based on the feedback from instructors that teach in both phases. The overarching reason that instructors had for using PBL was to prepare their students for life as clinical veterinarians. PBL was perceived to be a particularly effective tool as it helped to convey how the concepts being taught were relevant to clinical practice and it gave students opportunities for hands-on experiences.

For the second research question, the findings indicate that many different PBL typologies are actively being used in the College. Instructors have experience using more than one typology, and are actively exploring new typologies as they refine their courses from year to year. There is also a tendency for instructors to hybridize different PBL formats, or modify them to suit their individual objectives. Instructors take pride in their modifications, and deem them to be superior to using "pure PBL" approaches. Time and logistics are the primary barriers to achieving more widespread adoption of PBL in the College. The current prevalence of the fifty-minute, large classroom-based lecture, coupled with the lack of space for break-out rooms, are major contributors to the high rate of use for the Lecture-based cases typology.

The instructors felt that there was a disconnect between what is being taught, and what veterinary students really need to know to be successful upon graduation. Instructors believed that PBL can help solve some of the current issues in veterinary medical education, but only if faculty are properly educated on this and other innovative teaching strategies. The participants in this study felt that the College needs to make clear that it considers instruction to be one of its top priorities by providing the proper training as well as incentives, such as promotion and tenure, for faculty that engage in teaching activities.

Finally, the findings of this study indicate that instructors found problem-based learning to be beneficial to students, and plan to continue using it in the future. However, and most importantly, instructors were unclear regarding the best way to evaluate the impact of PBL. At this point in time, none of the instructors have an accurate method of measuring the effectiveness of PBL. Based on this information, it is unclear if PBL is of any real benefit to students, or if the instructors only *perceive* PBL to be effective. Before promoting continued use of PBL, this issue must be resolved.

Recommendations

This study generated a detailed description of how problem-based learning is being used at Michigan State University's College of Veterinary Medicine, based on the input of eleven experienced instructors. Through the use of the Academic Plan concept (Stark & Lattuca, 2009), several factors were evaluated to develop a deeper understanding of what influenced PBL use and development. In alignment with Situated Perspective theory (Bruce, 2003), the implementation of PBL varied greatly between courses and was found to be contextually adapted according to each instructor's own unique understandings, constraints, historical contingencies and circumstances. Each PBL instantiation was essential an innovation, perceived as having higher value than the PBL "ideal".

On a broader scale, this study revealed several shortcomings in the veterinary curriculum that need to be addressed. The following recommendations, based on the key findings of the study, propose methods for correcting these issues and maximizing the potential of current teaching innovations that will have a continued positive impact on veterinary medical education.

The DVM program could greatly benefit from a full analysis of the current curriculum, including all specific course objectives, to determine exactly what is being taught to students and also to identify where unneeded redundancy exists. As several participants noted, there is a tendency for instructors to keep adding additional information to their lectures, even though this may actually be detrimental to students. This has lead us to our current state, with demanding courses and credit loads that students can barely handle, as Steve described,

> The curriculum just keeps getting denser, and denser, and denser, as far as content, information that they're expected to know, and the credit loads!

Students could instead benefit from developing a better understanding of the underlying concepts, as Matt noted,

> The explosion of information is an issue. We're trying to teach everybody everything, and you can't do it. I think we need to get back to more basics.

Instructors, being experts in their field and passionate about what they are teaching, want to include as much as possible in their lectures; they feel that it is *all* relevant, as Raj described,

> Some people try to put too much into the curriculum. They do not know, or they do not understand. "I need to let them know everything that I know about a particular subject in the curriculum"… Teachers try to give too much within that one hour time. Us, as a whole, the curriculum, trying to teach them too many things, in that two and a half years.

What instructors really need is *assistance* with determining the relevance of their content. This would help counteract "the inability of faculty to decide what's important and what is not", as Nathalie put it. As Jaime stated, they need help "boiling it down" to determine what to include in their course, and what can be left for students to learn on their own. The end result will be a curriculum that is more precise and tailored to what practicing veterinarians need to know upon graduation.

At the same time, there needs to be better coordination and communication between courses. Instructors need to be more aware of what (and when) their colleagues are teaching, and how they can work together to benefit students. As Samantha described,

> Faculty need to focus much more attention on regular revisions, streamlining course content, and working harder to get moderators to understand where and how their courses

overlap (or don't). As a group of faculty instructors and administrators, we should work toward the goal of making sure that each instructor, and eventually the students, knows exactly why we teach what we do and when, and how each course builds on the courses from the previous semester.

As Samantha stated, these curricular adaptations need to happen as “regular revisions”. Changes should not occur only when there are major overhauls performed on the curriculum, since this could lead to delays of ten years, or even more. The curriculum needs to be dynamic and capable of responding to the rapid changes that are inherent in today’s society.

Faculty need better support and assistance with implementing the latest teaching advances in their courses. It is disturbing to realize that most of the College’s instructors have no training whatsoever in the field of education. While their focus should primarily be on content, faculty should receive some basic training on instructional techniques, if their appointment includes any mention of teaching duties. Unfortunately, more often than not, teaching is added as an afterthought, with priority given to clinical and research activities. Knowing at least the fundamental concepts of instruction would enable faculty to better communicate with both college and campus expertise. Based on the results of this study, it is clear that instructors are very capable of innovation. The primary goal of the College should be to elevate more faculty to a similar level in order to bring about true curricular change, based on the needs of the profession.

Finally, methods for accurately evaluating the effectiveness of PBL need to be explored. While all of the instructors in this study *perceived* PBL to be of benefit to students, none of them had devised techniques for actually determining if PBL had lead to any kind of performance

gain. The assessment techniques the instructors reported using tended to focus on content knowledge and were not reflective of the advanced aspects, such as communication skills and deeper levels of understanding, that students were supposedly learning from their PBL exercises. Also, students were not split into PBL and non-PBL groups (or given a choice to self-select), so there was no method for comparison between those that used PBL and those that did not. In short, methods for determining if PBL, in its many forms, actually *works* need to be determined before further, or expanded, use of PBL can be recommended.

Limitations of Study

This study has multiple limitations that need to be considered when interpreting the results. Instructors were invited to participate based on the presence of keywords related to problem-based learning in their syllabi. Out of the thirty-nine courses in the veterinary curriculum, fourteen of them contained such keywords. There is no way of knowing if the remaining twenty-five courses did not actually use problem-based learning, or if their syllabi merely did not include this information. Some of the syllabi that I reviewed were quite brief and only contained a listing of the lectures that would be presented. It is quite possible that these instructors utilized a lecture-based case typology and could have contributed value information to the study. Due to time and resource constraints, it was not possible to interview every instructor in the curriculum.

This study only examined problem-based learning from the perspective of the instructor. Students were not given an opportunity to express their point of view regarding the effectiveness of PBL. Interviewing a few students, in addition to the instructors, may have provided a more

inclusive view, along with a method to explore whether or not PBL was as useful as faculty believed.

I have been involved with the College in some form or another for about the last fifteen years. I believe this has given me a unique perspective since I have experienced the curriculum from "both sides", graduating from the DVM program in 2001, but also working with many of my former instructors in a different collegial capacity for the last decade. However, my experiences may have biased my interpretation of what was discussed during the instructor interviews. To minimize this, I created an interview guide, used in each and every interview, that contained primarily open-ended questions. My function was primarily as facilitator in the interview process. To help achieve transparency when reporting results, I used many direct quotes from the instructors. I wanted to accurately convey what they discussed, rather than taint their statements with my personal experiences with the DVM curriculum.

Finally, this study focused on the didactic portion of the curriculum only and did not consider any clinical rotations, which account for the last 1.5 years of the DVM program. When designing this study, my initial assumption was that problem-based learning would be most prevalent in the didactic courses, but would be non-existent in clinics. However, during the interviews, it became obvious that some instructors that taught in courses as well as clinical rotations were using PBL in both environments. This was the case for Endocrinology and Clinical Pathology. If I had expanded my interview pool to include instructors from every aspect of the curriculum, I may have discovered that more people were using PBL in clinical rotations.

Future Research

This study revealed that problem-based learning is being used in a variety of different ways across the DVM didactic curriculum. Compared to the total number of instructors in the curriculum, only a small fraction was actually interviewed. The majority of the instructors that accepted the invitation to participate in this study were already active in the scholarship of teaching and learning; users of innovative teaching methods such as problem-based learning, therefore may have be over-represented in this sample. Ideally, the next iteration of this study would be expanded to include additional instructors, including those that teach in the clinical rotations. This will allow a more complete picture of PBL use to be developed that includes the entire curriculum.

An initial, brief survey sent to all instructors at MSU CVM regarding their use of problem-based learning would be useful for additional research in this area. Rather than relying on course syllabi, which may not accurately reflect actual PBL usage, this approach could reveal additional instructors that are engaged in these activities. Some background information about the various forms of PBL, as well as examples of each of the typologies, would need to be included as well. Instructors that use cases at the end of their lectures, for example, may not self-identify as being PBL users.

Since the vast majority of classes at CVM are recorded using a lecture capture system, one possible next step would be to examine instructors' teaching methods directly with these resources. Even though all of the instructors involved in this study believed that they were in fact using some form of PBL, it would be useful to evaluate their teaching in greater detail, either

through the use of recordings or actually sitting in on several class sessions, to evaluate these claims.

In this study, only the instructor perspective has been considered. It would be useful to examine how students feel about participating in problem-based learning activities and how they gauge its effectiveness. This could be approached using focus groups, interviews or analysis of data from the classroom response system that was recently implemented.

Finally, before any further research on this topic can be recommended, methods for actually measuring the effectiveness of PBL need to be determined. While all of the instructors in this study *felt* that PBL was of benefit to students, most were unsure of the best way, or really any way, to quantify this assumption. Developing an even better understanding of how innovative teaching methods, such as PBL, are being used in the College, along with techniques to gauge the impact of these endeavors, will be crucial as veterinary medical education continues to evolve.

APPENDICES

Appendix A: Interview Guide for Course Instructors

Project Background

Thank you for agreeing to participate in the interview. Our discussion today is part of my dissertation project, designed to explore how faculty members are using the many forms of problem-based learning in their courses. I am particularly interested in learning about what makes your course unique and how problem-based learning may have helped you teach difficult topics to your students. You have indicated that you have used PBL in your teaching. PBL, as you know, can take many forms, so I'm interested in how you used PBL, how much time was allocated to it, your purposes for using PBL and your sense of student response.

Your Background

Please tell me a little more about yourself, how long you've been at MSU CMV and the courses that you teach.

Part I - PBL implementation and use

Please describe *how* you are using PBL in your course.

Why did you start using PBL in your course? What unique elements of your course lead you to think that PBL would be the best solution?

What challenges did you have with integrating problem-based learning into your course?

What are the strengths and weaknesses of the PBL approach?

What are the benefits you've seen of using PBL in your course?

Have you evaluated the effectiveness of PBL in your course? If so, how?

What effect has problem-based learning had on overall student performance?

Part IIa – PBL Typology

PBL comes in many different forms. I would like to further explore the *types* of PBL interactions that you are using. Which of the following PBL forms have you used?

1.) **Lecture-based cases**: The teacher presents the students with information in lecture and then a case or two, usually vignettes, to demonstrate the relevance of the information.

2.) **Case-based lectures**: Students are presented with case vignettes or more complete case histories before the lecture. The cases highlight material to be covered. The students have to analyze the case using their prior knowledge before any new knowledge is provided.

3.) **Case method**: Students are given a complete case for study and research in preparation for subsequent class discussion.

4.) **Modified case-based**: Similar to case method, but with more student self-direction and decisions on inquiry actions.

5.) **Problem-based**: Students are presented with the patient's presenting pictures in simulation formats that allow for free inquiry. Usually an active, teacher-guided exploration and evaluation of the problem, which directly activates the student's prior knowledge.

6.) **Closed loop or reiterative problem-based**: An extension of the problem-based method. Self-directed study with return to original patient problem for evaluation of resources used, prior reasoning and knowledge.

Part IIb – PBL Typology

There are many dimensions by which PBL can be classified. Using the criteria below, how do you characterize your PBL encounters?

1.) The person or group who selects the problem/topic

a. Instructor

b. Course moderator

c. Curriculum designer

d. Student

e. Other:

2.) The purpose of the problem

a. Basic sciences

b. Normal physiology

c. Underlying mechanisms

d. Essential clinical knowledge

e. Solve a patient problem

f. Clinical reasoning

g. Application of clinical knowledge

h. Transferrable skills / Communications

i. Other:

3.) Nature of the educational objectives and control over their selection

a. Instructor controlled

b. Student controlled

c. Both instructor and student controlled

d. Other:

4.) Nature of the task

a. Explain/describe a phenomenon

b. Make a diagnosis

c. Plan investigation and treatment

d. Explaining clinical techniques

e. Other:

5.) The presentation of the problem

a. Paper case

b. Virtual/computerized case

c. Simulated patient / client

d. Other:

6.) Format of the problem

a. One session

b. Two sessions

c. Three sessions

d. Four or more sessions

7.) The processes students follow

a. Students work individually

b. Students in class with moderator

c. Students in groups with moderators

d. Students in groups without moderators

8.) Resources utilized and how they are identified

a. Peers' knowledge and information given beforehand

b. Textbooks, journals, etc.

c. Subject matter experts

9.) The role of the moderator

a. Facilitator

b. Content expert

c. Facilitator and content expert

d. Observer

e. Observer and content expert

10.) Demonstration of learning through a product or a performance

a. Written examination

b. Presentation

c. Discussion

d. Self-evaluation

Part III – Wrap Up

In your view, what are the most important current issues and challenges in veterinary medical education?

What is the future of problem-based learning at MSU CVM?

Is there anything I missed that you would like to discuss?

Appendix B: List of Courses in the Veterinary Curriculum

Phase I – Normality

Semester 1 (Fall)
ANS 511 - Animal Science for Veterinarians
MMG 559 - Veterinary Microbiology and Immunology
PDI 514 - Veterinary Neurosciences
PDI 518 - Comparative Veterinary Gross Anatomy I
PDI 520 - Veterinary Tissue Structure and Function
VM 511 - Veterinary Clinical Examination and Techniques
VM 513 - Ethical and Animal Welfare Issues in the Veterinary Profession

Semester 2 (Spring)
MMG 571 - Veterinary Pathogenic Microbiology: Parasites
PDI 519 - Comparative Veterinary Gross Anatomy II
PDI 521 - Veterinary Organ Microanatomy
PHM 552 - Veterinary Pharmacology 1: Principles and Neuropharmacology
PSL 513 - Animal Physiology for Veterinarians
VM 514 - Comparative Lifestage Nutrition
VM 524 - Basic Science in Clinical Medicine
VM 541 - Veterinary Career Development and Practice Management
VM 548 - Principals of Diagnostic Imaging

Phase II - Abnormality)

Semester 3 (Fall)
MMG 563 - Veterinary Pathogenic Microbiology: Bacteria and Fungi
PDI 551 - General Pathology
PHM 553 - Veterinary Pharmacology 2: Systems and Infectious Diseases
PHM 557 - Veterinary Toxicology
VM 532 - Veterinary Integrative Problem Solving
VM 533 - Veterinary Epidemiology
VM 544 - Veterinary Public Health
VM 547 - Respiratory Diseases

Semester 4 (Spring)
LCS 560 - Clinical Competencies II
MMG 565 - Veterinary Pathogenic Microbiology: Viruses
PDI 553 - Systemic Pathology
PDI 554 - Veterinary Clinical Pathology
VM 543 - Cardiovascular Diseases

VM 545 - Principles of Anesthesia and Surgery
VM 546 - Musculoskeletal Diseases

Phase III – Intervention and Prevention

Semester 5 (Fall)
SCS 561 - Clinical Competencies III
VM 549 - Applied Diagnostic Imaging
VM 553 - Theriogenology and Urinary Diseases
VM 554 - Hematological, Oncological and Dermatological Diseases
VM 555 - Neurological and Ophthalmological Diseases
VM 557 - Operative Surgery
VM 558 - Digestive Diesases of Domestic Animals
VM 559 - Metabolic and Endocrinological Diseases

Clinical and Applied Veterinary Medical Science
(Years 3 and 4, Semesters 6,7,8,9)

Required Clerkships (33 credits; each clerkship is 3 credits)
LCS 616 - Large Animal Medicine and Surgery Clerkship (6 credits)
PDI 630 - Diagnostic Pathology Clerkship
SCS 611 - Diagnostic Imaging Clerkship
SCS 625 - Small Animal General Medicine Clerkship
SCS 626 - Small Animal Soft Tissue Surgery Clerkship
SCS 646 - Small Animal Orthopedic Surgery Clerkship
SCS 647 - Small Animal Internal Medicine Clerkship
SCS 648 - Anesthesia Clerkship
SCS 695 - Emergency and Critical Care Medicine Clerkship
LCS 621 - Equine Practice Clerkship –or-
LCS 631 - Food Animal Practice Clerkship

Elective Clerkships (27 credits; each clerkship is 3 credits)
LCS 610 - Clinical Problems in Large Animal Clinical Sciences
LCS 610F - Small Ruminant Production Medicine
LCS 610L - Large Animal Clinical Proficiency
LCS 611 - Research Problems in Large Animal Clinical Sciences
LCS 613 - Special Problems in LCS (off campus)
LCS 614 - Equine Clinical Proficiency Clerkship
LCS 615 - Equine Emergency and Critical Care Clerkship
LCS 622 - Equine Clinical Clerkship II
LCS 623 - Equine Musculoskeletal Diseases Clerkship
LCS 624 - Equine Theriogenology Clerkship

LCS 625 - Equine Herd Health Clerkship
LCS 626 - Advanced Equine Surgery Clerkship
LCS 627 - Advanced Equine Medicine Clerkship
LCS 628 - Techniques in Equine Anesthesia and Surgery
LCS 632 - Adv Food Animal Medicine and Surgery Clerkship
LCS 640 - Large Animal Anesthesia Clerkship
LCS 646 - Equine Neonatal Medicine Clerkship
LCS 660 - Wildlife Disease Ecology and Management
LCS 677 - Veterinary Preceptorship (off-campus)
LCS 678 - Government and Corporate Veterinary Practice
LCS 679 - Food Animal Production Medicine 1 (6 credits)
LCS 682 - Food Animal Production Medicine 2
LCS 685 - Ruminant Health Problem Solving Clerkship
LCS 690 - Veterinary Public Health Field Experience Clerkship
LCS 691 - Veterinary Public Health Research Clerkship
MMG 690 - Veterinary Microbiology Clerkship
PDI 610 - Veterinary Gross Anatomy Dissection
PDI 611 - Research Problems in Veterinary Anatomy
PDI 631 - Necropsy Clerkship
PDI 632 - Problems in Veterinary Pathology
PDI 633 - Special Problems in Veterinary Pathology (off campus)
PDI 634 – Endocrinology
PDI 635 - Special Problems In Vet Path Cytology
PDI 636 - Aquatic Animal Medicine Clerkship
PDI 637 - Poultry Medicine Clerkship
PHM 658 - Research Problems in Pharmacology or Toxicology
SCS 613 - Diagnostic Ultrasound Clerkship
SCS 630 - Spay/Neuter Clerkship
SCS 640 - Cardiology Clerkship
SCS 641 - Comparative Ophthalmology Clerkship
SCS 642 - Zoo and Wildlife Medicine Management Clerkship
SCS 643 - Neurology Clerkship
SCS 644 - Dermatology Clerkship
SCS 651 - Adv Comparative Ophthalmology Clerkship
SCS 654 - Clinical Medical Oncology Clerkship
SCS 670 - Small Animal Clinical Nutrition Clerkship
SCS 690 - Veterinary Molecular Biology Clerkship
SCS 693 - Problems in Small Animal Clinical Sciences
SCS 694 - Small Animal Specialty Practice (off-campus)
VM 611 - Veterinary Externship Clerkship (off-campus)

VM 690 - Special Problems in Veterinary Medicine Clerkship
VM 692 - Career Development and Business Skills Clerkship

Appendix C: Problem-based Learning Keywords from Course Syllabi

Semester	Course	Problem-based learning keywords
1	ANS 511 Animal Science for Veterinarians	None
1	MMG 559 Veterinary Microbiology and Immunology	None
1	PDI 514 Veterinary Neurosciences	None
1	PDI 518 Comparative Veterinary Gross Anatomy I	None
1	PDI 520 Veterinary Tissue Structure and Function	None
1	VM 511 Veterinary Clinical Examination and Techniques	None
1	VM 513 Ethical and Animal Welfare Issues in the Veterinary Profession	Small group case discussions, small group session, small group cases based on scenarios, small group meetings, discussion hour, contributions you made to the discussion
2	MMG 571 Veterinary Pathogenic Microbiology Parasites	None
2	PDI 519 Comparative Veterinary Gross Anatomy II	Clinically relevant details of anatomy, application of the material learned in anatomy to relevant clinical situations, better application of the learned material, clinical modules, clinical cases, without rote memorization, assigned to specific groups that consist of 7 or 8 of your classmates, clinical correlations, clickers quizzes
2	PDI 521 Veterinary Organ Microanatomy	None
2	PHM 552 Veterinary Pharmacology 1 Principles and Neuropharmacology	None
2	PSL 513 Animal Physiology for Veterinarians	Work in groups to integrate information, actively participate in VM 524
2	VM 514 Comparative Lifestage Nutrition	Hands-on activities, skills used in daily practice, scheduled interviews in LAC with simulated client-actors

Semester	Course	Problem-based learning keywords
2	VM 524 Basic Science in Clinical Medicine	Construct their own understanding, case-based format, team-based approach, critical thinking skills, small group work and learning, small group discussions and assignments, interacting with clinicians and faculty during question and answer sessions, interacting with simulated clients, solve clinical problems as a team, this course is case-based, client interviews
2	VM 541 Veterinary Career Development and Practice Management	None
2	VM 548 Principals of Diagnostic Imaging	None
3	MMG 563 Veterinary Pathogenic Microbiology Bacteria and Fungi	None
3	PDI 551 General Pathology	Gross Necropsy Rounds, cases are presented and discussed
3	PHM 553 Veterinary Pharmacology 2 Systems and Infectious Diseases	None
3	PHM 557 Veterinary Toxicology	None
3	VM 532 Veterinary Integrative Problem Solving	Integrate, problem solving, clinical reasoning, information gathering and processing, interpreting data, applying concepts, teamwork, life-long learning skills, case-based learning format, work in groups, discuss clinical cases, facilitator, student-led learning process, facilitator serves only as a guide, independent study and research of topics
3	VM 533 Veterinary Epidemiology	Clinical decision making skills, case study work, multiple learning methods, application (case studies)
3	VM 544 Veterinary Public Health	None
3	VM 547 Respiratory Diseases	None
4	LCS 560 Fundamental Clinical Skills for Large Animals	Scenarios, hypothetical case studies, clinical situations
4	MMG 565 Veterinary Pathogenic Microbiology Viruses	None
4	PDI 553 Systemic Pathology	Grand Necropsy Rounds, necropsy cases

Semester	Course	Problem-based learning keywords
4	PDI 554 Veterinary Clinical Pathology	Active learning, apply and extend content material, integration of course material in a problem solving format, group assignments, understand and use information in clinically relevant situations, actively engaged in class discussions, confidence and lasting learning, actual cases from clinical experience, collectively discussed/debated/argued, group assignments, case scenarios
4	VM 543 Cardiovascular Diseases	None
4	VM 545 Principles of Anesthesia and Surgery	None
4	VM 546 Musculoskeletal Diseases	None
5	SCS 561 Fundamental Clinical Skills for Small Animals	Clinical problem solving
5	VM 549 Applied Diagnostic Imaging	Interpreting clinical imaging studies, apply principles to clinical cases, groups of two students
5	VM 553 Theriogenology and Urinary Diseases	None
5	VM 554 Hematological, Oncological and Dermatological Diseases	None
5	VM 555 Neurological and Ophthalmological Diseases	None
5	VM 557 Operative Surgery	None
5	VM 558 Digestive Diseases of Domestic Animals	None
5	VM 559 Metabolic and Endocrinological Diseases	Interactive format, case examples

REFERENCES

REFERENCES

Barrows, H. S. (1986). A Taxonomy of Problem-Based Learning Methods. *Medical Education*, (20): 481-486.

Barrows, H. S. (1996). Problem-Based Learning in Medicine and Beyond: a Brief Overview. *New Directions for Teaching and Learning*, 68 (3): 3-12.

Barrows, H. S., and Bennett, K. "The Diagnostic (Problem-Solving) Skill of the Neurologist." *Archives of Neurology*, 1972, 26, 273-277.

Bruce, Bertram C., Peyton, Joy Kreeft & Trent W. Batson (Eds.). (1993). *Network-based classrooms: Promises and realities*. New York: Cambridge University Press.

Busari, J. O. (2000). Revisiting analogy as an educational tool: PBL and the game of basketball. Medical Education, 34 (12): 1029-1031.

Charlin, B., Mann, K., Hansen, P. (1998). The manu faces of problem-based learning: A framework for understanding and comparison. *Medical Teacher*, 20(4), 323-330.

Cooke, M., Moyle, K. (2002). Students' evaluation of problem-based learning. Nurse Education Today, 22(4): 330-339.

Dolmans, D., Grave, W. (2005). Problem-based learning: future challenges for educational practice and research. Medical Education, 39: 732-741.

Edwards, J. (2004). Global Perspectives of Veterinary Education: Reflections from the 27th World Veterinary Congress. Journal of Veterinary Medical Education, 31(1): 9-12.

Eyre, P. (2002). Engineering Veterinary Education. Journal of Veterinary Medical Education, 29(4): 195-200.

Henriksen, D. (2011) We Teach Who we are: Creativity and Trans Disciplinary Thinking in the Practices of Accomplished Teachers. (Doctoral Dissertation). Michigan State University. Retrieved from ProQuest Dissertations and Theses. (3489807).

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? Educational Psychology Review, 16(3), 235-266.

Kiley, M., Mullins, G., Peterson, R. and Rogers, T. (2000). *Leap into Problem-Based Learning*, The University of Adelaide A cUE.

Lum-Peng, L. and Ai-Yen, C. (1999), Challenges and relevance of problem-based learning in dental education. *European Journal of Dental Education*, 3: 20–26.

Marshall, T., Finkelstein, M. and Qian, F. (2011). Improved Student Performance Following Instructional Changes in a Problem-Based Learning. Journal of Dental Education, 75:466-471.

Maudsley, G. (1999), Do we all mean the same thing by "problem-based learning"? A review of the concepts and a formulation of the ground rules. Academic Medicine, 74: 178-185.

Pritchard, W. (1994). A Changing World and a Changing Profession Challenge Veterinary Medical Education. Journal of Veterinary Medical Education, 21(2): 119-123.

Radostits, O. (2003). Engineering Veterinary Education: A Clarion Call for Reform in Veterinary Education – Let's Do It!. Journal of Veterinary Medical Education, 30(2): 176-190.

Savery, J. R. (2006). Overview of Problem-Based Learning: Definitions and Distinctions. The Interdisciplinary Journal of Problem-Based Learning, 1(1): 9-20.

Schuring, G., Osburn, B. (2011). The North American Veterinary Medical Education Consortium (NAVMEC) Looks to Veterinary Medical Education for the Future: "Roadmap for Veterinary Medical Education in thr 21st Century: Repsonsive, Collaborative, Flexible". Journal of Veterinary Medical Education, 38(4): 320-327.

Shulman, L. S. (1998). Disciplines of inquiry in education: An overview. In R. M. Jaeger (Ed.), *Complementary methods for research in education* (pp. 3-17). Washington, D. C.: American Educational Research Association.

Simpson, E., Courtney, M. (2002). Critical thinking in nursing education: Literature review. International Journal of Nursing Practice, 8: 89–98.
Stark, J., Lattuca, L. (2009). Shaping the College Curriculum: Academic Plans in Context. Jossey-Bass, A Wiley Imprint.

Thammasitboon, K., Sukotjo, C., Howell, H. and Karimbux, N. (2007). Problem-Based Learning at the Harvard School of Dental Medicine: Self-Assessment of Performance in Postdoctoral Training. *Journal of Dental Education*, 71(8):1080-1089.

Tiwari, A., Lai, P., So, M. and Yuen, K. (2006), A comparison of the effects of problem-based learning and lecturing on the development of students' critical thinking. Medical Education, 40: 547–554.

Torp, L., and Sage, S. (2002). *Problems as possibilities: Problem-based learning for K-16 education* (2nd ed.). Alexandria, VA; Association for Supervision and Curriculum Development.

Wyatt, J. (1991). Use and Sources of Medical Knowledge. The Lancet, 338: 1368-1373.

Yuan, H., Kunaviktikul, W., Klunklin, A. and Williams, B. A. (2008). Improvement of nursing students' critical thinking skills through problem-based learning in the People's Republic of China: A quasi-experimental study. Nursing & Health Sciences, 10: 70–76.

Zhang, G., Zhang, G., Yang, Q., Cheng, S., Zhou, T. (2008). Evolution of the Internet and Its Cores. New Journal of Physics, 10: 2-11.