

# **Problem Based Learning: A Model for Excellence in Medical Education**

**James O. Alben<sup>1§</sup>, Wayne A. Krueger<sup>1</sup>, Ronald Berezniak<sup>1</sup>, Sarah A. Tjioe<sup>1</sup>,  
Silvia M. Ferretti<sup>2</sup>**

## **Abstract**

### **Background**

Problem Based Learning (PBL) provides a framework for building the foundations for leadership: self-direction, critical thinking, empathy and interpersonal skills. Communication of the expectation of excellence helps to guide highly motivated students toward their goals in medicine. This paper presents an analysis of outcomes which demonstrate the effectiveness and quality of a medical curriculum based on PBL for the basic medical sciences.

### **Methods**

We describe a large scale implementation of Problem Based Learning (PBL) to classes of 150 students per year with emphasis on student-directed learning of basic medical sciences and development of interpersonal skills. Essential elements of the program were developed on a smaller scale (35 students per year) at The Ohio State University College of Medicine and Public Health from 1990 to 2004. The Lake Erie College of Osteopathic Medicine (LECOM, Erie, PA) adapted the program with 40 students per year, from 1999 to present with continuing success. The Bradenton branch campus of LECOM began classes with 150 students in 2004, in a curriculum based entirely on PBL for the basic medical sciences, and graduated its first class June, 2008. Having graduated our first three classes, we present some results of student performance.

### **Results**

After the challenges of the first class, our students have achieved scores on COMLEX 1 (Comprehensive Osteopathic Medical Licensure Examination) significantly higher than the national average, with a 100% pass rate on the initial attempt for the past two years. Graduating students continued their education in a variety of residency programs with emphasis on primary care.

### **Conclusions**

Our experience implementing a successful large scale medical education program based upon a cost-effective PBL approach may serve as a guide to others.

-----

## **Background**

Problem Based Learning (PBL) has been widely adapted (e.g. see [1-6]) as a framework for medical education since its introduction in the 1960s [7]. Implementation has varied from a single course to integration of all basic medical science with clinical applications, and from highly directive case based diagnosis to self-directed learning and independent thinking. Differences in approach are determined by the skills and attitudes each school wishes to emphasize in their

medical graduates. The educational program at LECOM/Bradenton emphasizes self-direction in the learning process and independent thinking to build an understanding of themselves and all of the basic medical sciences in relation to clinical observations.

Studies [8,9] have compared what has been called “PBL” (or case based medicine) with highly directed lecture based education and have reported little difference in measured outcomes with minor exceptions. This suggests that the mechanics of PBL neither help nor hinder these measured outcomes. A significant exception has been reported from the University of Missouri at Columbia Medical School [10,11]. USMLE (United States Medical Licensure Examination) board scores showed significant improvement relative to the national average after implementation of their PBL-type program. How does that program differ from other PBL implementations? How does the program at LECOM/Bradenton differ? Does PBL offer a better option for the medical profession? This paper attempts to define some of the important aspects that have made the PBL curriculum at LECOM/Bradenton an effective delivery system for medical education.

The first requirement for PBL is that students must take full responsibility for their own level of understanding. This is not done in a vacuum since the PBL cases serve as a framework for exploring all of the basic medical sciences and their relation to clinical observations. Faculty provide a supportive infrastructure, but students must direct their own learning. Faculty do not specify what students are to learn but do convey an expectation of excellence in their level of understanding. Students are expected to be able to think through how each physiological system works and its relation to every other body system, and to relate every clinical observation to basic medical science causation. Guiding students through the transition from undergraduate memorization/recitation to an in-depth understanding is a function of the faculty. Faculty do not teach what to learn, but facilitate discussion to enable students to identify relevant information. The result is that students discover that they can evaluate new information, relate it to their present knowledge, and ask “does it make sense?”. They gain confidence in their own ability to think critically and to direct their own learning.

### **Leadership in Medicine**

Creating leaders in the medical profession is consistent with the mission of LECOM. A leader is one who can assess a situation in relation to global goals and who can guide events toward a desired outcome. Primary attributes for any leader are the ability to listen and to understand problems or situations that are presented, and to address them appropriately. This process requires perception, redefinition of questions, and analysis of possible responses (i.e. critical thinking). These skills are requisite and inherent in the implementation of the Problem Based curriculum at LECOM/Bradenton which requires students to direct their own learning.

Self-directed learning is both challenging and frustrating, but is essential to building leadership. Learning how to acquire knowledge in a PBL environment is akin to being taken to the middle of a lake, thrown into the water, and told “learn to swim”. Guidance and assurance is provided, but students are not told what they should study. Part of the learning process is for students to decide what they need to learn. Each student must learn how to learn for themselves.

Another essential component of leadership is the guidance of people. Group discussions in PBL provide an excellent real-life psychological laboratory for understanding group dynamics and refinement of interpersonal skills. Understanding one’s own reactions to challenges aids in understanding reactions of others to

frustrating situations, and allows one to manage or ameliorate causes of that frustration.

### **Expectation of Excellence**

Professional excellence is a requirement of leadership. Communication of the expectation of excellence takes many forms. PBL is ideally suited to this communication since faculty become well acquainted with students in the small discussion groups. Facilitation of the discussion includes setting expectation levels by asking in-depth questions. However, students are expected to assume the facilitator's role by asking their own questions. Every student is expected to become an excellent facilitator. Students' questions lead to areas of study upon which they wish to focus. These areas are reinforced as they are chosen as topics upon which to be examined. Thus students define their own areas of knowledge and direct their own learning process. Most importantly, students learn by their successes that they can achieve this. PBL cases provide a framework with a common goal of understanding the basic medical science underpinnings of clinical medicine.

Communication of the expectation of excellence begins with the recruiting process. Only applicants whose records meet our medical school standards are invited for interview. Applicants are evaluated by the interviewing faculty on their ability to sustain the rigors of the program and its workload, and to communicate with others in a professional manner. Each applicant is permitted to observe a PBL group in action, and to decide whether this learning approach fits their academic level, personality, and study habits. Applicants then decide whether to select the challenge of self-directed learning. Applicants are treated with the same respect that we expect them to earn.

## **Methods**

### **The PBL Process**

PBL provides a framework for self-directed study. The framework consists of a series of selected clinical cases for which students must explore areas of basic biomedical sciences, including anatomy, physiology, pathology, microbiology, immunology, biochemistry, pharmacology, and their clinical applications, in order to progress through the case information. Understanding each clinical case requires that students bring together information from each of the basic medical sciences, and relate it to problems that they identify in each case. The majority of the clinical cases being used were originally developed by Dr. John J. Curry and co-workers at The Ohio State University from original patient data. All cases were adapted to osteopathic medicine by LECOM [12]. The cases have since been modified and updated at LECOM/Bradenton with care to maintain the self-consistency of each original case. Cases provide a framework from which students decide what areas of basic medical science must be understood to understand each case. Students select information content from their textbooks, journals, and selected web sites. New information must be related to their previous understanding, and what makes sense to each student. PBL emphasizes the importance of self-directed learning and learning how to learn [13], which will be necessary throughout the physician's practice of medicine.

The method of case presentation is by progressive disclosure of information. Each case begins with the chief complaint that brings the patient to the physician's office. Students must explore possible causes for the initial complaint, extract further information from a history and then the physical examination, determine what additional information is needed to investigate and understand the disease process,

and then proceed to a diagnosis and development of a management plan. Students are given only the information that they request, or they may be told that the requested information is not available to them at that time. During the two hour PBL session, subject matter arises that leads to immediate discussion and exploration of resource information, with active participation of all students. When the case surpasses their current understanding, students will select topics in each of the appropriate basic biomedical sciences for study to help them understand the science behind the patient's problems. Topics for learning are chosen by group consensus and eventually defined by the group as examination topics. Between PBL sessions, the students work independently or with classmates, learning basic science related to the case. Students return to their group at the next session, present the current status of their understanding of the case, and progress to a conclusion that includes a diagnosis and plan for management of the patient's problems. Students are encouraged to understand how each piece of information from the case results from normal or pathological physiology, and how the proposed testing and treatment protocol may affect the patient and case presentation. This helps them to direct their study to learning issues of their choosing in each of the basic sciences for which they will be tested, and provides a basis for integration of that information and its application to clinical problem solving. This process also provides students with an introduction to information-resources that are available to them, and which they must critically evaluate. Students, therefore, "learn how to learn" when confronted with questions in clinical medicine about their paper patient. PBL students become experienced in self-directed study. We speculate that this learning process will then continue throughout their professional lives. Early on in PBL, students are told that they must master all of the sciences basic to medicine in their first two years. With this goal, students realize that the work load chosen for each case must be both relevant and voluminous.

Through their group discussions, students become adept at many skills that they will need in subsequent clinical practice, such as the ability to listen to what a patient says and understand the underlying problems that lead to the patient's concerns. Students must also learn to deal with personal frustrations as part of the learning process, as they strive to understand disease processes for which they do not yet have adequate information. Learning in a PBL environment can be highly frustrating, especially when the next person's understanding comes from a different depth or direction than one's own, or when the workload becomes daunting. Understanding one's own reactions to that frustration is an important beginning to acceptance and understanding of the next person. Understanding their own reactions helps students become more sensitive to group dynamics and interpersonal interactions. Students learn how to focus on problems and to understand the relation of those problems to the overall health of their patients.

Problem Based Learning at LECOM/Bradenton is designed to reinforce holistic aspects of medicine by focusing on not only the physical health of the patient, but also social and behavioral considerations. In some of the PBL cases, the focus extends to include the health of the community as well.

#### **Facilitator's Role**

The facilitator's function is to guide students in the process of learning how to learn definable information, and to mold attitudes and personal interactions associated with group dynamics. The facilitator must guide, not teach! The success of the facilitator's mentoring is measured by the ability of the group to guide their own progress without intervention by the facilitator. The facilitator sets the tone for the group activities. Ideally, each member should contribute equally to the understanding

of other members of the group, and refocus the discussion when it goes astray. Students earn the respect of other members when this is done. Equally important is the manner of their interpersonal interactions which must include acceptance and respect for other members of the group, as they listen and contribute to the process. The facilitator's job is to oversee this format and to guide students in learning how to work together. The facilitator helps set the desired depth of learning by asking questions such as "Why does it work that way?"

One of the major functions of the facilitator is to convey to the students the expectation of excellence, in their understanding of textbook information, in their interpersonal skills, and in their understanding of group dynamics. The facilitator can provide guidance to improve communications and show students how to become more systematic and thorough in their discussions. One of the tools that we use is the Faculty Assessment of Student Progress (FASP, Table 1), which lists some of the goals for student behavior in the group, and is subjectively scored as a part of their grade. The FASP includes subjective evaluation of students' preparation, participation in group discussion, interpersonal skills, and contributions to group progress. It provides a format for communication of the importance of individual contributions to a supportive learning environment. FASP scores become part of the students' final grade.

<sup>1</sup>Lake Erie College of Osteopathic Medicine, Bradenton Branch, Bradenton, Florida, USA

<sup>2</sup>Lake Erie College of Osteopathic Medicine, Erie, Pennsylvania, USA.

<sup>§</sup>Corresponding author

Email addresses:

JOA: [jalben@lecom.edu](mailto:jalben@lecom.edu)

WAK: [wkrueger@lecom.edu](mailto:wkrueger@lecom.edu)

RB: [rberezniak@lecom.edu](mailto:rberezniak@lecom.edu)

SAT: [stjioe@lecom.edu](mailto:stjioe@lecom.edu)

SMF: [ckonnerth@lecom.edu](mailto:ckonnerth@lecom.edu)

# Table 1: Facilitator Assessment of Student Performance

Student \_\_\_\_\_ Group \_\_\_\_\_

For items A to D give a numeric score as indicated below. Then add the scores from A to D to compute the final FASP score. Each numbered line is worth 5 points.

## A. Preparation (score 0 to 15) \_\_\_\_\_

1. Is prepared to begin the meeting on time
2. Comes prepared to discuss material relevant to case
3. Brings and uses appropriate resources

## B. Participation (score 0 to 30) \_\_\_\_\_

1. Is an appropriately active member of group
2. Presents new learning and ideas in an organized or systematic fashion
3. Consistently uses appropriate published references to illustrate a point or defend a position
4. Raises questions that effectively stimulate discussions
5. Communicates accurate self assessment
6. Makes significant effort to respond to areas of suggested improvement

## C. Interpersonal Skills (score 0 to 30) \_\_\_\_\_

1. Encourages other group members to participate
2. Demonstrates respect for opinions of other members
3. Demonstrates significant support for other members
4. Accepts feedback from others gracefully
5. Provides non-critical feedback to others about their behavior and participation
6. Responds responsibly to irritations and frustrations

## D. Contributions to Group Progress (Score 0 to 25) \_\_\_\_\_

1. Facilitates communication by clarifying, summarizing or tying disjointed ideas together
2. Makes effort to redirect group back to task when digressions occur
3. Demonstrates positive leadership; directs movement toward common goals
4. Initiates action to prevent or eliminate unhealthy group norms
5. Demonstrates insightful participation in group process or debriefing discussions

Final Score (Sum of A to D) \_\_\_\_\_

## **Maximizing the Benefit of Group Discussions in PBL**

Students come from a variety of educational and cultural backgrounds but with a common goal of serving the needs of their future patients. This common goal brings students together to form a mutually supportive learning group. Students must take responsibility for their own learning, but are also responsible for the learning of their peers. A deficiency of one affects the learning of all, but a supportive group can overcome many deficiencies. Building this mutual support group is an essential part of PBL. It includes acceptance of and gaining respect for each member of the group and appreciation of the contributions to one's own understanding as each member buys into the PBL process. Cohesive and supportive group dynamics depends heavily on the commonality of purpose of the members and the support of the facilitator.

### **The Ideal Group**

Students learn to trust their own abilities to define a situation and best manage the outcome. Self-understanding and acceptance lead to acceptance of others as they are, and in turn, the ability to see beyond the expression of frustration by others, so that reasons for that frustration may be properly managed. This can lead to an "ideal group" in which students are very supportive of the problem based learning process. Students become good listeners, and supportive of other students, while also making very positive contributions to the discussion. They are respectful of differing opinions, and actively find answers to questions from their multi-disciplinary reading. They come well-prepared and well organized, actively thinking about questions and what makes sense. They achieve good interpersonal skills. They create the PBL process. The facilitator can recognize deviations from this ideal process and guide the group toward improvement.

### **Behavior Modification**

There are many levels at which the need for student behaviour modification can be communicated in PBL. The first is at the end of each group meeting, where each student and the facilitator describe what went well during the meeting, and what did not. For example, a student might say "I felt very frustrated with the pace of the discussion today." The group would then discuss the pros and cons of moving faster or slower. When there is dissention within the group, the reasons should be openly discussed by the group so they can be dealt with more effectively. This can lead to mutual acceptance and support within the group. Additional guidance is provided with individual counseling. More difficult problems can be handled administratively.

## **Results**

### **Analysis of Outcomes**

There are many ways to measure effectiveness of a medical education program. One method is to compare standardized testing, such as board scores. Figure 1 presents mean scores achieved by the first five classes from LECOM/Bradenton for COMLEX 1 (Comprehensive Osteopathic Medical Licensure Examination), the accrediting examination for osteopathic medical schools, compared with national averages. After the inaugural class of 2008, each of the classes of 2009, 2010, 2011 and 2012, scored well above the national average. The percentage of students who passed COMLEX 1 on their first attempt progressively improved to reach 100% in classes of 2011 and 2012. Figure 2 compares the pass rate for COMLEX 1 for students from LECOM/Bradenton with national averages.

Clinical clerkships tend to be less structured, with students apprenticing in a variety of hospitals, clinics, and doctor's offices. Students' progress through their third year is measured by COMLEX 2-CE. Performance of students from LECOM/Bradenton was similar to the national average until the class of 2011, which showed a significant improvement in both mean score and pass rate. This class had been given an outline of topics that should be understood for each required clinical rotation, even if it was beyond immediate clinical observations. The summary list was coupled with communication of an expectation of excellence. Areas of weakness were identified by use of USMLE shelf exams. Students received no lectures but made use of their PBL learning skills and responded appropriately to this stimulus. The result was a jump in both mean score and pass rate for this class (Figures 3 and 4).

Another way to measure effectiveness is to compare PBL exam scores with board scores. A very high correlation (0.79-0.83) is routinely observed between PBL exam scores and COMLEX 1 board scores (Figure 5).

An effective educational program should also lead to a high fraction of students becoming qualified to continue their training. Our three graduating classes have continued into internship and residency programs. The Residency Match for the classes of 2008, 2009 and 2010 includes a variety of specialties, but with strong emphasis on primary care (Figure 6).

## Discussion

The concept of problem based learning is not new [1,6,13,14]. It provides a framework [15] for learning by presenting a series of questions that students must translate into directions for study. The major difference between PBL and the classic lecture presentation approach is the level of responsibility placed on the student. In PBL, each student must take responsibility for his or her level of understanding, and learn how and what to learn to achieve that understanding. This approach requires a certain maturity. Students must be able to question their own ideas, encompass new information, and determine what makes sense. They are not limited by the viewpoint of the lecturer but only by their ability to assimilate and understand new information and to manage their time. This element of self-direction is reduced when supplementary lectures or more directive case-based approaches [16] are added.

PBL applies concepts of graduate education, in which students are responsible for their own level of understanding, to medical school. Many medical schools have incorporated aspects of PBL or case-based medicine into their curriculum, but few have integrated the complex self-directed learning paradigm as practiced at LECOM/Bradenton. Most schools appear to either supplement PBL with lectures which direct students studies, or use case presentations to supplement a lecture program. Lectures dilute the need for students to direct their own learning and therefore, after an introductory anatomy course, supplementary lectures are not permitted in the PBL-covered basic medical sciences at LECOM/Bradenton. Optional enrichment lectures may be sponsored by student clubs, but are unrelated to examinations.

Two other aspects of PBL contribute to the success of this program. Learning and using all basic medical sciences at once to understand a case requires integration of information with its application. Using the case format to guide basic science studies allows all body systems to be studied in the first year and revisited in the second year. Repetition in a different setting also fosters greater depth of understanding and retention of the material.

Success of the program depends on students challenging their own thinking with new information and a faculty who convey the expectation of excellence. LECOM/Bradenton is the largest campus (150 students/class) to integrate all basic medical sciences into a completely PBL format without supplemental directive lectures. Students acquire many skills beyond what is normally measured by board scores. These include systematic approaches to clinical problem solving, listening and presentation skills, interpersonal interaction skills, understanding of group dynamics, caring, understanding of patho-physiology and human behavior, and integration of clinical observation with basic medical science. In addition, students gain confidence in their own ability to think, to challenge ideas, and to direct their own learning. That these abilities carry over into the clinical clerkships is suggested by the jump in COMLEX CE-2 scores following introduction to the class of 2011 of a summary list of expectations for each of the core rotations. Reinforcing expectations of excellence during the clinical years three and four through communication to our students and to our adjunct clinical faculty is requisite.

The core of established basic medical science is well defined in the major medical textbooks and elaborated in web sites of many universities, medical organizations, and more specialized journal articles. Students must understand the core of medical information to begin to appreciate fine points of the specialties. PBL provides the basic medical science core and teaches students how to extend their knowledge by directing their own further learning. The group discussions provide a format for testing students' level of understanding and displaying gaps in their knowledge. This learning paradigm can be utilized through the clinical clerkship and residency years, and provides the basis for building future expertise.

LECOM/Bradenton's first class (2008) survived the start-up challenges of a new branch campus and the barriers of a new learning paradigm. All students and most of the faculty were unfamiliar with PBL or self-directed learning and requests for supplemental lectures were frequent from both groups. Some faculty experienced difficulty in letting go of the security of the traditional medical education model (lectures) and embracing a more student-oriented approach. Faculty at LECOM/Bradenton have over time become convinced of the strengths of self-directed learning in medical education.

Subsequent classes are more indicative of what can be produced from this educational program. The classes scored well in all areas of COMLEX 1, which includes all of the basic medical sciences that are covered in PBL, and in behavioral science, which PBL reinforces. Our students have scored well above the national average in all basic areas.

It is understood that PBL may not be appropriate for all medical students. Those who are unsure of their own decisions or need to be told what to study may prefer a more highly directive program. Similarly, PBL may not be appropriate for all medical schools. Many faculty are unsure of the ability of their students to direct their own learning. Shanley [17] has described a litany of problems which he associates with PBL. The problems are not inherent in the PBL concept but suggest inadequate implementation of the program. Students at LECOM/Bradenton have proven what can be accomplished within a well-implemented PBL program.

## **Conclusions**

PBL provides a framework for learning and development of thinking processes and communication skills that are essential to medical practice. Success of the program depends on having intensely focused students guided by faculty who can

communicate the expectation of excellence. What sets LECOM/Bradenton apart from other medical schools may be the degree to which students are allowed, indeed required, to learn to direct their own learning. Critical thinking and self-direction are prerequisite to leadership. The available knowledge base includes well refereed medical textbooks, journals, and web sites, and faculty who understand the meaning of excellence. Key elements of this program include emphasis on self-directed learning and a supportive infrastructure.

## **Competing interests**

The authors are employed by Lake Erie College of Osteopathic Medicine. The authors declare that they have no competing interests.

## **Authors' contributions**

All authors have participated in the development and implementation of the PBL medical education program as described in this manuscript. All authors have read and approved the final manuscript.

## **Authors' Information**

Dr. Alben is Professor of Biochemistry, Lake Erie College of Osteopathic Medicine, Bradenton Branch, Bradenton, Florida, and Professor Emeritus, The Ohio State University, College of Medicine and Public Health, Columbus, Ohio.

Dr. Krueger is Professor of Anatomy and Founding Assistant Dean of Preclinical Education, Lake Erie College of Osteopathic Medicine, Bradenton Branch, Bradenton, Florida.

Dr. Berezniak is Assistant Dean for Academic Affairs, Lake Erie College of Osteopathic Medicine, Bradenton Branch, Bradenton, Florida.

Dr. Tjioe is Professor of Pharmacology and Founding Director of Problem Based Learning at LECOM, Bradenton Branch, Bradenton, Florida. She was formerly Associate Director of PBL at The Ohio State University, College of Medicine and Public Health, Columbus, Ohio.

Dr. Ferretti is Provost, Senior Vice President and Dean for Academic Affairs, Lake Erie College of Osteopathic Medicine, Erie, Pennsylvania.

Correspondence should be addressed to Dr. Alben, LECOM/Bradenton, 5000 Lakewood Ranch Boulevard, Bradenton, FL 34211, U.S.A.; telephone: (941) 782-5977; email: jalben@lecom.edu.

## **Acknowledgements**

This work has been supported by Lake Erie College of Osteopathic Medicine (LECOM). The authors thank the faculty of LECOM/Bradenton for their dedication and perseverance in making this program effective, and for critically reading this manuscript.

## References

1. Nevelle AJ, Norman GR: **PBL in the Undergraduate MD Program at McMaster University: Three Iterations in Three decades.** *Acad. Med.* 2007, 82:370-374.
2. Tavakol M, Dennick R, Tavakol S: **A descriptive study of medical educators' views of problem-based learning.** *BMC Medical Education* 2009, 9:66.
3. Schlett CL, Doll H, Dahmen J, Polacsek O, Federkeil G, Fischer MR, Bamberg F, Butzlaff M: **Job requirements compared to medical school education: differences between graduates from problem-based learning and conventional curricula.** *BMC Medical Education* 2010, 10:1.
4. Tokuda Y, Goto E, Otaki J, Jacobs J, Omata F, Obara H, Shapiro M, Soejima K, Ishida Y, Ohde S, Takahashi O, Fukui T: **Undergraduate educational environment, perceived preparedness for postgraduate clinical training, and pass rate on the National Medical Licensure Examination in Japan.** *BMC Medical Education* 2010, 10:35.
5. Groves M, Rego P, O'Rourke P: **Tutoring in problem-based learning medical curricula: the influence of tutor background and style on effectiveness.** *BMC Medical Education* 2005, 5:20.
6. <http://www.maastrichtuniversity.nl/web/Faculties/FHML.htm>
7. Berkson L: **Problem-based learning: Have the expectations been met?** *Acad.Med.* 1993, 10:S79-S88.
8. Koh GC-H, Khoo HE, Wong ML, and Koh D: **The effects of problem-based learning during medical school on physician competency: a systematic review.** *CMAJ* 2008, 178:34-41.
9. Hartling L, Spooner C, Tjosvold L, and Oswald A: **Problem-based learning in pre-clinical medical education: 22 years of outcome research.** *Med.Teacher* 2010, 32:28-35.
10. Blake RL, Hosokawa MC, and 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.* 2000, 75:66-70.
11. Hoffman K, Hosokawa M., Blake Jr. R, Headrick L, Johnson G: **Problem-Based Learning Outcomes: Ten Years of Experience at the University of Missouri-Columbia School of Medicine.** *Acad.Med.* 2006, 81:617-625.
12. Ferretti SM, Krueger WA, Gabel LL, and Curry JJ. **Lake Erie College of Osteopathic Medicine's Preclinical Problem-Based Learning Pathway Program: An Alternative Medical School Curriculum Design.** *J Am Osteopath Assoc.* 2007; 107:443-449.
13. Neame RLB, Powis DA. **Toward Independent Learning: Curricular Design for Assisting Students to Learn How To Learn.** *J Med. Educ.* 1981; 56:886-893.
14. Donner RS, Bickley H. **Problem-based learning in American medical education: an overview.** *Bull Med Libr Assoc.* 1993, 81:294-298.
15. Hmelo-Silver CE, Duncan RG, Chinn CA. **Scaffolding and Achievement in Problem-Based and Inquiry Learning: A Response to Kirschner, Sweller, and Clark (2006).** *Educ Psychol.* 2007, 42:99-107.
16. Srinivasan M, Wilkes M, Stevenson F, Nguyen T, Slavin S. **Comparing Problem-Based Learning with Case-Based Learning: Effects of a Major Curricular Shift at Two Institutions.** *Acad Med.* 2007, 82:74-82.

17. Shanley, PF. **Viewpoint: Leaving the “Empty Glass” of Problem-Based Learning Behind: New Assumptions and a Revised Model for Case Study in Preclinical Medical Education.** *Acad. Med.* 2007; 82:479-485.

...

## Figures

### **Figure 1 - COMLEX Score on Initial Attempt vs. National Mean.**

COMLEX 1 mean scores on initial attempt for LECOM/Bradenton classes of 2008-2012 are compared with national mean scores.

### **Figure 2 - Pass Rate for COMLEX 1 on Initial Attempt vs. National Mean.**

Pass rate for COMLEX 1 for first time takers for LECOM/Bradenton classes of 2008-2012 compared with national means.

### **Figure 3 - COMLEX 2-CE Score on Initial Attempt vs. National Mean.**

COMLEX 2-CE mean scores on initial attempt for classes of 2008-2011 are compared with national mean scores.

### **Figure 4 - Pass Rate for COMLEX 2-CE on Initial Attempt vs. National Mean.**

Pass rate for COMLEX 2-CE for classes of 2008-2011 (first time takers) are compared with national means.

### **Figure 5 - Class of 2012: PBL Final Exam Grade vs. COMLEX 1 Score on Initial Attempt.**

Comparison of mean COMLEX 1 scores with PBL final exam grades for class of 2012. A grade of 70 is passing for PBL, and a score of 400 is passing for COMLEX 1. The Pearson correlation coefficient is 0.81.

### **Figure 6 - Residency Match for Classes of 2008, 2009, & 2010.**

The residency matches for classes of 2008, 2009, and 2010 include a variety of specialties, but emphasize primary care.

Figure 1

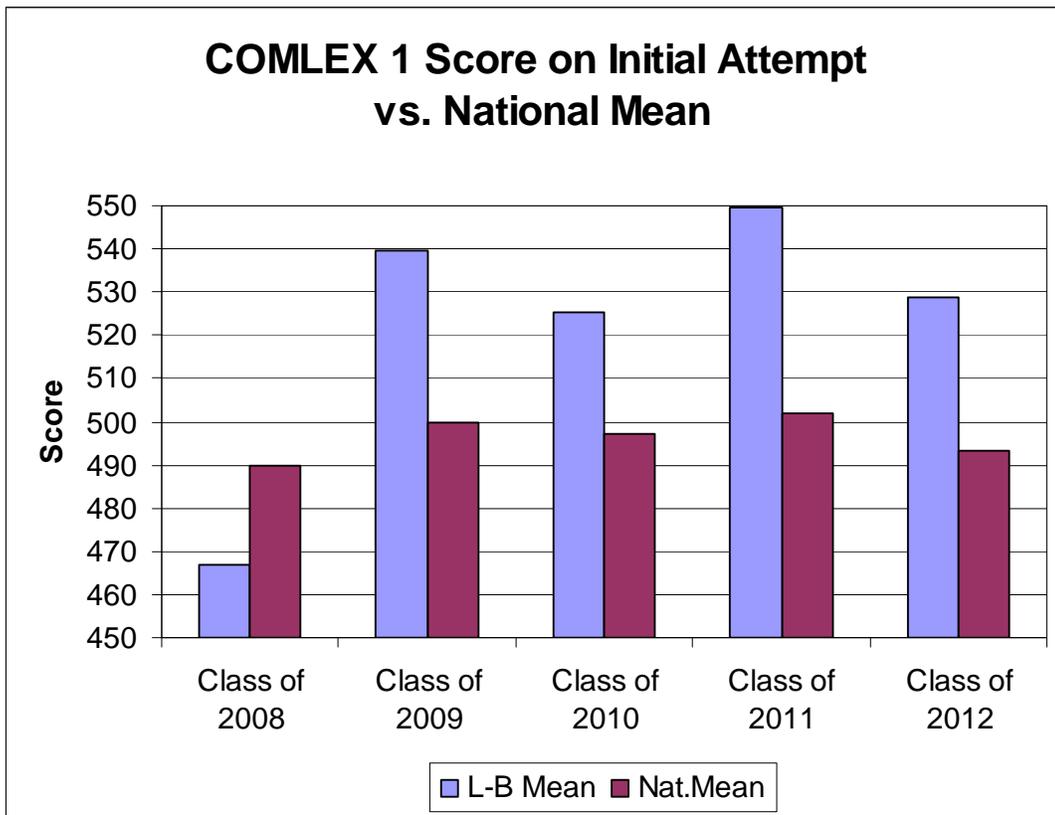


Figure 2.

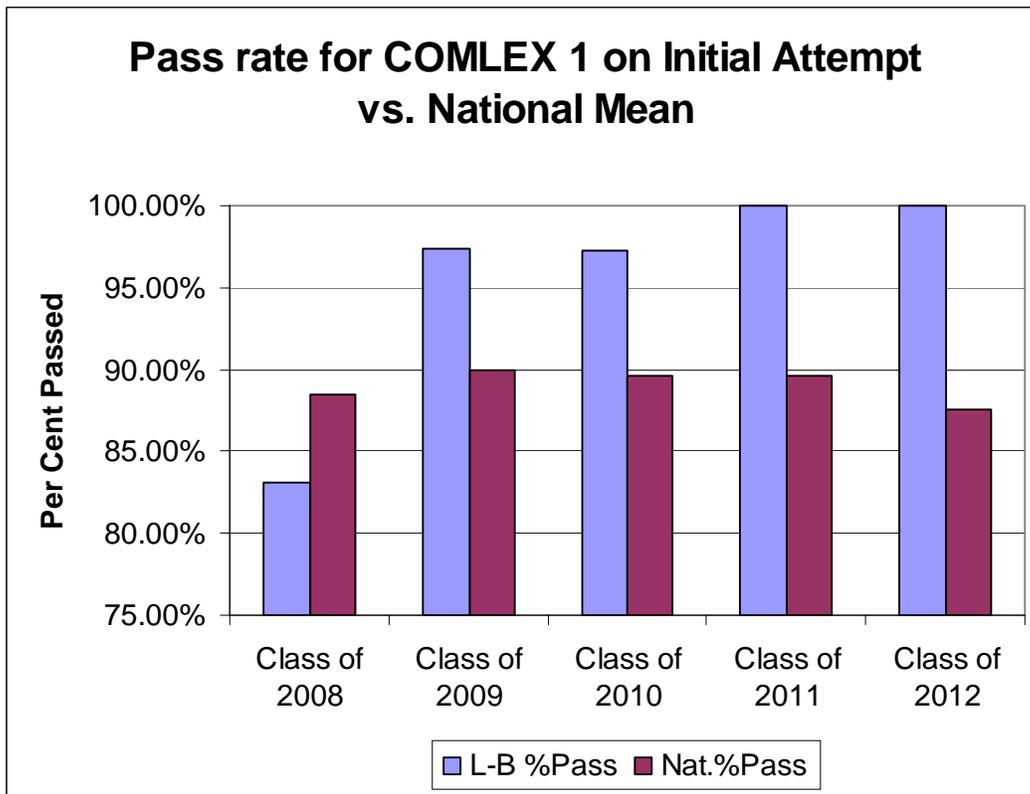


Figure 3.

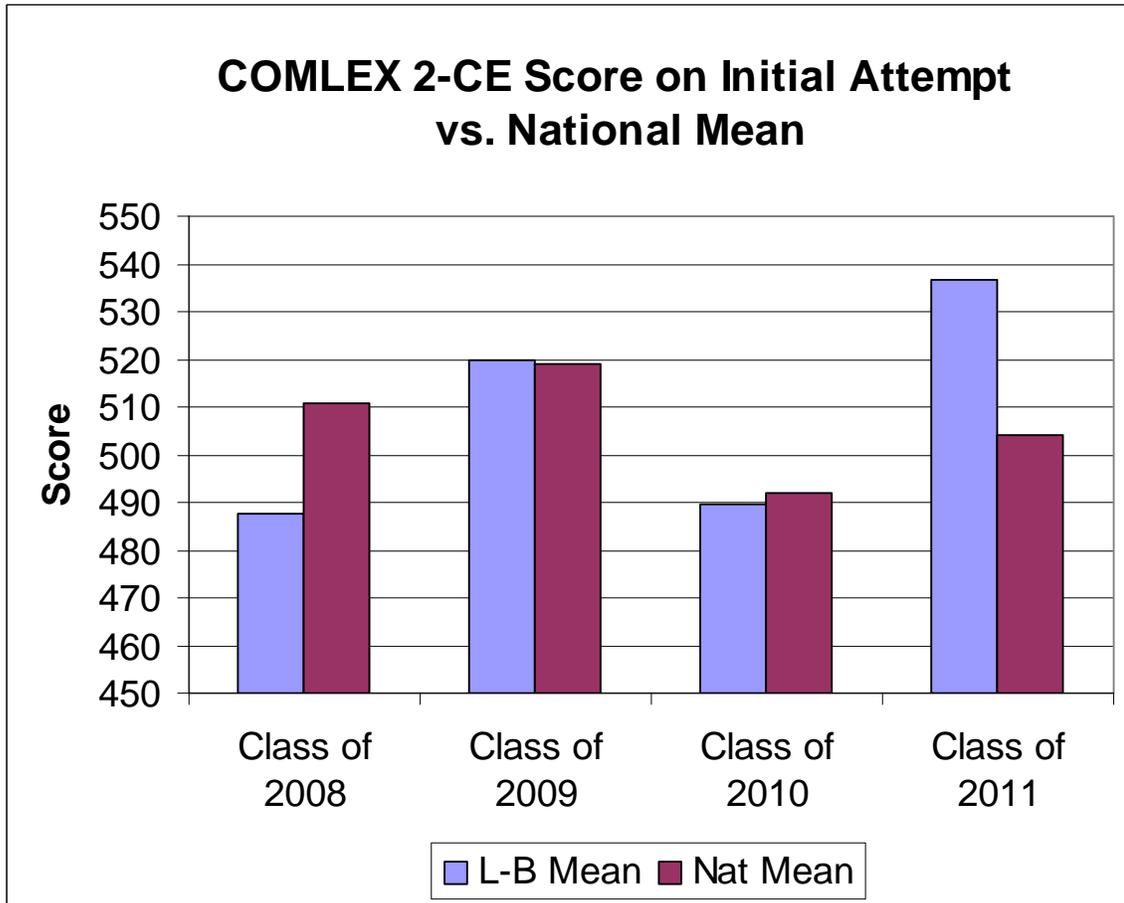


Figure 4.

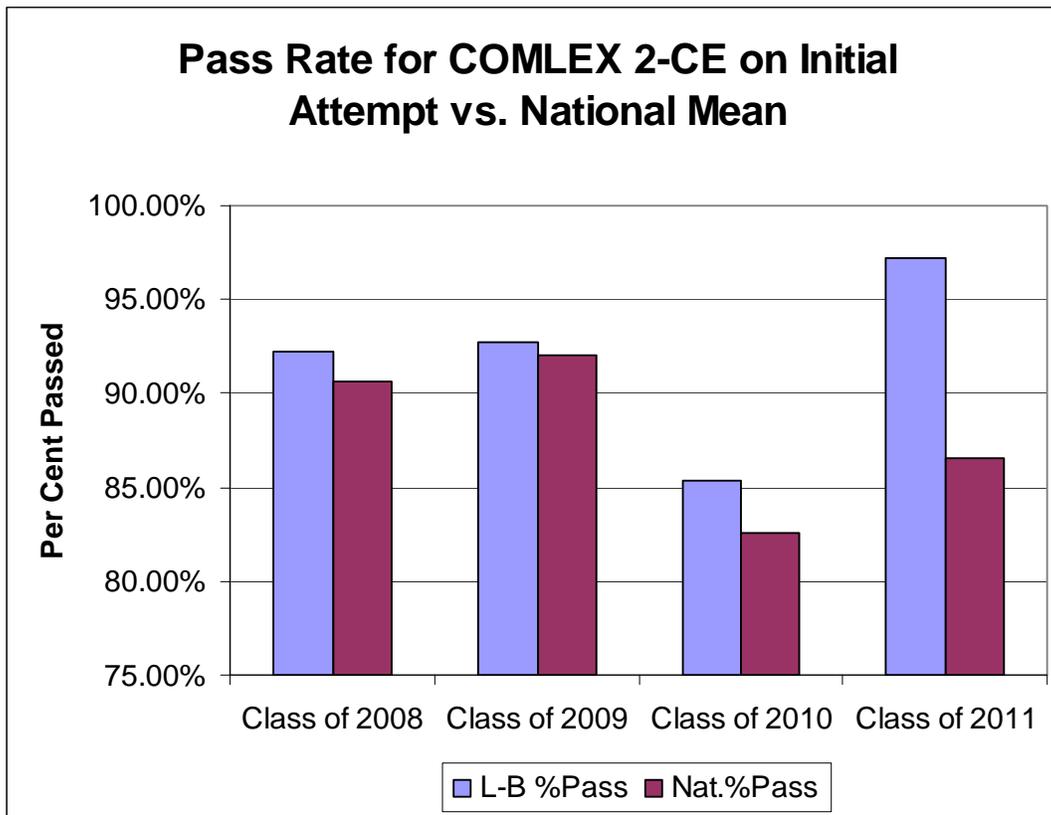


Figure 5.

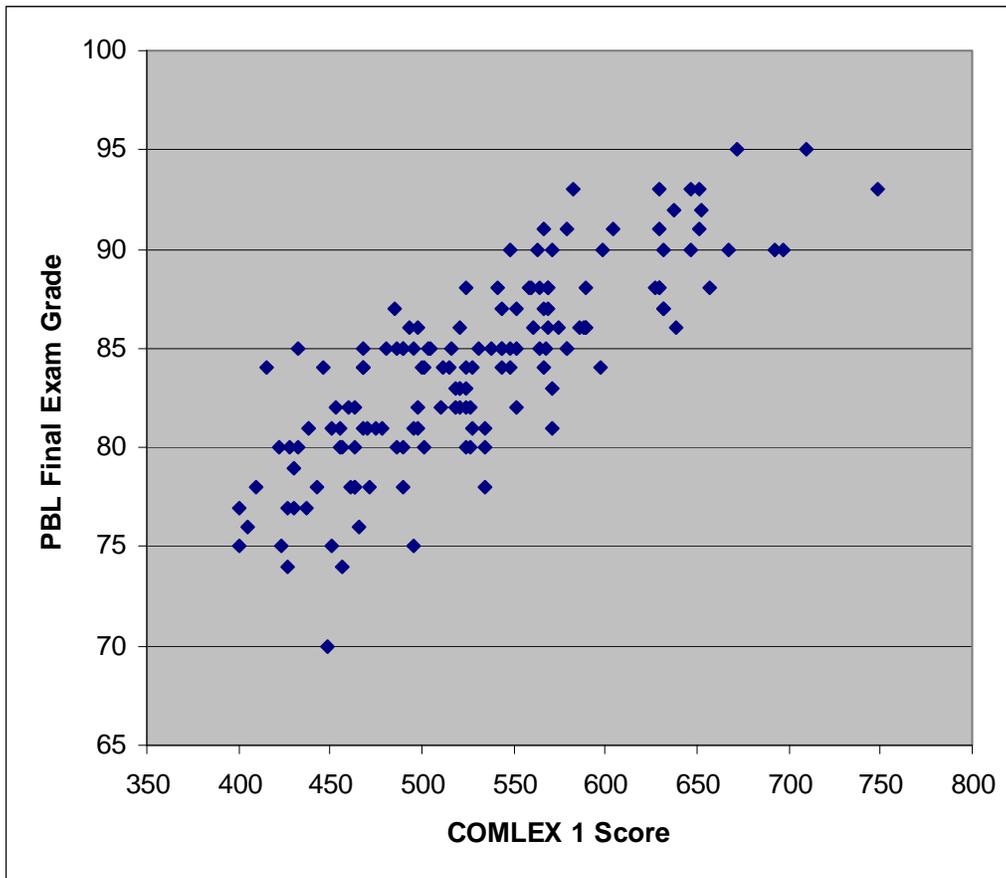


Figure 6.

