

# Formative and Summative Assessment of the Problem-Based Learning Tutorial Session Using a Criterion-Referenced System

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## ABSTRACT

Many medical schools have moved towards problem-based learning (PBL). Unfortunately, the use of PBL in many medical schools has not been followed with appropriate changes in evaluation of students. Assessment of PBL needs to focus on the objectives that PBL fosters in conjunction with the educational course objectives. In an effort to appropriately assess PBL sessions, The School of Medicine Tec de Monterrey uses a criterion-based system that includes three checklists: 1) tutor assessment of students, 2) self-assessment, and 3) peer-assessment. Each checklist contains criteria that correspond to the four objectives (rubrics) of PBL: knowledge application, critical thinking, self-directed study and collaboration, and a fifth rubric for professionalism and attitude during the discussion. Course objectives are integrated within each of the rubrics. The three checklists are used for summative and formative purposes in all PBL core courses of the Basic Medical Sciences department and for the Gynecology PBL core clinical course. Although no quantifiable data have been obtained, the use of this criterion-based system has helped establish appropriate standards of performance. Additionally, it has assisted in identifying those students who are having trouble developing critical thinking and decision-making skills and has greatly fostered feedback to students. If PBL assessment is consistent with curricular goals and course learning objectives, validity of assessment is enhanced and subjectivity across instructors' evaluations can be diminished.

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## INTRODUCTION

Great strides in curricular reform have been introduced into many medical schools since the presentation of the SPICES model by Harden.<sup>1, 2</sup> This model promotes a Student centered, Problem-based, Integrated, Community-oriented curriculum with Elective modules and a Systematic approach to learning, hence the acronym "SPICES". The School of Medicine Tec de Monterrey has developed a competency-based, integrated, spiral curriculum in which PBL is the predominant teaching-learning strategy.

Because of the logarithmic growth of medical information, medical students cannot reasonably be expected to master it all. Medical educators struggle with curricular overload while striving to foster application of students' knowledge and facilitate their independent and critical thinking skills. Meanwhile, medical students have to concentrate on the relevance of basic science to medicine, how to identify and solve clinical problems, and develop the behavior of lifelong learning. PBL is a pedagogic approach designed to achieve these diverse educator/student goals.<sup>3</sup>

Published studies have reported that PBL has four main objectives: 1) to apply a base of knowledge, 2) to develop clinical reasoning and judgment and decision making skills, 3) to foster self-directed learning and 4) to promote collaborative work.<sup>3, 4, 5, 6, 7, 8, 9, 10</sup> Tutorial sessions play the major role in the attainment of these objectives. Guided by the tutor (teacher) and through collaboration among them, students establish the learning objectives for each problem and then commit to independent study. During small group discussion they then apply their self-acquired knowledge to the patient's problem and use their clinical reasoning and decision-making skills to solve it and attain the learning objectives.

A model for a problem-based small group process includes:<sup>11</sup> 1) presentation of the learning scenario (problem), 2) definition of unfamiliar language or concepts, 3) brainstorm (comments) by students about issues that come to mind regarding the scenario, 4) identification of key areas for potential learning and organization of these within a logical, conceptual framework, 6) development of a learning plan with specific questions that ensures that all group members understand and subscribe to the learning

plan, 7) self-study (independent study) centered around the pre-established learning plan, 8) discussion of the problem centered around the learning plan and 9) evaluation of the learning experience of the particular session.

Not only are the learning method and the intent of its outcomes important, but also the evaluation of their achievement. Commonly, assessment of PBL tutorials focuses on the process only; the way students go through the process of the strategy and acquire self-study and thinking skills. One of the important principles of assessment is to match the assessment method to the learning mode, developmental level, subject matter and program outcomes.<sup>12</sup> Thus, assessment of tutorials should also include the knowledge that is being progressively attained. PBL assessment then, must consider student achievement of the objectives sought by the course and those promoted by PBL. Such assessment must be an integral part of the teaching-learning process; it should be continuous and not just take part at the end of it, and it should be both, summative and formative. Formative assessment is a part of the developmental or ongoing teaching-learning process. It includes delivery of feedback to the student, with the aim of improving teaching, learning and the curriculum. Summative assessment occurs at the end of a term or course and is used primarily to provide information about how much the student has learned and how well the course was taught.<sup>13</sup>

Because both the course objectives and those promoted by PBL are fostered and achieved during the tutorial sessions where there is an opportunity of ongoing assessment, a need of an assessment tool that focuses on the continuous attainment of both, the course and PBL objectives was identified. This was particularly important at the School of Medicine Tec de Monterrey where new faculty members were participating in PBL courses. Assessment standardization of the tutorial sessions was needed so that teachers knew exactly what to expect from students and vice versa.

The primary objective of this report was to present a criterion-based system that combines specific course objectives with those inherent to PBL. This system described herein is flexible enough to be adapted and used in any type of basic or clinical science PBL course.

## **MATERIALS AND METHODS**

Achieving a valid formative and summative assessment requires identification of criteria for each PBL objective. The four main PBL objectives were described as “rubrics”. In this report pre-established objectives for the Nutrition and Metabolism PBL core basic science course were considered. Specific criteria for each of the four objectives-rubrics were defined by the author and integrated with the course objectives. A fifth rubric with criteria was added, professional behavior, being an outcome emphasized in all courses of the curriculum. A numeric scale, ranging from one (not developed) to six (very well-developed) was used

for each criterion as well as a summative scale to integrate criteria within each rubric (Tables 1, 2 and 4). Three final checklists were developed: 1) an electronic checklist to assess daily student achievement, performed by the tutor (Table 1), 2) a self-assessment checklist (Tables 2 and 3) and 3) a peer-assessment checklist (Table 4).

### **Student assessment performed by the tutor (faculty member)**

Tutorial sessions of seven to nine students ran three times a week for two hours, every other day, for a total of 11 tutorials per monthly rotation in the four-month course. The scale for each criterion ranged from one (not developed) to six (very well-developed). Every criterion was not assessed daily; criteria that were considered for each tutorial session depended on the objectives to be covered in that particular session, which were defined during the previous session, and they also depended on the PBL step the group of students was working on. In each tutorial session the tutor of the course assigned each student one grade that ranged from one to six, for each of the five rubrics. The tutor added the total score for each rubric, giving a maximum of 30 points per tutorial session (six points per rubric). At the end of the month, the tutor summed the score obtained by each student for every tutorial. Tutor assessment of students had both, formative and summative value. A detailed description of the assessment system, including the three checklists, was provided to the students the first day of the course.

As set by departmental guidelines, daily assessment by the tutor had a summative value of 30% of the final monthly grade; 10% corresponded to assignments and 60% to the written monthly exam. An electronic format used to facilitate the tutor’s work is shown in Table 5. Once daily grades were entered, formulas calculated monthly grades. The tutor also used the daily assessment to give continuous feedback to students. At the end of the monthly rotation, the tutor assessed performance of the roles taken by each student during the tutorials (ie. leader, secretary and participant). Role assessment served a formative purpose to improve student performance in future tutorials, but had no summative value.

### **Self-assessment**

Self-assessment took place at the end of each monthly rotation, using the rubrics and criteria shown in Tables 2 and 3. Self-assessment was a formative way to get students to reflect on their abilities, performance and attitudes, but had no summative value.

### **Peer-assessment**

Peer-assessment took place at the end of each monthly rotation, using the rubrics and criteria shown in Table 4 (peer-assessment format). Each student handed over this written peer-assessment format to each one of his peers. Peer-assessment also took place in an open session, at the end of the rotation, in which each student gave oral feedback to every other student and to the teacher. Peer-assessment had no summative value; it fostered reflection by students on how their classmates assessed their performance.

**Table 1.** Criteria to Assess Students' Daily Participation in PBL Tutorials Performed by the Tutor

<b>Application of Knowledge Base</b>	<b>1: Not Developed - 6: Very well developed</b>					
Shows evidence of thorough reading of documented sources about...*	1	2	3	4	5	6
Shows breadth and depth of knowledge about the problem ...	1	2	3	4	5	6
Answers questions or shares his/her opinions about... without reading notes/books.	1	2	3	4	5	6
Applies acquired knowledge about.... to the problem.	1	2	3	4	5	6
<b>Clinical Reasoning and Decision Making skills</b>						
Discriminates important information of the problem from that which is not.	1	2	3	4	5	6
Lists the patient's problems...	1	2	3	4	5	6
Prioritizes the patient's problems...	1	2	3	4	5	6
Interprets (gives meaning) to the information given in the problem.....	1	2	3	4	5	6
Is able to support his clinical reasoning and decision making with evidence about...	1	2	3	4	5	6
Shows evidence and critical understanding of facts about...	1	2	3	4	5	6
Shows ability to generate diagnostic hypothesis about...	1	2	3	4	5	6
Is capable of making decisions regarding the diagnostic approach to the patient...	1	2	3	4	5	6
Is capable of making decisions regarding the therapeutic approach to the patient...	1	2	3	4	5	6
Shows ability to generate alternative diagnostic hypothesis according to new information given.	1	2	3	4	5	6
Shows evidence of following a sequential management of the patient's problems...	1	2	3	4	5	6
Is able at formulating conclusions about the problem...	1	2	3	4	5	6
<b>Self- Directed Learning (Self-study)</b>						
Defines learning objectives...	1	2	3	4	5	6
Shows evidence of accomplishment of learning objectives...	1	2	3	4	5	6
Shows evidence of reading diverse and recent bibliographic sources about...	1	2	3	4	5	6
Makes efforts to improve.	1	2	3	4	5	6
If necessary, seeks counseling to orient his/her study...	1	2	3	4	5	6
Drives him/herself to the limits of his/her knowledge and abilities.	1	2	3	4	5	6
Identifies his/her opportunity areas.	1	2	3	4	5	6
Establishes learning goals and defines a concrete action plan to meet learning needs about...	1	2	3	4	5	6
<b>Collaborative Work</b>						
Works towards achievement of the group's learning goals...	1	2	3	4	5	6
Shows effective interpersonal abilities.	1	2	3	4	5	6
Is interested in participating in daily discussion about...	1	2	3	4	5	6
Shares bibliographic sources with classmates about...	1	2	3	4	5	6
Respects classmates' opinions.	1	2	3	4	5	6
Helps classmates who lag behind.	1	2	3	4	5	6
Gives feedback in a constructive and fraternal way.	1	2	3	4	5	6
Works as hard as the rest of his teammates.	1	2	3	4	5	6
<b>Attitude during discussion and Professionalism</b>						
Accepts feedback with openness	1	2	3	4	5	6
Reacts positively to feedback and criticism	1	2	3	4	5	6
Manages his/her impulsiveness adequately.	1	2	3	4	5	6
Stands up for his/her points of view...	1	2	3	4	5	6
Makes an effort to adequate his/her behavior to circumstances	1	2	3	4	5	6
Shows ability to change his/her point of view in light of new information given or obtained.....	1	2	3	4	5	6
Attended every class and arrived on time	1	2	3	4	5	6
Shows responsibility and commitment	1	2	3	4	5	6
Is honest.	1	2	3	4	5	6
His/her appearance and clothing correspond with that of a medical professional.	1	2	3	4	5	6

\* ... = specific objectives of the course, of the class or of the problem are incorporated here.

**RESULTS**

This paper describes a criterion-referenced system using Tables 1-4. It was first used one and a half years ago for the Nutrition and Metabolism course. With the intent to standardize the assessment system at the school, as stated by the Assessment Committee, it has been incorporated into

each of the four PBL core courses of the Basic Medical Science Department, and has been adapted by the course directors for the Gynecology and Obstetrics core PBL clinical course to increase objectivity of tutorial assessment. Although no quantifiable data to assess the checklists have been obtained, through oral feedback received,

**Table 2.** Criteria for self-assessment

<b>Application of Knowledge Base</b>	<b>1: Not Developed - 6: Very well developed</b>					
I am able to obtain adequate information about the problem...*	1	2	3	4	5	6
I comprehend the physiology and pathogenesis of ...	1	2	3	4	5	6
I am good at recognizing and interpreting the signs and symptoms of ...	1	2	3	4	5	6
I understand the cost/benefit ratio of the diagnostic tests for ...	1	2	3	4	5	6
I am able to interpret (give meaning) the diagnostic tests for patients with...	1	2	3	4	5	6
I understand the rational basis for the treatment of patients with ...	1	2	3	4	5	6
I am aware of the impact in the morbidity/mortality ratio caused by...	1	2	3	4	5	6
I am capable of applying preventive measures for patients with...	1	2	3	4	5	6
<b>Clinical Reasoning and Decision-Making skills</b>						
I am able to identify the useful information in the problem...	1	2	3	4	5	6
I am able to list the patient's problems.	1	2	3	4	5	6
I am able to prioritize the patient's problems.	1	2	3	4	5	6
I am able to interpret (give significance) the information given in the problem.	1	2	3	4	5	6
I am able to support my clinical reasoning and decision making with evidence about...	1	2	3	4	5	6
I showed evidence and understanding of critical facts about...	1	2	3	4	5	6
I was able to formulate diagnostic hypothesis with fundamentals about...	1	2	3	4	5	6
I made decisions related to the diagnostic approach to the patient.	1	2	3	4	5	6
I made decisions related to the therapeutic approach to the patient.	1	2	3	4	5	6
I showed ability to formulate alternative diagnostic approaches according to new information presented.	1	2	3	4	5	6
I was able to prepare a follow-up management plan for the patient's problems...	1	2	3	4	5	6
I was able to formulate conclusions about the problem...	1	2	3	4	5	6
<b>Self-Directed Learning</b>						
I set learning objectives...	1	2	3	4	5	6
I showed evidence of accomplishment of the learning objectives...	1	2	3	4	5	6
I showed evidence of reading diverse and recent bibliographic sources about...	1	2	3	4	5	6
I made efforts to improve.	1	2	3	4	5	6
If necessary, I asked for counseling to orient my study about...	1	2	3	4	5	6
I pushed myself to the limits of my knowledge and abilities.	1	2	3	4	5	6
I identified my areas of opportunity for improvement.	1	2	3	4	5	6
I set goals and established a concrete action plan to achieve my learning needs about...	1	2	3	4	5	6
<b>Collaborative work</b>						
I worked towards the attainment of the team's learning objectives...	1	2	3	4	5	6
I showed effective interpersonal skills.	1	2	3	4	5	6
I was always eager to participate in discussions.	1	2	3	4	5	6
I shared bibliographic sources with my classmates	1	2	3	4	5	6
I participated in all group activities	1	2	3	4	5	6
I attended on time every team meeting and fulfilled my assignments	1	2	3	4	5	6
I showed responsibility and commitment in all the team's tasks	1	2	3	4	5	6
I respected other people's opinion.	1	2	3	4	5	6
I helped classmates who lagged behind.	1	2	3	4	5	6
I offered feedback to my classmates in a constructive, friendly way.	1	2	3	4	5	6
I worked as hard as the rest of the group.	1	2	3	4	5	6
<b>Attitude during discussion / Professionalism</b>						
I was able to discuss a topic and stand up for my point of view about...	1	2	3	4	5	6
I attended every class and arrived on time.	1	2	3	4	5	6
I studied and prepared for every class.	1	2	3	4	5	6
I did my best effort in each class and assignment...	1	2	3	4	5	6
I was always eager to participate in the tutorial discussion...	1	2	3	4	5	6
I handed my work on time.	1	2	3	4	5	6
I showed responsibility and commitment in all the assigned tasks...	1	2	3	4	5	6
I was open to criticism and reacted favorably	1	2	3	4	5	6
I used feedback to improve my attitudes.	1	2	3	4	5	6
I am able to identify my strength and opportunity areas...	1	2	3	4	5	6
My appearance and clothing correspond with that of a medical professional.	1	2	3	4	5	6

\* ... = specific objectives of the course, of the class or of the problem are incorporated here.

**Table 3.** Marking Scale for Student Self-assessment

<b>Knowledge Base</b>	
More than 45 points:	excellent
Between 39 and 44 points:	good
Between 32 and 38 points	fair
Less than 32 points:	poor
<b>Clinical Reasoning and Decision Making Skills</b>	
More than 45 points:	excellent
Between 39 and 44 points:	good
Between 32 and 38 points	fair
Less than 32 points:	poor
<b>Self-Directed Learning</b>	
More than 45 points:	excellent
Between 39 and 44 points:	good
Between 32 and 38 points	fair
Less than 32 points:	poor
<b>Collaborative work</b>	
More than 45 points:	excellent
Between 39 and 44 points:	good
Between 32 and 38 points	fair
Less than 32 points:	poor
<b>Attitudes and Professionalism</b>	
More than 45 points:	excellent
Between 39 and 44 points:	good
Between 32 and 38 points	fair
Less than 32 points:	poor

it has been perceived that teachers' and students' opinions have been positive. This checklist system has established objective standards for both teachers and students. Teachers know what to expect and students know the performance standard.

It has especially helped new faculty who have just begun teaching in a PBL course. Rubrics and criteria let them know exactly what to expect from students during a tutorial. Before its use, many teachers awarded all students with the maximum number of points that each tutorial session was worth. Teachers now assigned students a daily grade, which according to oral feedback from students, has been more fair. Feedback to students has been enhanced since the use of this checklist system; individual and group feedback has been fostered.

During individual meetings with teachers, they reported an increase in student participation. Presumably, this was because students knew what was expected from them. Moreover, teachers indicated that students' participation was more directed towards knowledge sharing and decision making skills. Additionally, it helped standardize PBL tutorial assessment across the basic medical science department and has since been adapted for one clinical rotation PBL course.

**Table 4.** Criteria for peer-assessment

<b>Attitudes: My classmate</b>	<b>1: Not Developed - 6: Very well developed</b>					
Was able to discuss a topic and stand up for his/her point of view...*	1	2	3	4	5	6
Attended every class and arrived on time.	1	2	3	4	5	6
Studied and prepared for every class...	1	2	3	4	5	6
Did his/her best effort in each class and assignment. ...	1	2	3	4	5	6
Was always eager to participate in discussion...	1	2	3	4	5	6
Was open to criticism and accepted feedback openly.	1	2	3	4	5	6
Used feedback to improve his/her attitudes.	1	2	3	4	5	6
Participated actively in the tutorials.	1	2	3	4	5	6
Shared important and valuable information with the group.	1	2	3	4	5	6
Showed responsibility and commitment	1	2	3	4	5	6
<b>Collaborative Work Attitudes: My classmate.....</b>						
Handed work in on time...	1	2	3	4	5	6
Attended every group meeting and arrived on time.	1	2	3	4	5	6
Worked as hard as the rest of the group.	1	2	3	4	5	6
Helped classmates who lagged behind.	1	2	3	4	5	6
Worked towards achievement of the group's learning objectives...	1	2	3	4	5	6
Listened to classmates.	1	2	3	4	5	6
Respected other people's opinions.	1	2	3	4	5	6
Showed responsibility and commitment in all the team's tasks.	1	2	3	4	5	6
Offered feedback to his/her classmates in a constructive and friendly way.	1	2	3	4	5	6

\* ... = specific objectives of the course, of the class or of the problem are incorporated here.

By assessing knowledge base, critical thinking and decision making skills, self-study, collaborative work and professional attitudes, through this criterion-based system we observed four main groups of students: 1) those who studied much and strived to make an effort, but who had underdeveloped critical thinking and decision making skills, 2) students who did not study much but had developed critical thinking and decision-making abilities, 3) those very few with personal attitudes and or collaboration problems and 4) those students that studied much, had developed critical thinking and decision making skills and had good attitudes.

**DISCUSSION AND CONCLUSIONS**

Critical thinking and a scientific approach to problem-solving are imperative not only for research scientists, but also for physicians.<sup>3</sup> Life long skills such as self-directed learning and collaboration with other health care professionals are also necessary attributes of practicing physicians. These skills are incorporated into medical



objectives are included in the criterion-based assessment tool presented (i.e. tutor assessment of students, self-assessment and peer-assessment). Self and peer review are learning experiences, in and of themselves. They promote the development of reflective skills that are required for self-directed, life-long learning of prospective physicians. The checklists described herein, are tools to assess attainment of acceptable standards of performance during PBL tutorials.

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