

## Problem Based Learning and its Impact on Learning Behavior of Pharmacy Students in RAK Medical and Health Sciences University

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### Abstract

The study was conducted for a period of two semesters on a cohort group of pharmacy students in five courses. The main objective of the study was to assess the impact of Problem Based Learning (PBL) on the learning behavior, especially Knowledge, Skill and Attitude of the students, who entered the university after 12 years of schooling. It was a prospective study involving about 40 students of 10 nationalities with varying social, cultural, ethnic, religious and racial background. The performance within the cohort group and between the two cohort group of students and the assessment of facilitators who were faculty members with varying teaching experience, qualification and nationalities were compared. Standard, validated questionnaires were used for the assessments by students and facilitators. The data was subjected to statistical studies with t-test and chi square test to find out the significance. Bar charts were used to represent the data for easy understanding and comparison. Pre and post tests were administered in each course using Multiple Choice Questions (MCQ) and Restricted Response Essay (RRE), to assess the improvement in the overall knowledge in each course PBL in a specific content area.

The study showed positive impact of PBL on the learning behavior – Knowledge, Skill and Attitude (KSA) of students. Baseline and end PBL assessment by facilitators showed improvement in student's K, S and A. Pre and post test on the PBL topics showed significant improvement in the students content knowledge.

### INTRODUCTION

Problem-based learning (PBL) was first implemented in a medical education curriculum by Toronto's McMaster University in the late 1960s. Numerous definitions of problem-based learning are available. Both Albanese and Anderson-Harper provide excellent reviews of PBL and PBL in pharmacy education respectively.<sup>1,2</sup>

Problem based learning is an innovative instruction strategy, which is student centered and not teacher oriented like classroom teaching. Many argue that PBL is a powerful and engaging learning strategy that leads to sustained and transferable learning.<sup>3-5</sup> PBL fosters the development of self directed learning strategies and make it easier for students to retain knowledge and apply knowledge and solution strategies to new and unfamiliar situations.<sup>6-8</sup> PBL deviates from conventional instructional mode by restructuring traditional teacher/student interactions toward active, self directed learning by the student.<sup>9-11</sup> In PBL, teachers coach

students with suggestions for further study or inquiry but don't assign predetermined learning activities. Research has revealed that human and individual learning approaches and knowledge construction are related to personal experience and pre-learned knowledge.<sup>12</sup> When a new concept is introduced, student has her/his unique way of adding this new idea into their original concept scheme and thus everyone can be said to learn in a different way. Recent research concluded that traditional teacher-centered learning models are more likely to result in surface level learning. Additionally, research indicates that higher quality learning is more likely to come from a more student-centered approach to study.<sup>12</sup>

Problem-based learning has been increasingly used in pharmacy education. PBL serves to enhance skills, such as critical thinking and problem-solving.<sup>13</sup> Students should require developing a problem solving strategy, to acquire new knowledge and to make judgments, approximations and deal with omitted/excess information.<sup>14</sup> In recent years PBL has been successfully applied in analytical chemistry. A comprehensive PBL approach to the third year of analytical chemistry course

was carried at Hunan University of china 2003<sup>15,16</sup>. PBL also helps to activate and elaborate prior knowledge<sup>17</sup>. PBL students are highly motivated better problem-solvers and more self-directed learners than traditional curriculum<sup>6</sup>. When assessing the effectiveness of PBL, it is important to consider both the design of the curriculum and the extent to which the instructor had been trained in the content area and delivery of PBL. It will decide the effectiveness of PBL.

A study showed that PBL was an appropriate teaching method for the introductory pharmacotherapy laboratories at the College of Pharmacy at the University of Texas at Austin. The most significant changes in learning-style scores, the increases in “avoidant” and decreases in “participant” learning-style scores, may have been a reflection of the difficulty in adapting to the change in learning style from didactic to PBL as well as problems adapting to working in a group<sup>18</sup>.

An approach to using problem-based learning in the *Medicinal Chemistry* course sequence seems to work as evidenced by positive feedback from course, instructor, and LEARN team evaluations. While this approach to problem-based learning is not “pure” PBL, it appears to be a viable method of active learning our student population. We believe that this method provides both the content and higher-order concepts we desire to instill in our students. We are currently investigating the student-learning outcomes of the current format of course delivery<sup>19</sup>.

A study focuses on the way students approach solving problem scenarios in class, and using professional pharmacy databases on-line. Qualitative variations in student approaches to solving problem scenarios in both learning situations are identified. These turn out to be associated with qualitatively different conceptions of PBL and also with levels of achievement. Conceptions and approaches that emphasize learning for understanding correlate with attaining higher course marks. The outcomes of the study reinforce arguments that we need to know more about how students interpret the requirements of study in a PBL context if we are to unravel the complex web of influences upon study activities, academic achievement and longer-term professional competence. Such knowledge is crucial to any theoretical model of PBL and has direct practical

implications for the design of learning tasks and the induction of students into a PBL environment<sup>20</sup>.

Students were required to work in groups and to acquire other skills and knowledge not taught in the classroom. Formal decision theory was used in designing and obtaining the assessment criteria for evaluating the outcomes of PBL. The method invited students to participate in the evaluation process, creating a non-threatening environment for learning and providing a fair method of assessment. Their approaches to learning have been analysed using the Study Process Questionnaire (SPQ).

RAKMHS University adopted PBL since its inception in 2006-07 for medical, pharmacy, nursing and dental students. First batch of pharmacy students were introduced to the PBL in their 2<sup>nd</sup> semester in 2008, after completing general education courses in 1<sup>st</sup> semester. Every course has a PBL component in all the subsequent semesters.

In present study an attempt is made to investigate the impact of PBL on the learning behavior of pharmacy students.

#### **METHODOLOGY AND IMPLEMENTATION OF PBL**

Students and faculty (facilitators) were oriented separately towards PBL. The important responsibilities of students and facilitators were highlighted in addition to objectives of PBL, process of PBL and assessment. Mock PBL session with a topic was conducted in order to get the actual experience of PBL session and assessment.

PBL sessions were conducted in the PBL rooms/class room and the students were divided into groups consisting of 6-8 members, randomly chosen. A facilitator was assigned to each group who supervised and assessed the students performance. There were 3 sessions in each PBL of a course. Each session lasted for 2 hours and the timeslots were indicated in the semester time-table. There was a gap of 2 to 3 days between the sessions in order to complete library, self study and preparation sessions for the PBL participants. The PBL topics were announced to the students in advance at the beginning of the semester.

The 7 steps approach was adopted while conducting the PBL sessions. The first session was used for brainstorming, identification of variables (issues)

hypothesis and listing of Student Centered Learning Objectives (SCLO). Facilitators were silent spectators intervening whenever necessary to involve the mild and to control the dominating student and to keep the PBL on meaningful track. The facilitators assured that the SCLO matched with the author generated objectives (Table 1 & 2). Few book and other references were recommended to the students in order to read and solve the problem. The second session was meant for discussion on the PBL topic with the objectives, sharing the notes, learning from each other and team based working with group norms. Students were encouraged to share books and other references used by them. Students discussed various aspects of the problem with sharing and caring attitude. The third session was meant for formal presentation by each student to the group. Selected students from each group or all students made podium presentation to the whole class. This helped the students to share the information with all the students. Self, Peer Facilitator assessment was done at the end of 3<sup>rd</sup> session with standard questionnaire.

In order to assess the prior knowledge of the students on the PBL topic pre test was conducted for each course before commencement of 1<sup>st</sup> session. Pre test included 5 Restricted Response Essays (RRE) and lasted for 15 minutes. Post test was conducted at the end of 3<sup>rd</sup> PBL session. It included 10 Multiple Choice Questions (MCQ). The pre test and post test performance and feedback was given to students by the course faculty.

A standard questionnaires containing 12 questions on knowledge, skill and attitude were administered at baseline & at end of PBL (Table 3). Students self and peer assessment was carried out by using a standard questionnaires with twelve questions (Table 4), four questions for each of knowledge, skills and attitude. Knowledge criteria covered student's suggestions for learning, ideas, comments and asking questions and information. Skill criteria involved student participation in group working, attention and subject focusing, listening to other student and clarification of ideas. Attitude criteria involved student sharing in group work, helping each other, emotional and accreditation of others for their ideas. Facilitators were assessed by all the PBL participants (Table 5) with questions such as encouraged inquiry, demonstrated sensitivity to students, facilitated

learning, leadership etc. Assessment by facilitator was done using a standard questionnaire with nine questions, three questions each for knowledge, skill and attitude. Knowledge assessment involves student preparation for the session, critical thinking, and effective teaching skills (Table 6). Students skill assessment involved active participation in group learning, demonstration of effective group skills/ awareness and skillful in communication with peers. Students attitude assessment involved responsibility for own learning, professional behavior and communication.

For all evaluation terms a five point scale, Likert type response format was used with the range: 1-not satisfactory, 2- satisfactory, 3- good, 4- very good and 5- excellent. All data were calculated as average percent for all the studied parameters knowledge, skill and attitude. All values were subjected to statistical analysis, students t-test, chi-square test, were used. Bar charts were used for graphic presentation. The level of significance selected was P equal or less than 0.05, 0.01 and 0.001.

## RESULTS AND DISCUSSION

In the first session, the students were able to discuss and decide student centered learning objectives (SCLO). Table 1 gives the faculty generated PBL scenario and objectives and Table 2 lists the variables, hypothesis objectives derived by the students themselves. This showed that given an opportunity and with facilitator support, students can independently generate their own learning objectives. This is the fundamental need in PBL which was satisfactorily accomplished.

Baseline and end PBL evaluation of students (Figure 1) showed improvement in all students in all the three aspects of learning behavior namely knowledge, skill and attitude as indicated in bar charts for Pharmaceutical Inorganic Chemistry – 1 and Pharmaceutical Analytical Chemistry courses offered in two subsequent semesters. The improvement was significant. ( $P < 0.01$ )

The impact on individual students in the above courses before and after the PBL implementation is given in Figure 2. It can be easily seen that each student's knowledge, skill and attitude domains improved significantly ( $P < 0.05$ ). PBL has a positive impact on their learning behavior and improved their reasoning, critical thinking and team work skills.

However students evaluated themselves inappropriately

for self and peer evaluation. Over marking and overrating was observed as each one was giving more mark for the others for all the three domains knowledge, skill and attitude (Figure 3). Students marks were more than the facilitator. This may be due to intentional or ignorant marking by the students to help each other to get more marks or they did not do it judiciously. However facilitator evaluation was correct and appropriate due to their experience and competency over the students. Facilitators provided the feed back to the students to improve their self and peer assessment skills.

Comparison of knowledge, skill and attitude for all courses of Sem 2 (2007-08) are given in figure 4 & 5. The courses included were Pharmaceutical Inorganic Chemistry, Pharmaceutical Analytical Chemistry, Pharmaceutics, Pharmaceutical Organic Chemistry and Human Anatomy and Physiology. Students marking was 10% to 20% higher than the facilitator. Students marked invariably above 90% for self and others as well for knowledge, skill and attitude domains. But the facilitator's marks were between 67% to 87% and was appropriate assessment of the students.

Pre and post test average performance of students in Pharmaceutical Inorganic Chemistry and Analytical Chemistry are given in figure 6. The knowledge about the topic scenario of learning through PBL showed significant improvement. This showed that PBL is a good tool to make students learn as a team and solve problems. PBL helped improve reasoning critical thinking and problem solving skills which will help in their professional career.

Facilitators were evaluated by all the students using the questionnaire given in table 5, which has twelve (12) criteria, each to be marked on 1 to 5 scale, 1 being requires revision and 5 indicated excellent. Students rating were added and average was calculated. A facilitator scored 89% in the Pharmaceutics course indicating that facilitator encouraged students to develop reasoning, leadership, team behavior and communication skills.

#### **Limitations and future of the study:**

Only 40 cohort students participated in the study. If the number of students is more probably it will give better and more representative average in the study domains. More students are likely to be involved in the similar study in future as admission strength increases.

As some of the facilitators were new recruits and did not have through experience of conducting PBL, their involvement and commitment while conducting the PBL sessions varied amongst facilitators. Facilitators need continuous training to review and improve the PBL process and assessment.

#### **CONCLUSION:**

The students' academic performance depends not only on their own efforts but also on the total environment in which they participate in PBL. To stimulate students' interest and encourage them to participate in the whole learning process, facilitator's role is critical and crucial.

The present study showed significant improvement in oral and written communication, group behavior and team skills of students. Their knowledge about the topic discussed in the PBL improved significantly as learning was participative, explorative and team based than regular class room lecture.

Result of assessment by students – self & peered always showed higher value in comparison with the facilitator for both base line and end PBL assessment. Facilitators need to motivate students for a better self & peer evaluation to improve the quality of PBL. Further research is planned to evaluate the learning style changes with introduction of PBL on a long-term basis as well as to examine the effect of facilitator teaching-style preferences on these changes.

#### **ACKNOWLEDGMENT:**

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**Table 1**

<b>Pharmaceutical Analytical Chemistry</b>	
<b>PBL - Scenario</b>	
A 25 year old lady visits the doctor complaining of hair loss. The doctor asked her, how long you suffer from this case? She said since in UAE for three months. The doctor said do you take any medication for other health problems? She said no. The doctor said your problem is due to water, as it contains different kinds of elements. The lady decided to analyze a sample of water for its content to know the causes for her hair loss and how to overcome the problem.	
<b>PBL Objective:</b>	
1.	What type of water is that?
2.	What is the difference between hard and soft water?
3.	Where does hard water come from?
4.	What other health problems does hard water cause?
5.	What is the most common way to soften water?
6.	What is the most appropriate analytical method used for the determination of water hardness?
<b>References:</b>	
1-	Analytical Chemistry, 6 <sup>th</sup> Edition by Gary D. Christian.
2-	Practical Pharmaceutical Chemistry by A J Beckett and J B Stenlake, 4 <sup>th</sup> Edition.
3-	British pharmacopoeia
Remington the science and practice of pharmacy, 21 <sup>st</sup> Edition.	

**Table 2**

<b>Variable and Hypothesis Worksheet</b>	
<i>VARIABLE 1</i>	Analysis of Cl ions in water
HYPOTHESIS 1 A	By precipitation reaction
HYPOTHESIS 1 B	Using AgNO <sub>3</sub> as titrant
HYPOTHESIS 1 C	Potassium chromate as indicator
<i>VARIABLE 2</i>	Analysis of Ca <sup>+2</sup> Mg <sup>+2</sup> ion
HYPOTHESIS 2 A	Complexation titration
HYPOTHESIS 2 B	Using EDTA
HYPOTHESIS 2 C	Erichrome black – T as indicator
<i>VARIABLE 3</i>	Treatment by softening process
HYPOTHESIS 3 A	Ion – exchange mechanism
HYPOTHESIS 3 B	Chemicals contains zeolites
HYPOTHESIS 3 C	Converts hard water to soft
<b>Student Centred Learning Objectives (SCLO)</b>	
1	Sources of water
2	Differentiate b/w Hard and soft water
3	Types of hardness
4	The effects of other ions
5	Analysis of water by Cl <sup>-</sup> ions
6	Analysis of water by Ca <sup>+2</sup> , Mg <sup>+2</sup>
7	Softening process
8	Treatments by chemicals
9	Home remedies

**Table 3**  
**RAK Medical & Health Sciences University**  
**RAK College of Pharmaceutical Sciences**

**Problem Based Learning (PBL)**

**Baseline/End PBL evaluation**

Course :  
Student Name :  
Facilitator :

Date:

Please rate yourself / the student by ticking (√) your choice on the following characteristics.

Please put in a rating from 1-5 in each of the boxes below on the following key.

Excellent-5                      V.Good-4                      Good-3                      Satisfactory-2                      Not-Satisfactory-1

**A) KNOWLEDGE**

RATING	ITEM				
	5	4	3	2	1
1) I/He/She know(s) about PBL & well prepared for sessions.					
2) I am/He is/She is highly skilled in critical thinking					
3) I/He/She can effectively teach others about the topic concerned					
4) I help/He/She helps others to get involved in discussions.					

**B) SKILLS**

RATING	ITEM				
	5	4	3	2	1
5) I/He/She actively participate in group learning (listening)					
6) I/He/She can demonstrate effective group skills (interpersonal)					
7) I/He/She can skillfully communicate with peers (presentation)					
8) My/His/Her ideas were clear & easy to understand					

**C) ATTITUDE**

RATING	ITEM				
	5	4	3	2	1
9) I/He/She accept(s) responsibility for own learning (self-directed)					
10) I/He/She have/has highly developed professional behavior (attendance & relationship)					
11) I am/He is/She is skillful in communicating with peers (sensitivity & non emotional)					
12) I am/He is/She is able to appreciate others ideas (appreciation)					

Score =  
Total Score  
**Max. Score =60**

Signature of Facilitator

**Table 4**  
**Problem Based Learning (PBL)**  
**FORM FOR STUDENTS SELF/PEER ASESMENT**

Academic Year: 2008-09

Semester: I/II

Facilitator Name:

Course Title:

Dates of PBL:

PBL Assessment Date:

**Rating: Excellent (5), V.Good (4), Good (3), Satisfactory (2), Requires revision (1)**

Please rate each member by marking appropriate rating number in the space below students name A to H.

A. Knowledge:								
S.N	Criteria	Rating						
	Student Name	(A)	(B)	(C)	(D)	(E)	(F)	(G)
1	I /He / She made helpful suggestions for learning							
2	I/ He / She offered helpful suggestions based on the basis on the ideas of others.							
3	I/ He / She made good comments about the ideas of others							
4	I/ He / She helped others to get involved by asking questions, asking for more information, clarification of ideas							

B. Skills								
S.N	Criteria	Rating						
	Student Name	(A)	(B)	(C)	(D)	(E)	(F)	(G)
1	I / He / She actively participated in the work of the group							
2	I / He / She paid attention and stayed focused on the subject							
3	It was easy for everyone to hear me him/her							
4	My / His / Her ideas were clear and easy to understand							

B. Skills								
S.N	Criteria	Rating						
	Student Name	(A)	(B)	(C)	(D)	(E)	(F)	(G)
1	I / He / She shared the work in the group							
2	I/ He / She helped group members to get along and agree as a group							
3	I / He / She showed sensitivity to other member ' s feelings							
4	I / He / She gave credit to others for their ideas							

Names of Students

(A)      (B)      (C)      (D)      (E)      (F)      (G)

Name of Student Self/Peer Assessor:

Signature:

**Table 5**  
**FORM FOR STUDENT 'S ASSESSMENT OF FACILITATOR**

Module / System :

Serial Number :

Student Name :

Facilitator :

Date :

Please rate each group member by ticking ( ) the appropriate box.

Sl.No	CRITERIA	RATING				
		Excellent (5)	V.good (4)	Good (3)	Satisfactory (2)	Requires Revision (1)
1	Encouraged thinking inquiry, and critical reasoning					
2	Encouraged a safe environment to express ignorance/ideas without fear of embarrassment					
3	Demonstrated sensitivity and respect for students.					
4	Struck a balance between providing information and actively involving group members.					
5	Facilitated participation of all members of the group.					
6	Refocused the group when discussion was wandering.					
7	Encouraged and valued contributions from students.					
8	Encouraged student responsibility for the learning objectives.					
9	Questioned and probed the reasoning process.					
10	Encouraged critical appraisal of information.					
11	Encouraged students to assume leadership responsibilities.					
12	Overall effectiveness of the tutor					
	<b>Total</b>					

**COMMENTS (if any) :**



**Table 6**  
**FORM FOR STUDENT EVALUATION BY FACILITATORS**

Module / System : \_\_\_\_\_  
 Serial Number : \_\_\_\_\_  
 Student Name : \_\_\_\_\_  
 Facilitator Name : \_\_\_\_\_ Date: \_\_\_\_\_

Please rate each group member by circling your choice on the following characteristics.

Please put in a rating from 1-5 in each of the boxes below based on the following key.

Excellent – 5      V. Good – 4      Good – 3      Satisfactory – 2      Not-Satisfactory – 1

**A. KNOWLEDGE:**

EXCELLENT	RATING	REQUIRES REVISION
<b>Consistently well-prepared for sessions:</b> E.g., uses a variety of references; supports statements with appropriate references; makes concise summaries.	Preparation 5 4 3 2 1	<b>Consistently seems unprepared for sessions:</b> E.g., inadequate reading or researching of learning issues; contributes little to group knowledge; does not summarize material.
<b>Highly skilled in critical thinking:</b> E.g., consistently demonstrates skill in performing key tasks such as generating hypotheses, applying knowledge of PBL cases, critically appraising information, making sound deductions, explaining reasoning process.	Critical Thinking 5 4 3 2 1	<b>Consistently seems unprepared for sessions:</b> E.g., inadequate reading or researching of learning issues; contributes little to group knowledge; does not summarize material.
<b>Effective teaching skills:</b> Presents learning issue report at appropriate level, related to the case and in an organized fashion. Uses handouts or summaries to help others remember the material	Teaching 5 4 3 2 1	<b>Ineffective teaching skills:</b> Presents learning issue report at inappropriate level, fails to relate material to the case and presents in a disorganized fashion. Fails to use handouts or summaries to help others remember the material

**B. SKILLS:**

EXCELLENT	RATING	REQUIRES REVISION
<b>Active participation in group learning:</b> E.g., actively participates in discussion; willingly takes on assignments	Participation 5 4 3 2 1	<b>Passive participation in group learning:</b> No. active participation in discussion; reluctantly takes assignments.
<b>Demonstrates effective group skills/awareness</b> E.g., takes the lead or intervenes appropriately; shows respect and sensitivity for others, helps to resolve misunderstandings and conflicts.	Group Skills 5 4 3 2 1	<b>Demonstrates poor group skills/awareness:</b> E.g., intervenes inappropriately; shows poor judgment by interrupting, withdrawing, ignoring others, dominating or impatience.
<b>Skillful in communicating with peers:</b> E.g., listens actively; sensitive to non-verbal and emotional messages.	Teaching 5 4 3 2 1	<b>Difficulties communicating with peers:</b> E.g., poor listening skills; unable to attend to non-verbal or emotional message

**C. ATTITUDE**

EXCELLENT	RATING	REQUIRES REVISION
<b>Accepts responsibility for own learning:</b> E.g., directs own learning agenda; actively tries to improve; critiques resources.	Responsibility 5 4 3 2 1	<b>not accept responsibility for own learning:</b> E.g., depends upon others for learning agenda; covers up mistakes; rarely critiques resources.
<b>Highly developed professional behavior:</b> E.g., excellent attendance; reliable; willingly accepts feedback and learns from it.	Professionalism 5 4 3 2 1	<b>Deficiencies in professional behavior:</b> E.g., absent without an excuse; untrustworthy; difficulty accepting feedback.
<b>Skillful in communicating with peers:</b> E.g., listens actively; sensitive to non-verbal and emotional messages.	Communication 5 4 3 2 1	<b>Difficult communicating with peer:</b> E.g., poor listening skills: unable or unwilling to attend to non-verbal emotional messages.

Fig. 1

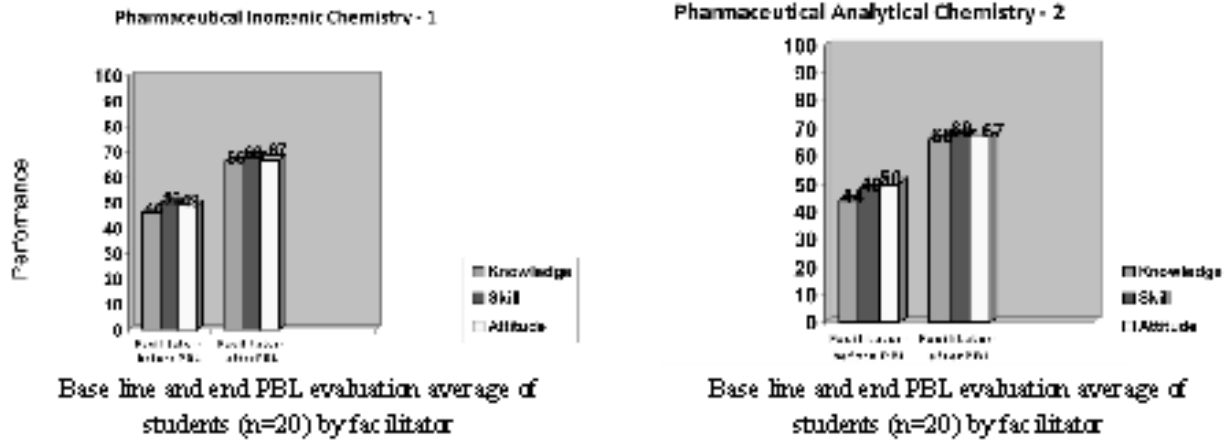


Fig. 2  
Facilitator evaluation of the Impact of PBL on individual students  
Pharmaceutical Inorganic Chemistry

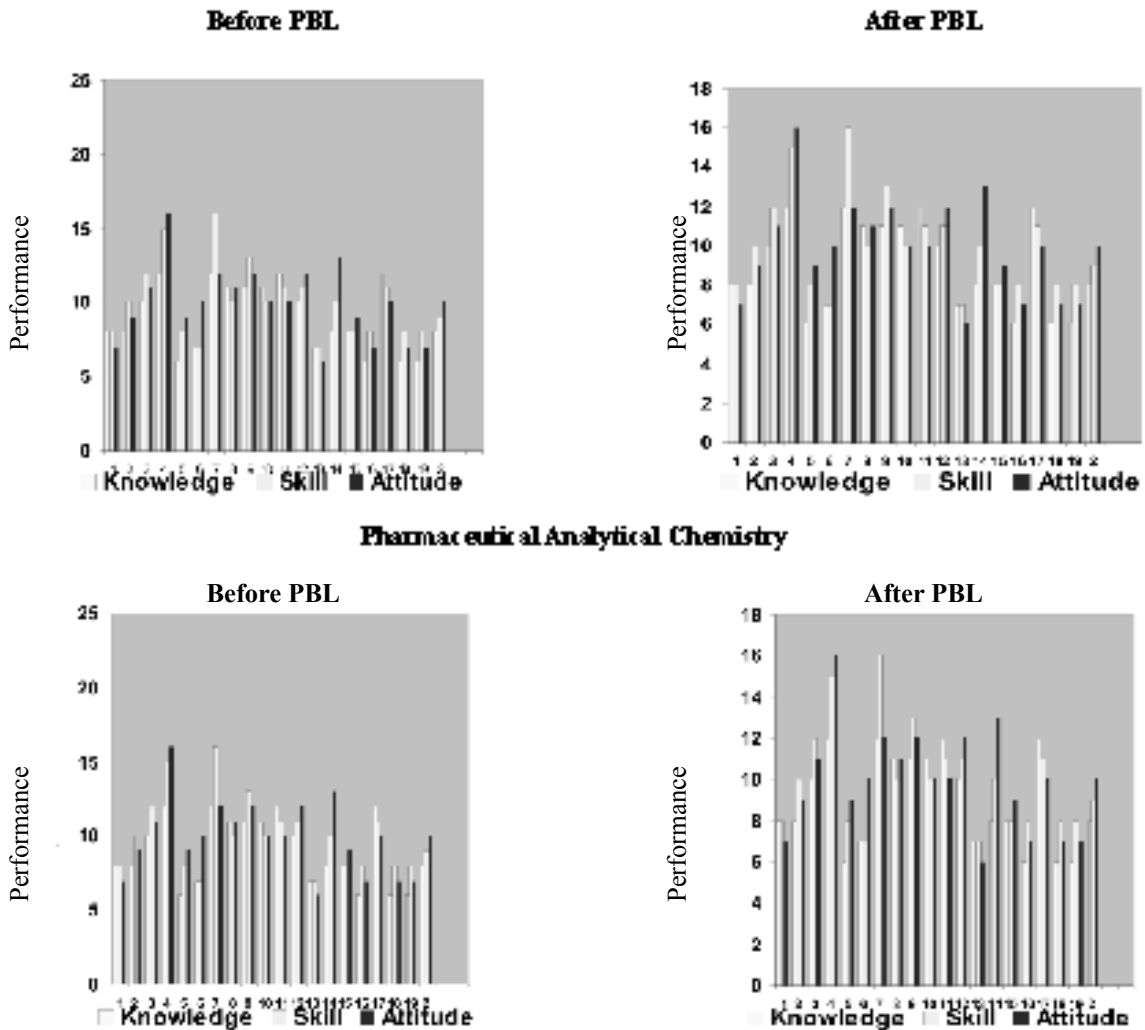
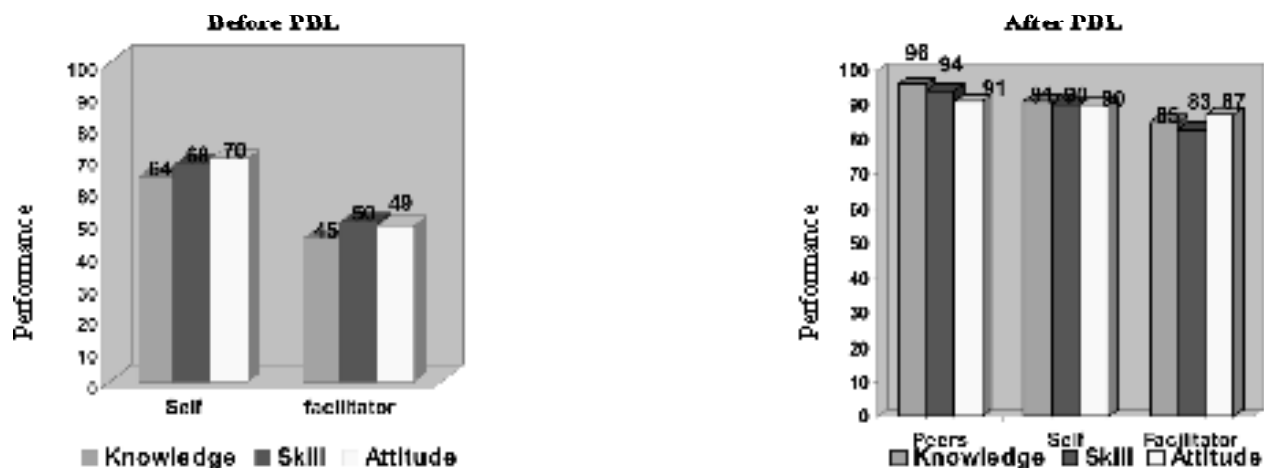


Fig. 3

Summary of Knowledge, Skill, Attitude (KSA) comparison between Student-self, peers and facilitator assessment before and after PBL

Pharmaceutical Inorganic Chemistry



Pharmaceutical Analytical Chemistry

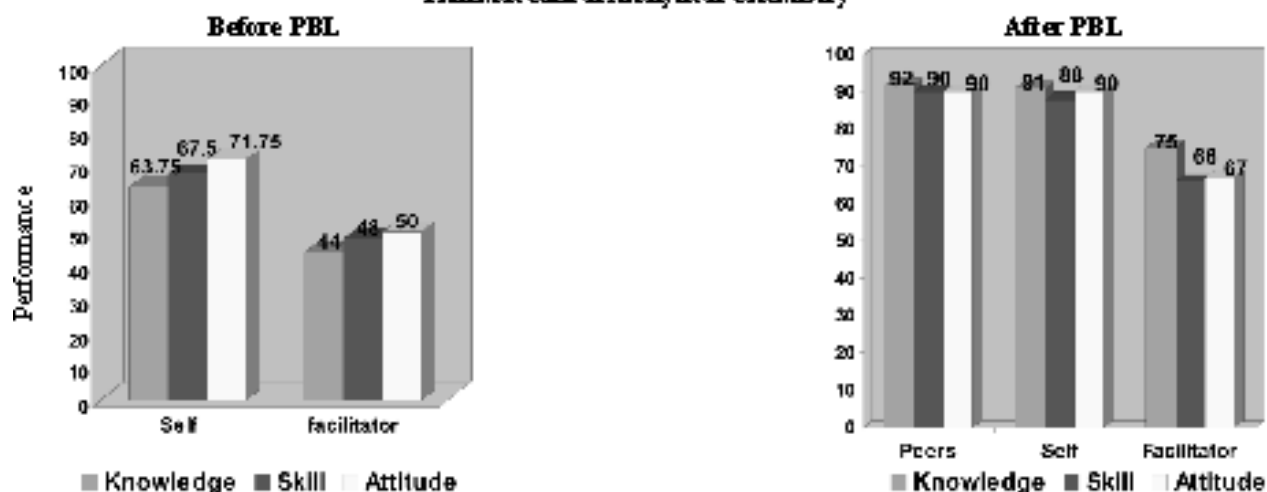
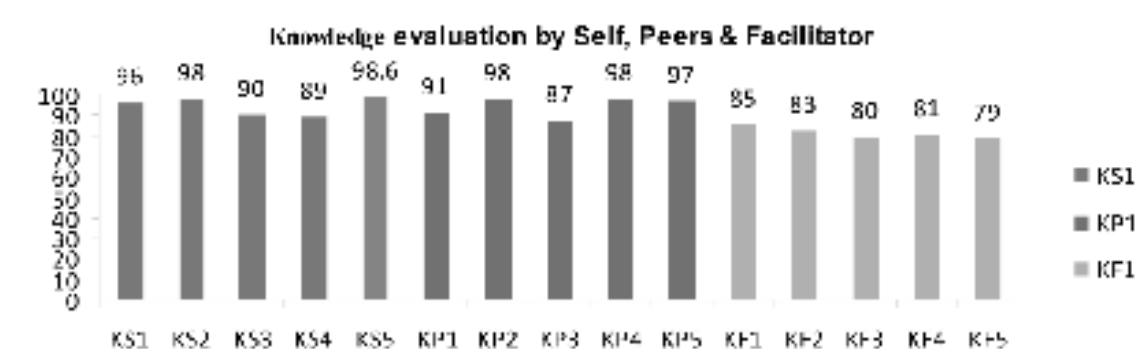
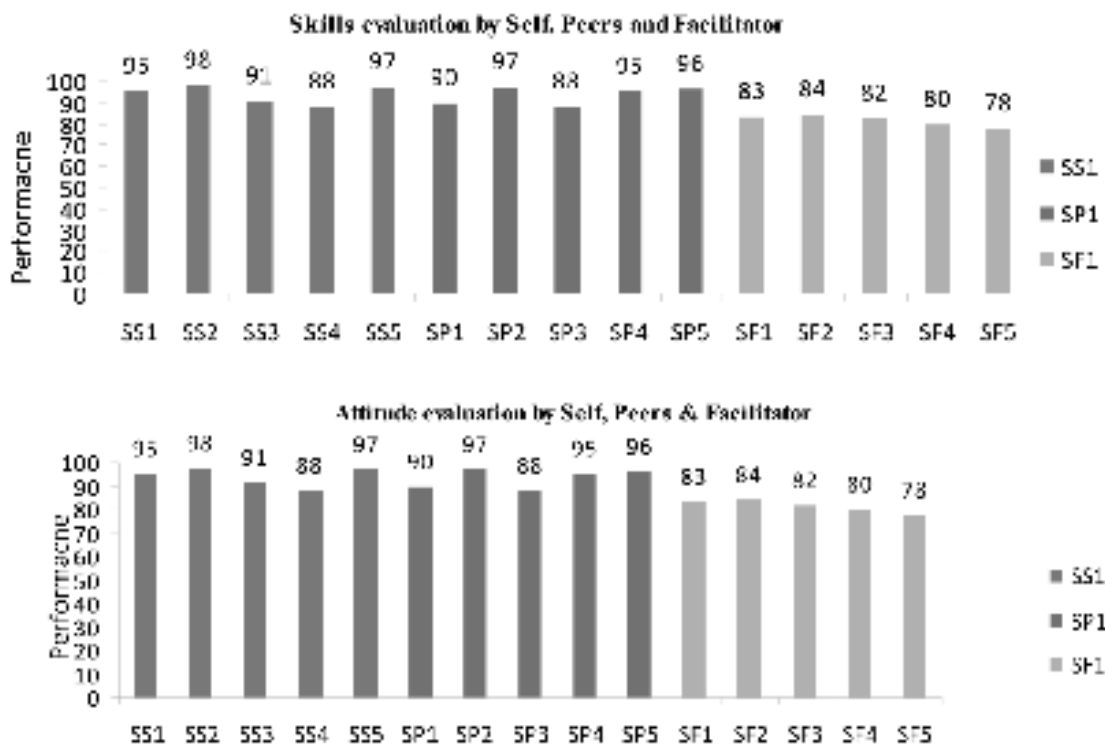


Fig. 4

Comparison of Knowledge, Skill and Attitude for all courses average of all students: Sem 2, 2007-08

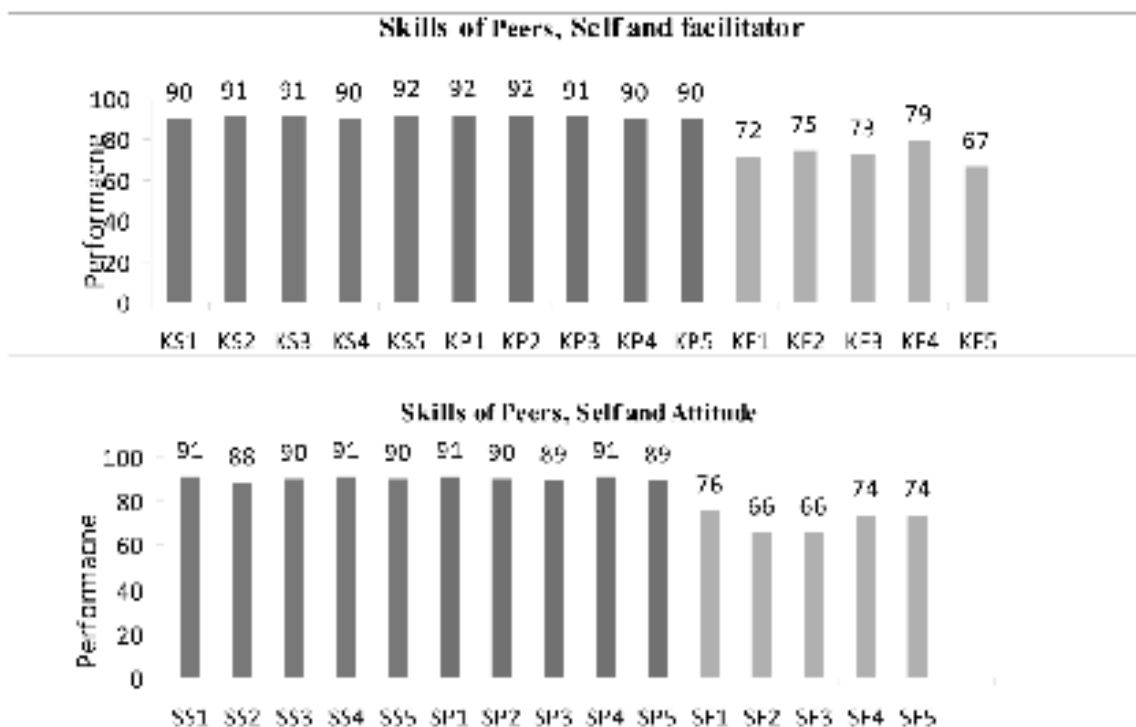




K – Knowledge, S<sub>1</sub> to S<sub>5</sub> – Self, P<sub>1</sub> to P<sub>5</sub> – Peer, F<sub>1</sub> to F<sub>5</sub> – Facilitator  
 S – Skill 1-Pharmaceutical Inorganic Chemistry 4- Pharmaceutical Organic Chemistry  
 A – Attitude 2- Pharmaceutical Analytical Chemistry 5-Human Anatomy and Physiology  
 3- Pharmaceutics

Fig. 5

Comparison of Knowledge, Skill and Attitude for all courses average of all students: Sem 3, 2008-09

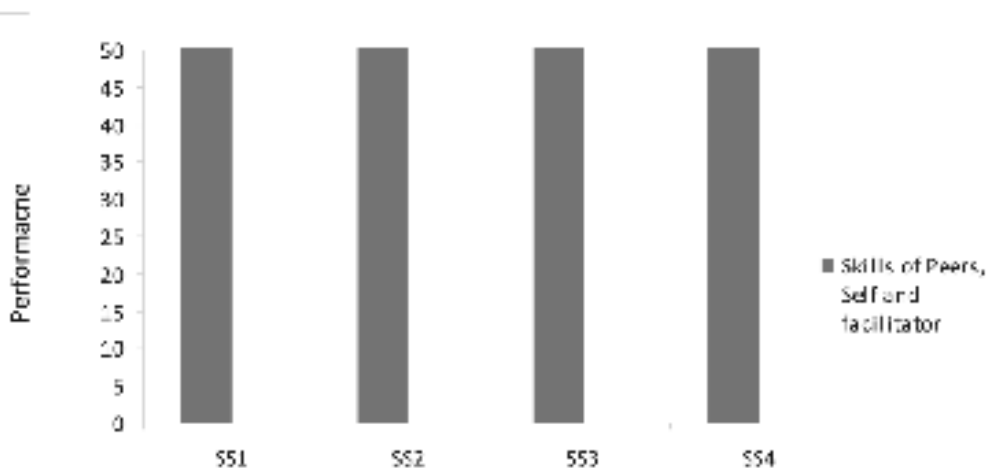




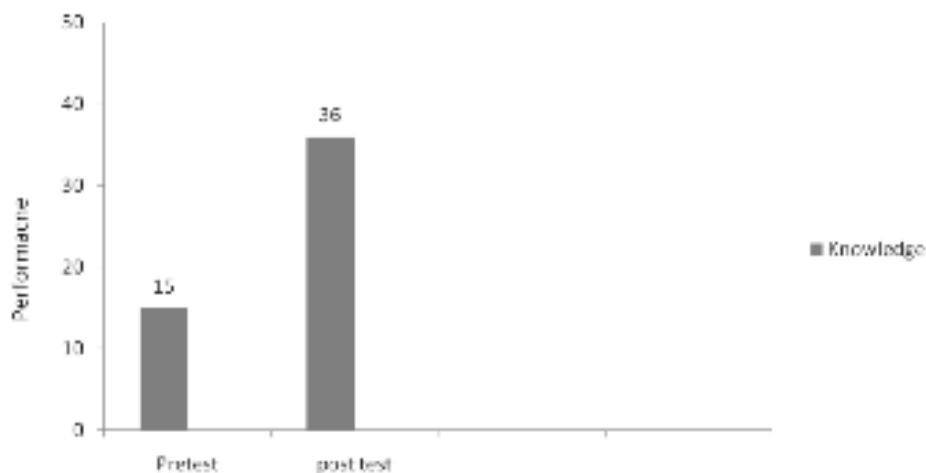
K – Knowledge, S<sub>1</sub> to S<sub>5</sub> – Self, P<sub>1</sub> to P<sub>5</sub> – Peer, F<sub>1</sub> to F<sub>5</sub> – Facilitator  
 S – Skill 1-Pharmaceutical Inorganic Chemistry 4- Pharmaceutical Organic Chemistry  
 A – Attitude 2- Pharmaceutical Analytical Chemistry 5- Human Anatomy and Physiology  
 3- Pharmaceutics

Fig. 6

Pre and Post test in Pharmaceutical Inorganic Chemistry in 2007 for PBL scenario (content knowledge) n=20



Pre and Post test in Pharmaceutical Analytical Chemistry in 2008 for PBL scenario (content knowledge) n=20



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