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ABSTRACT

This article will provide an overview of the problem-based learning process, and an illustration of how problem-based learning can facilitate development of critical appraisal necessary for evidence-based practice. It will trace the development of problem-based learning as an educational methodology for entry-level health professional education. The information seeking and appraisal themes common to both problem-based learning and evidence-based practice will be examined, along with the roles and responsibilities of faculty and tutors who are part of problem-based learning courses or curricula. Examples of strategies for student assessment will be discussed, for both mastery of didactic content and for contribution to the interactive processes that are part of problem-based learning courses and curricula. A "case" will be presented to illustrate application of problem-based learning principles as a means of facilitating skills necessary for effective evidence-based practice. (*J Prosthet Orthot.* 2002;14:40–50.)

KEY INDEXING TERMS: Problem-based learning, student-centered learning, self-directed learning, evidence-based practice, professional education, case-based learning, adult learning, higher education

Given the complexity and the pace of today's health care environment, educators of health professionals are increasingly challenged to insure that graduates of entry-level programs have requisite knowledge, skills, and attitudes for competent patient care, as well as the capability of adapting to change, generating new knowledge, and critically reflecting on and improving their practice.[1] The standards for accreditation for entry-level physical therapy, occupational therapy, orthotics/prosthetics, and nursing programs have in common the expectation that graduates will be capable of information-seeking, critical appraisal, and knowledge management skills that are necessary for effective evidence-based practice and foundational to being a lifelong learner.[2–5]

Lifelong learning used to be tagged to the broad area of "professional growth" alone, but is now seen as essential to delivery of effective patient care in the context of a rapidly growing and changing body of professional knowledge, and an increasingly complex health care environment. Fraser and Greenhalgh[1] define competence as what individuals know or are able to do in terms of knowledge, skills, and attitudes. They define capability as the extent to which individuals can adapt to change, generate new knowledge, and continuously improve performance.[1] While traditional lecture-based educational models are effective in building competence of graduates, there is less evidence that such ways of learning facilitate graduates' capability to function effectively in an ever-changing, complex clinical environment.[6] Today's "expert" practitioners are not those with the most discipline-specific knowledge or skills; they are individuals who access and evaluate emerging, as well as frequently conflicting or ambiguous, evidence from a variety of fields and resources, establish conceptual links across and among the evidence sources, and tailor their conclusions to the specific needs of an individual patient.[7,8,1] Process-oriented teaching and learning methods such as the problem-based learning (PBL) paradigm are alternative educational methodologies aimed at preparing graduates to be capable of the active, contextual, nonlinear, and transformative learning necessary to today's dynamic clinician.[9,10,1]

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WHAT IS PROBLEM-BASED LEARNING?

PBL is a student-centered, collaborative, nontraditional approach to education that was first implemented in medical education at McMaster's University in 1965.[11] This approach to health education has been adopted by many entry and postprofessional educational programs in medicine,[12–15] nursing,[16–19] physical therapy,[20,21] occupational therapy,[22,23] and pharmacy,[24] among others.

The PBL approach contends that learning occurs most

efficiently when it taps and uses a student's prior knowledge; that knowledge is best expanded and elaborated through active discussion and debate; and that assimilation and retention of knowledge occurs best when learning occurs in a context similar to the one in which students will eventually use that knowledge.[25,20] The PBL approach assumes that responsibility and potential for active learning ultimately lies with the student; the instructor assumes the role of facilitator or guide through the learning process, rather than the "content expert" who imparts his or her advanced knowledge to students via traditional lecture (Figure 1). Learning activities are centered around small group discussion, during which a tutor insures that key learning issues are addressed by the group by raising questions and probing the depth of students' understanding, and facilitates group process so that collaborative learning can best occur. Most PBL "tutorial" discussion sessions revolve around a real or instructor-designed patient case; while problem-solving skills are employed to sort through information being explored, the emphasis in tutorial is on the acquisition of new information and its effective integration into students' professional knowledge base rather than on solving the problem presented in the case.[26,27]

In the last 20 years, the focus of entry-level education in physical therapy, occupational therapy, orthotics and prosthetics, and other health professions has shifted from mastery of technical skill to preparation of professionals involved in assessment, the diagnostic process, implementation of interventions, and assessment of outcomes.[28,29] As a result, greater emphasis has been placed on developing students' clinical reasoning and decision-making skills, ability to access the developing clinical research literature, and ability to integrate new knowledge and changing perspectives into clinical practice. Faculty who have chosen to employ a PBL approach believe that PBL is a more effective mechanism to integrate theory into clinical practice.[30] Most faculty involved in PBL courses and curricula expect that, as an outcome of the PBL process, students will have greater retention of learning, increased ability to apply knowledge in clinical settings,[31] and enhanced clinical reasoning skills.[26,32] The PBL learning process is similar and readily extrapolates to habits of lifelong learning.[33,20,34]

Figure 1. The underlying assumptions of problem-based learning approaches to health professional education.

There is much variation in how PBL strategies are implemented in health professional education. The four most frequently reported variations are:[18,20,21,22,35,36]

(1) A completely "integrated" PBL approach to an entire curriculum: all learning (didactic and psychomotor) revolves around the case-based tutorial process.
(2) A transitional PBL curriculum: the program may begin with a combination of traditional delivery and introduction to PBL methods. There is increasing emphasis on small group tutorial, student-centered learning, and integration of content across courses as students move through their plan of study.
(3) A modified PBL curriculum: case-based tutorials are used from the first semester of study to integrate content across concurrent basic science, clinical science, and professional development courses.
(4) A single PBL course or module within a plan of study, in which one or more courses in a curriculum focus on small group, case-based, or context-based exploration of patient care.

The characteristics that all of these variations in problem-based learning approaches have in common include:[37,38,20]

(1) Student-centered learning activities (tutorial, clinical laboratory experiences, large group/integrative discussion) in which faculty facilitate dialogue based on a student-generated agenda rather than delivering information.
(2) Study of clinical problems, cases, or scenarios based on interaction with real or hypothetical patients or situations, grounding learning in a clinical context as a means of facilitating both acquisition and exploration of new knowledge.
(3) Use of patient cases to integrate basic sciences, medical assessment and intervention, interdisciplinary patient management, and psychosocial influences that affect patient management.
(4) Small group brainstorming, discussion, and debate.
(5) Collaborative and self-directed study and evaluation of available "evidence" (from the research literature, "expert" opinion/resources, student's own clinical experience).
(6) Delineation of individual learner's process and content goals; frequent formative and summative feedback of progression toward accomplishment of goals.

PROBLEM-BASED LEARNING AND EVIDENCE-BASED PRACTICE

In the 1980s, medical educators and clinicians recognized a widening gap between their clinical practice of medicine (often based on tradition and authority) and rapidly increas-

ing "new knowledge" generated from clinical research.[39] In response, they challenged the medical community to better integrate the best research evidence available with clinical expertise and the preferences and concerns of patients to guide decision making[40] (Figure 2). This integrated, evidence-based approach to practice (EBP) would enhance quality of care, reduce risk of harm, and improve outcome of intervention. Such integration would facilitate formulation of a valid prognosis, the professional's ability to choose among possible interventions by weighing potential benefit and risk of harm, as well as greater facility with assessing efficacy of outcomes.[41] Many health professionals, educated within traditional lecture paradigms, are unsure about their ability to access, understand, and critically appraise evidence from the basic and clinical science research literature.[42] Problem-based learning can be an effective means of introducing the learner to the principles of critical appraisal, of building information-seeking and management skills, and facilitating use of an evidence-based approach to patient care, prior to students' entrance into clinical settings.

There are five essential steps in the EBP process:[40,41,43-47]

(1) Formulating an answerable clinical question; one that clearly defines the problem or issue at hand and identifies the key words or concepts to guide the search for information.
(2) Searching for and obtaining the relevant evidence necessary to answer the question. This might involved searching for information by accessing unscreened databases (e.g., Medline, Cumulative Index of Nursing or Allied Health Literature) and critical reviews found in screened resources and databases (e.g., Best-evidence ACP Journal Club, the Cochrane Library, or PEDro), and/or clinical guidelines.
(3) Critically appraising the evidence: "weighing" the validity (truth), impact (effect size), and applicability (usefulness) of the information that has been found.
(4) Integrating the appraised information with one's existing knowledge and clinical experience/expertise as well as with the concerns, characteristics, and circumstances of the patient requiring a management decision.
(5) Assessing the outcome of the process: the efficiency of the search and appraisal process, and the effect of the integrated evidence on clinical decision making.

In the PBL process the patient case and its associated issues list (Figures 3 and 4) are designed to facilitate and reinforce the student's ability to develop answerable clinical questions. Early in their professional education, students learn to identify not only the broad questions of clinical interest from a patient case, but also the foundational knowledge needed before the clinical question can be addressed. They search for evidence, using a variety of resources to help them understand normal and abnormal structure and function, disease processes and associated medical management,

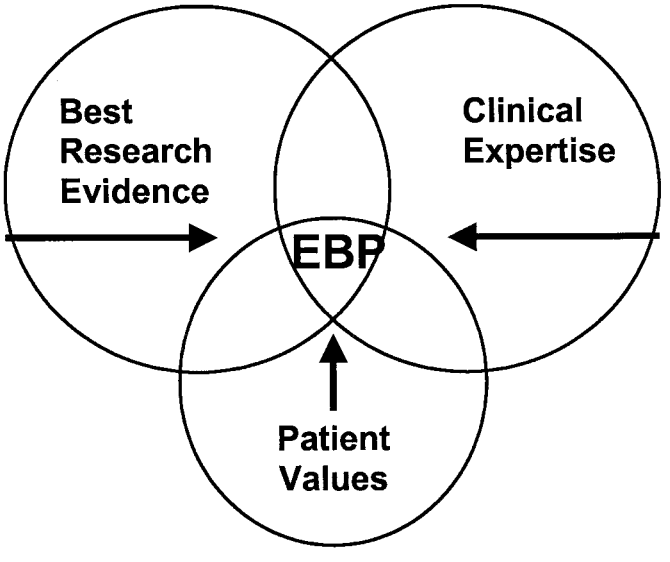

Figure 2. Evidence-based practice is the product of integration of information from three important sources: new knowledge generated from clinical research, practitioner's clinical experience and expertise, and patient values, concerns, and expectations.

Paul Miller is a 26 year-old graduate student who sustained multiple injuries in a snowmobile roll over three weeks ago. Unconscious at the scene, he was airlifted to a major trauma center. Glasgow coma scale in the ER was 7/15. Emergency splenectomy was performed on admission. Severe crush injury to distal L femur necessitated standard length transfemoral amputation. He underwent surgical open reduction/internal fixation (ORIF) of displaced compound distal tibia-fibula fracture of the right lower extremity.

He is now admitted to a comprehensive rehabilitation facility for pre-prosthetic mobility, prosthetic prescription and fitting, and prosthetic training. His cognitive function is rated at a Rancho Los Amigo's level of 7 (Automatic Appropriate). He has mild left hemiplegia with some impairment of body position sense. Volume control for his L transfemoral residual limb is being managed with compressive ace dressing. There is a ¾ inch length area of superficial dehiscence of the lateral surgical incision, which occurred when staples were removed two days ago; this area is draining moderate amounts of serosanginous fluid, and is being reinforced with steri-strip bandages. He has been fitted with a PTB fracture brace to protect his healing distal tibia-fibula fracture repair, and has been cleared for ambulation weight bearing as tolerated (WBAT) on the right with appropriate assistive device. Post-operative pain is being managed with Percocet and NSAIDs prn. He reports moderate burning and itching of his "foot" (phantom sensation) on the amputated left lower extremity which is somewhat relieved by re-applying his ace wrap. Prior to injury, Paul lived independently on the 3rd floor (walk up) of a 3-family home near his urban university. His two roommates are also graduate students working on their dissertation research. His family lives 2 hours away in a neighboring state. You are preparing for an interdisciplinary rehabilitation team meeting, where an appropriate plan of care will be developed. Based on his history, your clinical experience, and evidence from medical/rehabilitation literature, what will you recommend for Paul's plan of care?

Figure 3. Tutorial Case Example. Students read the case, underlining key words that will then be used to develop an "issues list" for further investigation.

- Head injury: rating severity (Glasgow Coma Scale), patterns of recovery (Rancho Los Amigos cognitive levels), assessing ability to learn, assessment and management of hemiplegia with perceptual impairment, cognitive rehabilitation
- Amputation: surgical technique, wound management, volume management, preprosthetic programs (strength, range of motion, mobility)
- Fracture care: surgical technique and appliances, patterns of post-operative healing, fracture brace design and use.
- Strategies for post-operative pain management
- Etiology, natural history, and management of phantom sensation
- Functional limitations: selecting and using appropriate assessments and interventions (mobility with WC, appropriate assistive device, multiple surfaces, multiple levels (stair and curb management)
- Prosthetic prescription and fitting: choosing appropriate socket design, knee unit, prosthetic foot, suspension, determining & adjusting alignment (bench, static, dynamic)
- Prosthetic training: skin care, donning/doffing, assessing suspension and fit (sock ply) when using initial/training prosthesis, gait training, endurance, functional training in complex environments
- Application of principles of motor learning to enhance rehabilitation interventions and outcomes
- Influence of cognitive impairment and perceptual impairment on prosthetic prescription and training
- Influence of the healing tib-fib fracture impact on prosthetic prescription and training?
- Psychosocial issues: Influence of Paul's living arrangements, availability of assistance and support, and interruption of his social roles and involvement in graduate school, what evidence is available to guide your planning for his eventual discharge?
- How are rehabilitation and prosthetic needs likely to change over time (prognosis)?
- How might rehabilitation be different if the etiology of amputation was disease (ex. vascular impairment and concurrent diabetic polyneuropathy) rather than trauma.

Figure 4. Issues list: The course instructor/semester coordinator prepares a comprehensive list of topics to be investigated/discussed based on learning objectives for the unit or course. Tutors use this list to facilitate students "dissection" of the case, and to insure that salient issues will be investigated. Students independently generate their own issues list after reading the case, group issues into related topic categories to facilitate their research process, and select topics they will present/report to the group in the next tutorial session. Tutors may help students shape background or foreground level answerable clinical questions as appropriate to their professional development and learning objectives for the course.

and the types of information that tests and measures might provide. As they move through the program, students ask more specific clinical questions that will help them sort through possible options for assessment, intervention, and the determination of effect. The discussion that is part of a PBL tutorial becomes an opportunity to collectively weigh evidence, to discuss decision options among possible assessments or intervention, and to begin to predict anticipated outcomes. The patient cases used in PBL are purposefully dynamic; there are multiple ways to define and/or organize the issues to be researched, many types and levels of information that might be found, variation in the quality of the selected evidence, and no single perfect "answer" to be found. In this way, the PBL case mimics the relatively ambiguous clinical environment; it helps students develop skills necessary to effectively sort through options, and to recognize that ambiguity can be best approached (but not necessarily resolved) by analysis of available evidence. The process also helps students appreciate that "evidence" does not mean "answer", but instead informs decision making among options.

In EBP, clinicians seek documented evidence to integrate with their own clinical expertise and with the patients' preferences and values (Figure 2). In exploring issues associated with patient cases, students in PBL courses seek sources of evidence to understand the "how, what, why, when, and where" of the clinical examination process (history, systems review, test and measures); diagnostic tests, measures, and imaging; options for patient management/interventions (medical and rehabilitative); and outcomes prediction/prognosis determination. They learn to consider the impact of comorbidities and psychosocial and economic factors on selection and implementation of assessments and interventions, as well as determination of prognosis. Because their learning is patient centered, students consider not only the evidence but also the perspectives and values of patients in their clinical decision-making process. The third component of EBP, clinical expertise, is gathered from faculty, from clinicians with whom the students interact, and through the students' evolving clinical experience.

The research process required in a PBL approach assists students in developing efficient strategies to access evidence. Initially, students tend to rely on a broad variety of texts and on Internet searches. As cases become more complex and issues begin to include management decisions as well as foundational information, professional journals become increasingly important tools, with students gaining skill and comfort with electronic cumulative databases such as Medline and CINAHL. Most also learn to access and assess the value of preprocessed (screened) resources, such as PEDro, Cochrane Reviews, and ACP Journal Club publications.

Through extensive exposure to published evidence of many kinds and through the PBL process, students have ongoing opportunity to develop critical appraisal skills that will serve them well once they enter clinical practice. These include recognizing the strengths and weakness of various study designs, identifying the appropriate methodology and

statistical analysis for various types of clinical questions, assessing the strength of the evidence provided in the study, and drawing independent conclusions from study results and applying those conclusions to their own patient care. They learn to consider factors such as availability, affordability, applicability, patient and professional values and preferences, as well as potential barriers, when making informed clinical decisions about patient management.

THE PBL PROCESS AT SACRED HEART UNIVERSITY

There is considerable variation in implementation of PBL strategies across health professional curricula, and sometimes across courses within a curriculum. The entry-level physical therapy plan of study at Sacred Heart University, a "modified" PBL program, provides an example of a workable implementation strategy. Discussion will begin with an overview of the logistics or structure of students' learning experience, will address faculty development needs specific to PBL, and will conclude with a discussion of strategies that are used to assess students' learning.

THE MODIFIED PBL CURRICULUM AT SACRED HEART UNIVERSITY

Each semester, students are enrolled in a central six-credit tutorial course and three three-credit supportive courses (Figure 5). The clinical cases investigated in tutorial are designed to build upon and integrate the content across all courses in a given semester's plan of study.

The tutorial course has three components: tutorial sessions (two per week), psychomotor lab sessions (two per week), and large group discussion sessions (two per week). Tutorial groups include six or seven students and a faculty or clinician "tutor"; the group is involved in three different activities during each tutorial session. The first is presentation of the information students have researched relevant to the case under consideration, followed by an integrated discussion facilitated by the tutor. The goal of this discussion is to link information from basic sciences, knowledge of pathological processes, and strategies for assessment so that students build an understanding of the processes of physical therapy diagnosis, determination of prognosis, implementation of appropriate intervention, and assessment of outcome.[28] This typically takes two thirds to three fourths of the 3-hour tutorial period.

Time	Monday		Tuesday	Wednesday	Thursday		Friday
8:00							
8:30	Tutorial Sections A, B, C	Lab Sections D, E, F	Adv. Practice Lab Sections A,B,C		Tutorial Sections A, B, C	Lab Sections D, E, F	
9:00				Advanced Practice Discussion			Professional Practice Discussion
9:30							
10:00			Tutorial Discussion				
10:30				Supportive Science Discussion			Tutorial Discussion
11:00							
11:30							
12:00							
12:30			Professional Practice Discussion				Grand Rounds: Cross-course activities and discussion
1:00	Tutorials Sections D,E,F	Lab Sections A,B,C			Tutorial Sections D,E,F	Lab Sections A,B,C	
1:30							
2:00			Adv. Practice Lab Sections D,E,,F				
2:30							
3:00							
3:30	Supportive Science Discussion						
4:00							
4:30							
5:00							

Figure 5. An example of a student schedule in the primary and supportive courses in the modified problem-based learning physical therapy curriculum at Sacred Heart University. On tutorial days (Mondays and Thursdays) students attend one tutorial and one lab session. The cases discussed in tutorial draw on information presented in the three supportive courses (supportive sciences, professional practice, and advanced practice) as well. Lab activities, also tied to the case under consideration, focus on mastery of psychomotor skills necessary for effective assessment and intervention of patients with similar pathologies, impairments, or functional limitations.

Next, students "dissect" the case to be discussed in the next tutorial session (Figure 3), and define case-related issues to be researched (Figure 4). They determine how much they currently understand about issues raised in the case, define what they need to find out, identify possible resources for the information they need, and assign responsibility for investigation of each issue they have identified. Initially, this dissection process may require 45 minutes of effort; however, as students become more adept at the process of breaking up a case into its components, the process become more efficient in both organization and time requirement.

The final component is an informal self-evaluation and peer evaluation of one of the tutorial group members. Students provide and receive constructive criticism focused on an individual's effectiveness as group member, in terms of presentation skills, creativity, effectiveness of participation in discussion and group process, and progress toward achievement of that individual's professional development goals. As students progress through the curriculum, they build their interpersonal and process skills based on cumulative feedback. The result is that the level of expectation and the effectiveness of tutorial performance rise over time.

Psychomotor lab sessions of 20 to 25 students are facilitated by the semester coordinator and a clinical laboratory instructor. During lab session, attention is focused on the students' development of psychomotor skills for assessment and intervention, especially on impairment and functional limitation, clinical reasoning and problem solving with application of diagnostic process, patient education, and outcomes assessment.[28] The large group discussion brings all students together for integrative discussion that is facilitated by the course coordinator. Ideally, the agenda for the discussion is student generated: students are charged to bring forward issues (from tutorial) that need clarification due to lack of sufficient evidence, insufficient clinical experience, or conflicting evidence. The course coordinator may occasionally use 15 to 20 minutes of discussion time as "mini-lecture" to address key content that is particularly confusing.

In the Sacred Heart University program, year I tutorial focuses on application of basic sciences, with an emphasis on functional anatomy and kinesiology in the first semester, and neuroscience in the second. Year II tutorial courses focus on clinical aspects of musculoskeletal and neuromuscular practice. Year III tutorial courses emphasize assessment and

management of cardiopulmonary and complex multisystem patient cases. Tutors meet weekly with the semester coordinator to insure consistency of learning across tutorial groups. These meetings are used to identify content issues requiring further clarification or discussion; to effectively link learning activities in tutorial, lab, and discussion; to appropriately address group process issues or problems that arise; and to provide mentoring and professional development for tutors.

The supportive courses are designed to facilitate students' development as they progress through the curriculum in three interrelated themes. The "Professional Practice" theme begins in the first semester with the history of the health care system and health professions; principles of education are covered in the second semester. In the second year, focus is on community health and service and on current issues in health care practice; career development issues are covered in the final on-campus semester. The "Supportive Sciences" theme begins with basic assessment and measurement issues, continues with research design and critical assessment of the literature, principles of normal physiology and pathophysiology (inflammation, tissue response to injury, degenerative processes, and neoplasm from a systems perspective), and exercise prescription. In year 1 of the program, the "Advanced Practice" thread provides foundation for basic physical therapy assessment and intervention (e.g., goniometry, assessing muscle performances, safe transfers, guarding, and gait training). The impact of lifespan development and the family system on patient care, and advanced practice issues in musculoskeletal and neuromuscular rehabilitation are addressed in the third, fourth, and fifth academic semesters.

FACULTY ROLES AND FACULTY DEVELOPMENT IN PBL

There are two levels of instructor involvement in the PBL process: a group of "tutors" and a course coordinator (primary instructor). Tutors serve as facilitators of group process and of clinical reasoning rather than as primary content experts; as a "guide at the side" rather than a "sage on the stage".[48] For an effective PBL process, there must be as much attention to the development of effective tutors as there is to development of the curriculum.[49] PBL requires a different set of process skills and a shift from teacher-centered to student-centered instruction; to be effective, faculty members who tutor must embrace the guide and mediator role rather than rely on the role of an authority or clinical expert.[50–52] Tutor-training strategies include a tutorial-like process to facilitate skill development for the novice tutor, beginning with a group discussion focused on philosophy of PBL, a practical "how to" component on effectively facilitating the PBL process, and follow-up with critical appraisal of one's own competence as facilitator and the changes or improvement in practice of facilitation that result.[53,54]

Three key determinants of tutor effectiveness have been identified: the tutor's understanding of the PBL process, skill in tutoring, and familiarity (not necessarily expertise) with course content as it applies to clinical practice.[55,56] In fact, tutors with significant content expertise may be more likely to dominate and direct discussion[57] while tutors with moderate content familiarity can be quite effective in helping students identify key learning issues to research, reflect clinical relevance of what is being learned, and assist students with individual and group learning-process goals[58,20]

In addition to defining course objectives and carefully constructing clinical cases with their embedded "clues", the primary instructor/coordinator serves as "manager" of the course.[20] The coordinator must insure that all tutorial groups are in sync and moving effectively toward meeting learning objectives, and must be actively involved in the mentoring, training, and development of tutors involved in the course. The coordinator evaluates students' mastery of course content as well as effectiveness during the tutorial process.

ASSESSMENT OF LEARNING

Multiple assessment strategies are used to assess an individual student's learning and involvement in tutorial. While many strategies are similar to those used in traditionally delivered curricula, written and psychomotor assessments are likely to be more consistently grounded in patient cases in PBL programs. Because student contribution to the learning process is so important, there are both formal and informal strategies to assess the quality of such contributions. In the entry-level physical therapy and occupational therapy programs at Sacred Heart University, for example, 80 percent of a student's course grade is based on mastery of content, and is 20 percent is based on assessment of effective contribution to tutorial process. In order to insure competence, students must successfully "pass" each of these components of the course.

Mastery of content is evaluated by traditional multiple choice, short answer, and structured essay exams presented in the context of a clinical case; by critical review of presentations, projects, papers, literature reviews, and case reports; and by performance on an objective structured clinical examination (OSCE) that integrates clinical reasoning and practical examination of psychomotor skills.[59,60] These assessments tend to focus on use of information in clinical context, reflecting course objectives written at the analysis, integration, and synthesis levels of Bloom's Taxonomy of Learning.[60,61]

Each student's contribution and effectiveness as a member of a tutorial group are assessed by routinely occurring informal and formal self-, peer-, and tutor assessments.[20,60] These evaluations consider tutorial skills and affective domain (communication skills, ability to effectively collaborate, respect for peers, development of self-appraisal skills, and ability to define appropriate goals for self and group) rather than mastery of course content.[62] Informal feedback is provided to one of the members of the group after every tutorial session; in this way students are able to track progression toward the learning or behavioral goals they set for themselves at the beginning of the semester. Formal written feedback (Figure 6) occurs at midterm and semester end. Students, initially

Behavioral Criterion	Rating: Never	Rarely	Sometimes	Often	Always
1. Effectively organizes own material with appropriate breadth and depth of preparation Comments:	0	1	2	3	4
2. Communicates own researched material to facilitate problem-based learning. Comments:	0	1	2	3	4
3. Contributes to discussion in a way that demonstrates preparation across topics. Comments:	0	1	2	3	4
4. Synthesizes group information to facilitate problem-based learning (e.g. poses appropriate questions, ties together information, raises new or unresolved issues). Comments:	0	1	2	3	4
5. Remains appropriately focused on group discussion and process. Comments:	0	1	2	3	4
6. Expresses own thoughts and questions to the group. Comments:	0	1	2	3	4
7. Apropriately challenges opinions of and material presented by others based on one's own knowledge or understanding of the topic. Comments:	0	1	2	3	4
8. Provides support and encouragement to other group members (outside of peer evaluation) Comments:	0	1	2	3	4
9. Responds appropriatey to feedback from others. Comments:	0	1	2	3	4
10. Interacts in a respectful and constructive manner with others, including peer evaluations. Comments:	0	1	2	3	4
11. Makes a complementary contribution to group process. Comments:	0	1	2	3	4

Figure 6. Formal peer- and self-assessment of the tutorial participation process: Students complete a self-evaluation as well as evaluation of two peer-members of the group. Tutors provide a summary evaluation, incorporating the peer and self-assessments as well as observation of an individual's effectiveness during group process. Evaluations are completed at midterm and at the end of the semester. The course instructor/semester coordinator uses these ratings to determine 20% of students' grade for the course.

anxious and uneasy with this evaluation process, come to value the frequent targeted feedback it affords them.[63]

EVIDENCE OF EFFECTIVENESS OF THE PBL APPROACH

The variation in implementation of PBL across programs and settings has made it somewhat challenging to assess the long-term efficacy of the PBL approach, as compared to traditional approaches in health professional education.[64] Many of the studies reported in the literature are descriptive; the extent to which PBL is used in the curriculum is not always clearly described, and there are relatively few controlled clinical trials of PBL as an educational intervention. Additionally, while PBL is designed to provide the foundation for lifelong learning and evidence-based practice, its efficacy in the clinical environment (postgraduation) is influenced by reinforcing factors, including:[65,34]

(1) the degree to which the clinical environment is supportive of skills and learning techniques mastered in PBL (use of PBL principles via rounds, case reports, professional journal club, or study groups as expectation of practice setting), and

(2) the type of feedback and extent of reinforcement received by the learner about the importance of continued self-directed, lifelong learning.

Because learning styles are malleable, constraints within the practice environment (such as limited time due to workload demands, reliance on practice traditions, and resistance to change) may forestall or limit continued used of PBL and EBP principles.[66]

Despite these limitations, the evidence suggests that a PBL approach is at least as effective as traditional lecture-based curriculum in preparing students for clinical practice.[37,67,68] One of the strengths of a problem-based approach is its attention to principles of adult learning, and its very deliberate integrated curricular design. Because PBL emphasizes the learning process as well as mastery of course content, students enrolled in a PBL curriculum encounter a different set of demands as learners. To be successful, they must develop effective communication (teaching and listening) skills, learn to collaborate rather than compete, build effective information-seeking and critical appraisal skills, as well as develop effective self-assessment and peer-assessment skills.[69]

When compared to students enrolled in traditional or conventional entry-level health professional programs, PBL students tend to use more textbooks, journal articles, and informal discussion with faculty and classmates as resources.[70,71] They are likely to use more library and online resources in addition to the instructor's lecture notes, course syllabi, and class notes typically used by students in traditional programs.[70,71] PBL students are more likely to study for understanding than for recall; they tend to analyze what they need to know for a given situation and organize their studying accordingly.[72] When compared to traditionally prepared peers, graduates of PBL programs tend to report greater mastery and more effective preparation for independent learning, problem solving, self- and peer evaluation, information gathering, communication and listening skills, effectively addressing social and emotional issues of their patients, working collaboratively, and managing meetings.[73,12–14] PBL appears to provide students an academically equivalent but more enjoyable and richer learning experience.[73,74]

CHALLENGES AND CRITICISMS OF PBL

The problem-based learning approach is not without its own issues and problems. Students new to the PBL process express frustration and concern about differences in approach across tutorial groups, have difficulty determining the appropriate depth and breadth of their preparation, and are anxious about whether they have mastered content enough to pass exams.[20] Having been socialized to be competitive in their high school and college preparation for professional school and to believe it is the instructor's responsibility to "tell them" what they need to know, students are initially uneasy about trusting peers to contribute effectively to their learning. The development of effective communication skills is itself a cumulative process; early in the PBL process, mastery and integration of new information into students' knowledge base is influenced, to some degree, by their evolving communication efficacy.[75,20] Early student presentations, before group process develops enough for effective collaborative learning, may be "mini-lectures" rather than means toward integrative discussion.[76] Students new to the PBL process may be reluctant to provide constructive criticism to their peers, and to honestly share their own critical self-appraisal with tutors and peers. Many are anxious about the inevitable conflicts or stresses that arise from group process, and must develop the appropriate affective and interpersonal skills to manage group process.[77] As tutorial skills develop, however, students become increasingly comfortable and adept as self-directed, problem-based learners.[78]

Problem-based learning can be a time intensive process, both for students and faculty. Tutorials typically meet for two 2- to 3-hour sessions per week. Students, especially those new to the PBL process, spend a great deal of time seeking information and preparing for their tutorial presentations. They are uneasy when information from key resources is ambiguous or conflicting. Over time, however, students become adept and efficient at information seeking and appraisal, and learn to tolerate the ambiguity of no established endpoint to an information search and no single "right" solution to a question. Students enrolled in a completely integrated or modified PBL curriculum are typically much more frustrated and concerned about whether they are actually mastering content early in the curriculum, but express great satisfaction with tutorial process as the academic program nears completion.[35,20] Students who are concurrently enrolled in a PBL course and several traditionally delivered courses express frustration with significant difference in expectations for their participation and study strategies across courses.

For the course coordinator, the time commitment is different than that in conducting a traditional course. Rather than spending time preparing formal lectures over the semester, the biggest investment of time is in planning the course, including embedding course objectives into the preplanned cases in a way that will provoke attainment of all objectives during interactive learning experiences. The course coordinator manages the course through the weekly semester coordination meeting with tutors to insure equitable progression of learning across tutorials. One of the major criticisms of the PBL approach is the need for multiple tutors for a single course. It may be far less "efficient", in terms of time utilization, to have multiple tutorial groups of seven students investing 6+ hours a week for what might be "delivered" in a traditional instructor-focused lecture to the entire group in half that time. This inefficiency is often effectively offset by the unique advantages of the PBL process, including the intensity of interaction with students, and the energy that their growing joy in discovery produces.

CONCLUSION

A problem-based learning approach to entry-level health professional education can effectively facilitate a student's development of the critical appraisal and integrative thinking skills necessary for effective evidence-based practice. The goals and methodology of PBL and EBP are so similar that they are likely to translate from the classroom to the clinical setting relatively seamlessly. Students enrolled in PBL programs become quite adept at formulation of relevant clinical questions, at finding information from a variety of resources, at appraising the quality and relevance of the information as it relates to the clinical problem of interest, and in fitting this new information into their expanding knowledge framework. As students move through the curriculum, the problem-based approach helps them make informed choices about options for individual patients by encouraging them to consider possible benefits and tradeoffs among assessment and intervention strategies. This is, in essence, the foundation for an evidence-based clinical practice.

While PBL has the potential to have a tremendous positive impact on professional education, its adoption as a teaching and learning strategy must be considered in light of the time and resource demands that are part of the PBL paradigm. At this point in time, the PBL approach appears to be at least as effective as traditional programs in helping students build the knowledge base necessary for their discipline's clinical practice. While the evidence that PBL improves students learning as compared to traditional curricula is not strong, there is evidence that positive outcomes of PBL include enjoyment and excitement about the learning process. There is growing evidence that students graduating from PBL programs are more comfortable seeking and using information. Certainly, future research efforts will help us better understand the impact of PBL on students' transition to clinical practice and on lifelong learning. It is interesting to consider whether the efficacy of PBL as methodology for learning may be masked by difficulty in measuring particular outcomes, such as effective and efficient problem solving, more flexible decision making, or the ability to effectively collaborate or work efficiently in teams. These skills, when combined with the ability to critically appraise evidence from clinical research and to

integrate such evidence with clinical expertise and patient values, provide a firm foundation for effective clinical practice.

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