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# Problem-Based Learning in Veterinary Education

Elizabeth A. Lane

## ABSTRACT

Problem-based learning (PBL) replicates life experiences to stimulate learning, the integration of knowledge, and lifelong learning skills, all of which are requirements for veterinary medical education. As the curricular content of veterinary schools expands to immense proportions following advances in medical knowledge and biotechnology, it becomes impracticable to ensure that all students at the beginning of their careers have such a wide knowledge base. Students who are faced with vast amounts of information to learn by rote, much of which may seem irrelevant to their prospective career, may become disillusioned with their chosen course, hence the temptation to convert to a PBL curriculum. The PBL strategy of teaching is becoming increasingly popular in veterinary faculties worldwide, encompassing both curriculum content and a process of learning. In PBL, clinical cases are carefully selected to provoke deep student learning by the acquisition of both basic scientific and clinical knowledge critical to the case; cultivate problem-solving abilities; and encourage the development of team-building, self-directed learning, communication, and self- and peer-assessment skills. Problem-solving skills, understanding of the basic sciences, and clinical performance are all improved by the PBL process. The aim of this paper is to review a decade of literature pertaining to the inclusion of PBL in veterinary and medical curricula.

**Key words:** problem-based learning, PBL, veterinary undergraduate education, lifelong learning, self-directed learning

## INTRODUCTION

Veterinary practice requires a problem-oriented approach and a commitment to lifelong learning.<sup>1,2</sup> Problem-based learning (PBL) replicates real-life situations to stimulate learning, the integration of knowledge, and lifelong learning skills. This strategy of teaching has its beginnings rooted in the medical school of McMaster University, Canada, four decades ago. It is becoming an increasingly popular method of teaching in veterinary faculties worldwide, and has been cited as an attractive curricular alternative for veterinary education.<sup>3</sup> It encompasses both curricular content and a process of learning. In PBL, clinical cases are carefully selected to provoke deep student learning by the acquisition of both basic scientific and clinical knowledge critical to the case; cultivate problem-solving abilities; and encourage the development of team-building, self-directed learning, communication, and self- and peer-assessment skills.<sup>4</sup> Students' problem-solving skills,<sup>5-8</sup> understanding of the basic sciences,<sup>9</sup> and clinical performance<sup>10-14</sup> are improved by the PBL process. This paper aims to review a decade of literature pertaining to the success and limitations of PBL in veterinary and medical curricula.

## WHY ALTER TRADITIONAL METHODS OF TEACHING?

Universities traditionally employ didactic forms of teaching (e.g., lectures) to impart much of the curriculum content in the pre-clinical courses of veterinary medicine and allied disciplines. However, it is becoming increasingly accepted that this form of teaching encourages a superficial approach to learning.<sup>15</sup> A study conducted by Levine and Fonnan has suggested that students retain the least amount of information from this type of teaching encounter and, after passing the required examinations, much knowledge is forgotten.<sup>16</sup> Many students are unable to effectively reason and their application of knowledge, as gained by traditional methods

of education, to real-life situations is often less than optimal. Further to this, it seems that advances in medical knowledge and biotechnology are expanding the curricular content of veterinary schools to enormous proportions, to the point that it could be considered impracticable to ensure that all students have such a broad knowledge base at the beginning of their careers.<sup>17</sup> An extensive review conducted by Nandi et al. has reported that students of traditional curricula are more likely to describe their pre-clinical experience as irrelevant, passive, and boring, and, based on supervisors' assessments, perform less well after graduation compared with students who graduated from a PBL curriculum.<sup>18</sup> The ability of graduates from traditional courses to undertake self-directed study as part of their continued professional development has also been questioned.

In contrast, a deep learning approach is fostered in an environment where a greater understanding of the information is required. The learning process is enhanced if the context of relevant information is established and if content is related to other pertinent information.<sup>19</sup> In contrast to PBL, traditional methods of teaching often do not meet the criteria for contextual learning. Because of this, many schools are now altering the proportion of teacher-centered approaches of didactic teaching to student-centered approaches of learning such as PBL. Ultimately, the aim is to pass on lifelong learning skills to students, and to allow them the independence to learn effectively.<sup>20</sup> There is strong support for the inclusion of PBL within veterinary schools.<sup>7,12,21-23</sup>

## THE PROBLEM-BASED LEARNING PROCESS

PBL, as a strategy to promote deep learning and higher-order thinking skills,<sup>24</sup> looks at a problem based on life experience. Before embarking on PBL sessions, it is

imperative that the ground rules are agreed as to what constitutes acceptable behavior within the group regarding punctuality, preparation, equal sharing of workload, length of individual presentations, use of handouts, and speaking without interruption. The creation of suitable groups with regard to group size and a mix of genders, cultural backgrounds, personality types, and ages is important to the success of the PBL process.<sup>25</sup> In addition, the grouping of students with different learning styles may increase the success of the PBL process.<sup>26</sup>

A staff member acts as a facilitator for the process, and aims to motivate the students to carry the process themselves. The staff member must not, however, feel it necessary to impart their own knowledge to the group. There is evidence to suggest that tutors with greater expertise in the case being studied may increase the number of learning issues generated by the case,<sup>27</sup> therefore, tutors should be well informed regarding the case and its objectives, and, furthermore, be well versed in the PBL process. Facilitators should pose higher-order questions to promote discussion and activate students' reasoning processes, and ask students to explain phenomena or define terms used. However, they must also learn to tolerate silence and should not feel obliged to fill every void.

Within veterinary medicine, clinical cases lend themselves easily to this method of learning. In the Faculty of Veterinary Medicine at University College Dublin (UCD), Ireland, it is considered important that genuine clinical cases are selected<sup>28</sup> because these tend to be complex, with idiosyncrasies and frequently unpredictable outcomes. The information is presented to the group as it would be in a real-life situation, detailing the history of the patient and their presenting clinical signs. As part of the team-building process, the students are expected to pool their knowledge to brainstorm and formulate a list of learning issues, which may or may not be relevant to the case. Learning issues should include basic scientific and clinical topics. The students are expected to formulate an action plan and divide the agreed learning issues among themselves, and to use suitable resources to research the relevant topics. As the case progresses, the students are expected to request diagnostic investigations that are relevant to the case and identify new learning issues, working the case up until it has been resolved. Once resolved, the students engage in peer- and self-assessment, skills essential to effective independent learning. Some institutes, however, dispense with this part of the process and have the facilitators alone assess students' performances.

Examination procedures for PBL focus on the process of PBL rather than curricular content; hence, the students' approach to the problem is assessed rather than the resultant knowledge they display. A drawback to this type of examination is that the individual student's problem-solving ability is assessed, rather than their teamworking ability.

The extent to which PBL is included in curricula varies widely both within and across institutes. For example, the Faculty of Veterinary Medicine at UCD has replaced part of its pre-clinical course with PBL, and has included it as part of the fourth clinical year of their five-year undergraduate program.<sup>28</sup> The Bristol School of Veterinary Science,

England, has replaced 20% of the first two years of its five-year program with PBL-type processes, with some courses using up to 40% of student contact time for PBL. Similarly, the Purdue School of Veterinary Medicine, Indiana, uses a hybrid approach for the first two years of its four-year program with PBL. Some institutes, for example the Royal Veterinary College, London, have adopted the principles of PBL and include self-directed learning sessions similar to PBL sessions, but these comprise a very small component of the course.

### SUCCESS OF THE PROBLEM-BASED LEARNING PROCESS

PBL has been described as fun, interesting, motivating,<sup>29</sup> stimulating, and engaging, while traditional courses have been described as irrelevant, passive, and boring.<sup>19</sup> The integration of PBL into a traditional veterinary curriculum was well received at UCD,<sup>28</sup> and students felt their subject understanding improved.<sup>7,12,22,30</sup> A meta-analysis by Dochy has shown support for the contention that while PBL students may gain less knowledge, they tend to remember more of the acquired knowledge.<sup>31</sup> Indeed, questionnaires completed by UCD veterinary students enrolled in the pre-clinical course, a significant proportion of which is PBL, have indicated that PBL facilitates both deep and strategic learning.<sup>32</sup> An important aspect of the PBL process is that students recognize the relevance of basic scientific content from the beginning of their course. Too often, students begin their studies full of enthusiasm and motivation, but later question their suitability for the program as they fail to see the relevance of their pre-clinical courses to their chosen career.<sup>28</sup> The relevance of the basic scientific subjects to clinical cases and, hence, vertical integration through all years of the curriculum is enhanced by PBL. PBL also improves critical-thinking and problem-solving abilities,<sup>8,12,29,33</sup> promotes independent learning,<sup>8,34-36</sup> activates prior knowledge,<sup>37</sup> and encourages a holistic approach to a case.<sup>34,35</sup> Crucially, in the majority of studies, facilitators have agreed that the set course learning objectives are met by PBL.<sup>33,36</sup>

Curricula with a significant proportion of PBL have been shown to improve<sup>10,11,38,39</sup> or, at least, not adversely affect<sup>40-42</sup> performance at National Medical Licensing Examinations in North America. Significantly, most studies have reported improved clinical reasoning<sup>35</sup> and improved clinical skills for nursing,<sup>34</sup> medical,<sup>11</sup> and veterinary.<sup>12,13</sup> students following the inclusion of PBL into curricula. Recent work conducted at the medical college of Aga Khan University, Pakistan, has reported that students who completed the PBL curriculum demonstrated higher participation in research activities and were more confident in both conducting and reporting research than those who completed a traditional medical curriculum.<sup>43</sup> This suggests that PBL is successful in stimulating an interest in evidence-based medicine—a key lifelong learning skill.

There is certainly evidence to suggest that the PBL process improves generic life skills, especially teamwork.<sup>29,34</sup> In one study, over 80% of facilitators reported that teamwork had improved after four PBL cases.<sup>33</sup> Communication and interpersonal skills are also developed by the process.<sup>8,12,18,22</sup>

## DISADVANTAGES ASSOCIATED WITH THE PROBLEM-BASED LEARNING PROCESS

Despite the cited advantages conferred on students who have come through a PBL curriculum compared with those on a conventional curriculum, a study conducted by Nandi et al. has seriously questioned the ability of PBL curricula to provide the core knowledge required for entry into the medical profession.<sup>18</sup> To date, the majority of studies regarding the use of PBL in veterinary curricula have been based on the perceptions of students, as explored through questionnaires, rather than looking at professional examination results as evidence of performance. It would be useful if these studies could be conducted in the near future. One study has reported that although students acknowledged the gains made via the PBL process, they preferred subject-based tutorials as they felt that these provided information in a more efficient manner.<sup>33</sup> Work conducted by Hendry et al. has highlighted the need for facilitators to aid students to self-regulate their learning in PBL programs;<sup>44</sup> suggesting, perhaps, that the provision of learning outcomes might be beneficial in promoting student motivation while limiting the uncertainty associated with entirely student-driven PBL.

Research into the performance of medical students in basic scientific examinations has revealed conflicting opinions regarding the performance of PBL learners compared with those studying a traditional curriculum. While some studies have reported an improved understanding of the basic sciences with PBL,<sup>9,45</sup> the results of two extensive meta-analyses have demonstrated that PBL learners achieve lower scores than traditional learners on Part I of the National Board Medical Examination, which tests knowledge of the basic science subjects.<sup>11,18</sup> These studies have queried the capability of PBL-based curricula to deliver the knowledge required to pass professional examinations and, therefore, the replacement of traditional programs with a PBL-based curricula must be questioned.

## DIFFICULTIES ASSOCIATED WITH THE IMPLEMENTATION OF A PROBLEM-BASED LEARNING PROGRAM

PBL may be unsuccessful where teaching staff do not commit to the process. In the UK and Ireland, changes in teaching strategies often occur in response to government or funding agency prompting, but, without consultation, individual teaching staff will not engage with the changes. In addition, inadequate training may result in a misinterpretation of the PBL process. Classes in which a lecturer poses a question at the beginning of the lecture (the problem) followed by a didactic lecture have been erroneously termed PBL. Training for teaching staff is necessary for the successful implementation of PBL. Extensive consultation should take place prior to its introduction in order to promote commitment and goodwill from teaching staff, and to alleviate the anxiety that may occur as a result of changes associated with radical alterations of the curriculum.

Another issue that acts against the initiation of a PBL-based curriculum is the associated costs with regard to teaching-staff hours. Research has shown that PBL is both time and labor intensive,<sup>34</sup> and it had been suggested that the benefits

associated with a PBL-based curriculum cannot be justified based on the increased costs of implementing the change.<sup>39</sup> One study has demonstrated that a PBL curriculum does not place undue demands on the time of basic science faculty;<sup>46</sup> this study, however, did not assess the demands on the clinical staff in relation to their other commitments—an important issue considering that many clinicians consider themselves to be under severe time pressures. In addition to time commitment, supplementary resources required for a successful PBL program (e.g., a learning resource center with separate spaces for individual study groups) must be provided by the school.

The role of the student is altered by the PBL process and many students, especially those new to university, have difficulty with the transition from more traditional teaching methods.<sup>24</sup> This problem has also been highlighted in a study conducted by Ryan et al. at the UCD veterinary school,<sup>32</sup> where mature students who had previously completed at least an undergraduate degree program were more likely to employ deep or strategic learning strategies compared with younger students who were entering the veterinary undergraduate program directly from a second-level school. Thus, facilitating change in learning strategies must be considered when dealing with students who are accustomed to traditional teaching methods.

Cultural issues may also pose problems for the effectiveness of the PBL groups.<sup>25,47</sup> Speck has described the educational ideal that students ought to learn to effectively criticize each other's work; he suggests that to negatively comment on another person's work may be counter to certain cultural ideals.<sup>25</sup> Speck further suggests that tutors should be aware of these cultural differences and deal with them respectfully and sensitively in the classroom. Therefore, it is essential to provide orientation and to take students' cultural backgrounds into account when dividing students into PBL groups. Similar to unprepared staff, anxiety may occur if students are not informed, within reason, of prospective alterations to the curriculum and the reasons for the changes. Following the implementation of a PBL process within the school it is necessary to monitor its progress and determine its acceptance among teaching staff and students. Unless the process, including the method of examination employed, is continually assessed and modified accordingly, suboptimal acceptance may result.

Dysfunctional student groups may undermine the PBL process. A study conducted by the University of Sydney's medical school revealed the three highest-ranking problems for tutors and students: (1) quiet students, (2) lateness and absenteeism, and (3) dominant students.<sup>48</sup> This study also identified a number of issues that posed the greatest hindrance to learning; namely, the dominant student, a disorganized process, a superficial approach, rushing through the problem, and group frustration with a tutor's lack of content expertise. However, Howell et al. state that problems associated with PBL can be overcome if students and facilitators are made fully aware of the process.<sup>22</sup>

The point at which PBL is instigated during the program may also affect its acceptance and success amongst students. The University of Glasgow's medical school introduced PBL as part of its final-year course in 1992. While students found the PBL interesting, they felt it was less relevant than their

lecture course.<sup>49</sup> A similar PBL program was initiated for veterinary students studying clinical sonography at the University of Sydney. Although staff believed that the students gained a reasonable understanding of the subject, half of the students felt that the subject should also have been covered by traditional lectures.<sup>50</sup> Care ought to be taken in introducing new teaching methods to students who are used to a more traditional didactic curriculum, especially late in the program.

Particular courses lend themselves to the PBL process. Implementation is easier in North American veterinary schools, where students have already completed an undergraduate degree in core pre-veterinary subjects. Certainly, evidence in the literature suggests that students must have a solid knowledge base prior to engaging in PBL.<sup>34</sup> In the UK and Ireland, students entering a veterinary program have different levels of background knowledge. Some students enter a veterinary curriculum directly from second-level schools. Most of these will have come through a teacher-centered system, which encourages and rewards learning through memorization rather than understanding. Conversely, other students will have completed doctorate degrees; a process that is almost entirely based on problem solving. These differing experiences result in a great variation in the analytical ability of students within groups and, more critically, experienced students may become bored with the process.

In the case of veterinary medicine, the importance of small-group practical sessions cannot be emphasized enough, more so than for medical students. Veterinary graduates require a high level of competence in practical skills on graduation, while medical students learn these during their post-graduate residency training programs. Unlike medical graduates, veterinary graduates may opt to enter private practice directly, with no further post-graduate training; hence, competency in practical skills is crucial at graduation. Small-group practical sessions and extramural studies (i.e., "seeing practice" with experienced clinicians) allow veterinary students to learn the skills required for their career from experienced practitioners and cannot be replaced by paper-based learning. The importance of extramural studies has been highlighted by a survey of veterinary graduates from universities in Great Britain and Ireland<sup>51</sup> and was subsequently confirmed by Baguley.<sup>52</sup>

#### THE FUTURE OF PROBLEM-BASED LEARNING IN VETERINARY PROGRAMS

Following extensive evaluation of the literature, Nandi et al. and Spencer and Jordan have suggested that a combination approach may provide the most effective training for medical students.<sup>18,53</sup> Indeed, research conducted by Howell et al.<sup>22</sup> at the University of Tennessee College of Veterinary Medicine advocates adding "thin slices" of PBL to the traditional curriculum as a very successful method of introducing problem solving to students. It is difficult to advocate the replacement of an entire curriculum with a PBL program, especially in the European setting where students enter an undergraduate course from such diverse academic backgrounds, and, indeed, as question marks remain regarding its effectiveness in instilling the core

factual knowledge required for professional examinations. Interestingly, professional courses such as veterinary medicine have little control over the standards required for professional examinations because entry-level standards are set by the regulatory authority of the profession.

There is certainly evidence to suggest that PBL should be integrated into veterinary courses alongside other effective teaching methods such as large-group interactive lectures and small-group seminar sessions. Huge resources are invested in teaching staff, and it is appropriate that teachers are used in a structured manner to stimulate deep learning by students and are not employed by the university simply as a resource for PBL. Recent work by Shields et al. at the Harvard Medical School indicates that altering the role of the facilitator to that of a discussion leader can optimize the PBL process and increase student satisfaction ratings.<sup>54</sup> As a discussion leader, whereby the tutor questions, summarizes, and illustrates concepts, the experience of teaching staff is used in a beneficial manner. Large group lectures do not have to be given in a traditional didactic manner. By employing an interactive method of lecturing, the staff member can engage with their students in a similar manner to in small-group seminars.<sup>15,55</sup> Finally, as highlighted earlier, the importance of small-group practical sessions and extramural studies for veterinary students cannot be emphasized enough.

#### CONCLUSION

There is evidence that institutes that have implemented a PBL process, to a greater or lesser extent, are satisfied with the outcomes to date. While many studies have illustrated the advantages conferred on students who have come through this type of education as compared to a traditional course, there is a need to complement PBL exercises with other, well-established methods of teaching that have been shown to be effective in promoting deep learning. This will ensure core knowledge at entry into the veterinary profession. Finally, there is a need to continually evaluate teaching strategies employed within veterinary schools to ensure effective learning.

#### REFERENCES

- 1 Blayney N. Problem-based learning: a new approach in medical education. *In Practice* 25:101-106, 2003.
- 2 Gottstein B, Eckert J. Various approaches of teaching veterinary parasitology. *Vet Parasitol* 108:267-272, 2002.
- 3 Whitney MS, Herron MA, Weeks BR. Preclinical curricular alternatives: history and rationale of problem-based medical education. *J Vet Med Educ* 20:2-8, 1993.
- 4 Barrows HS, Tamblyn RM. *Problem-Based Learning: An Approach to Medical Education*. New York: Springer, 1980.
- 5 Hmelo CE, Gotterer GS, Bransford JD. A theory-driven approach to assessing the cognitive effects of PBL. *Instructional Science* 25:387-408, 1997.
- 6 Hmelo CE. Problem-based learning: effects on the early acquisition of cognitive skill in medicine. *J Learning Sci* 7:173-208, 1998.

- 7 Haynes JS, Myers RK. A case-based, cooperative learning approach to teaching veterinary systemic pathology. *J Vet Med Educ* 25(1):12-16, 1999.
- 8 Morales-Mann ET, Kaitell CA. Problem-based learning in a new Canadian curriculum. *J Adv Nurs* 33:13-19, 2001.
- 9 Finucane PM, Johnson SM, Prideaux DJ. Problem-based learning: its rationale and efficacy. *Med J Aust* 168:445-448, 1998.
- 10 Mennin SP, Friedman M, Skipper B, Kalishman S, Snyder J. Performances on the NBME I, II, and III by medical students in the problem-based learning and conventional tracks at the University of New Mexico. *Acad Med* 68:616-624, 1993.
- 11 Vernon DT, Blake RL. Does problem-based learning work? A meta-analysis of evaluation research. *Acad Med* 68:550-563, 1993.
- 12 Bauer M, Ogilvie G. Incorporation of problem-based learning into a third-year veterinary curriculum. *J Vet Med Educ* 23:43-46, 1996.
- 13 Farnsworth CC. Measuring the effects of problem-based learning on the development of veterinary students' clinical expertise. *Acad Med* 72:552-554, 1997.
- 14 Schwartz RW, Burgett JE, Blue AV, Donnelly MB, Sloan DA. Problem-based learning and performance-based testing: effective alternatives for undergraduate surgical education and assessment of student performance. *Med Teach* 19:19-23, 1997.
- 15 Canfield PJ. An interactive, student-centered approach to teaching large-group sessions in veterinary clinical pathology. *J Vet Med Educ* 29:105-110, 2002.
- 16 Levine HG, Forman PM. A study of retention of knowledge of neurosciences information. *J Med Educ* 48:867-869, 1973.
- 17 Bushby PA. Tackling the knowledge explosion without overlapping the student. *Aust Vet J* 71:372-374, 1994.
- 18 Nandi PL, Chan JN, Chan CP, Chan P, Chan LP. Undergraduate medical education: comparison of problem-based learning and conventional teaching. *Hong Kong Med J* 6:301-306, 2000.
- 19 Edmondson KM. Applying what we know about learning to veterinary education. *J Vet Med Educ* 28:54-55, 2001.
- 20 Stickle JE. Teaching to different learning styles. *J Vet Med Educ* 26(2):13-15, 1999.
- 21 Cox JE. Veterinary education and problem-based learning. *Vet J* 162:84-87, 2001.
- 22 Howell NE, Lane IF, Brace JJ, Shull RM. Integration of problem-based learning in a veterinary medical curriculum: first-year experience with Application-Based Learning Exercises at the University of Tennessee College of Veterinary Medicine. *J Vet Med Educ* 29:169-175, 2002.
- 23 McLennan MW. Lectures and other types of teaching. *Aust Vet Practit* 33:15-19, 2003.
- 24 Hung W, Harpole Bailey J, Jonassen DH. Exploring the tensions of problem-based learning: insights from research. *New Direct Teach Learn* 95:13-23, 2003.
- 25 Speck BW. Fostering collaboration among students in problem-based learning. *New Direct Teach Learn* 95:59-65, 2003.
- 26 Hur Y, Kim S. Different outcomes of active and reflective students in problem-based learning. *Med Teach* 29(1):e18-e21, 2007.
- 27 Eagle CJ, Harasym PH, Mandin H. Effects of tutors with case expertise on problem-based learning issues. *Acad Med* 67:465-469, 1992.
- 28 Doherty ML, Jones BR. Undergraduate veterinary education at University College Dublin: a time of change. *J Vet Med Educ* 33:214-219, 2006.
- 29 Cooke M, Moyle K. Students' evaluation of problem-based learning. *Nurse Educ Today* 22:330-339, 2002.
- 30 Rand JS, Baglioni AJ Jr. Subject-based problem-based learning in the veterinary science course at the University of Queensland. *Aust Vet J* 75:120-125, 1997.
- 31 Dochy F, Segers M, Van den Bossche P, Gijbels D. Effects of problem-based learning: a meta-analysis. *Learn Instruct* 13:533-568, 2003.
- 32 Ryan MT, Irwin JA, Bannon FJ, Mulholland CW, Baird AW. Observations of veterinary medicine students' approaches to study in pre-clinical years. *J Vet Med Educ* 31:242-254, 2004.
- 33 Azila NM, Sim SM, Atiya AS. Encouraging learning how to fish: an uphill but worthwhile battle. *Ann Acad Med Singapore* 30:375-378, 2001.
- 34 Williams AF. An antipodean evaluation of problem-based learning by clinical educators. *Nurse Educ Today* 19:659-667, 1999.
- 35 Becker S, Viljoen MJ, Botma Y, Bester IJ. Integration of study material in the problem-based learning method. *Curationis* 26(1):57-61, 2003.
- 36 Yeung E, Au-Yeung S, Chiu T, Mok N, Lai P. Problem design in problem-based learning: evaluating students' learning and self-directed learning practice. *Innovations in Education and Teaching International* 40:237-244, 2003.
- 37 Blake RL, Hosokawa MC, Riley SL. Student performances on Step 1 and Step 2 of the United States Medical Licensing Examination following implementation of a problem-based learning curriculum. *Acad Med* 75:66-70, 2000.
- 38 Donner RS, Bickley H. Problem-based learning: an assessment of its feasibility and cost. *Hum Pathol* 21:881-885, 1990.
- 39 Habib F, Baig L, Mansuri FA. Opinion of medical students regarding problem based learning. *J Pak Med Assoc* 56:430-432, 2006.
- 40 Farquhar LJ, Haf J, Kotabe K. Effect of two preclinical curricula on NBME Part I examination performance. *J Med Educ* 61:368-373, 1986.

- 41 Verhoeven BH, Verwijnen GM, Scherpbier AJ, Holdrinet RS, Oeseburg B, Bulte JA, der Vleuten CP. An analysis of progress test results of PBL and non-PBL students. *Med Teach* 20:310–316, 1998.
- 42 Antepohl W, Herzig S. Problem-based learning versus lecture-based learning in a course of basic pharmacology: a controlled, randomized study. *Med Educ* 33:106–113, 1999.
- 43 Khan H, Taqui AM, Khawaja MR, Fatmi Z. Problem-based versus conventional curricula: influence on knowledge and attitudes of medical students towards health research. *PLoS ONE* 2(7):e632, 2007.
- 44 Hendry GD, Lyon PM, Prosser M, Sze D. Conceptions of problem-based learning: the perspectives of students entering a problem-based medical program. *Med Teach* 28:573–575, 2006.
- 45 Colliver JA. Effectiveness of problem-based learning curricula: research and theory. *Acad Med* 75:259–266, 2000.
- 46 Anderson WJ, Glew RH. Support of a problem-based learning curriculum by basic science faculty <<http://www.med-ed-online.org>>. Accessed 09/05/08. *Med Educ Online* 7:1–11, 2002.
- 47 Das Carlo M, Swadi H, Mpofo D. Medical student perceptions of factors affecting productivity of problem-based learning tutorial groups: does culture influence the outcome? *Teach Learn Med* 15:59–64, 2003.
- 48 Hendry GD, Ryan G, Harris J. Group problems in problem-based learning. *Med Teach* 25:609–616, 2003.
- 49 Morrison JM, Murray TS. An experiment in problem-based learning. *Med Educ* 28:139–145, 1994.
- 50 Wood AK, Lublin JR, Hoffmann KL, Dadd MJ. Alternatives for improving veterinary medical students' learning of clinical sonography. *Vet Radiol Ultrasound* 41:433–436, 2000.
- 51 Fitzpatrick JL, Mellor DJ. Survey of the views of graduates (1993 to 1997) on undergraduate veterinary clinical curriculum in the British Isles. *Vet Rec* 153:393–396, 2003.
- 52 Baguley J. The role of final year extramural placements in the undergraduate veterinary curriculum. *Aust Vet J* 84:182–186, 2006.
- 53 Spencer JA, Jordan RK. Learner centred approaches in medical education. *Brit Med J* 318:1280–1283, 1999.
- 54 Shields HM, Guss D, Somers SC, Kerfoot BP, Mandell BS, Travassos WJ, Ullman SM, Maroo S, Honan JP, Raymond LW, Goldberg EM, Leffler DA, Hayward JN, Pelletier SR, Carbo AR, Fishman LN, Nath BJ, Cohn MA, Hafler JP. A faculty development program to train tutors to be discussion leaders rather than facilitators. *Acad Med* 82:486–492, 2007.
- 55 Peters MW, Smith MF, Smith GW. Use of critical interactive thinking exercises in teaching reproductive physiology to undergraduate students. *J Anim Sci* 80:862–865, 2002.

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