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# An investigation into the effectiveness of problem-based learning in a physical chemistry laboratory course

Ahmet Gürses*, Metin Açıkyıldız, Çetin Doğar and Mustafa Sözbilir
*Atatürk University, Turkey*

The aim of this study was to investigate the effectiveness of a problem-based learning (PBL) approach in a physical chemistry laboratory course. The parameters investigated were students' attitudes towards a chemistry laboratory course, scientific process skills of students and their academic achievement. The design of the study was one group pre-test–post-test. Four experiments, covering the topics adsorption, viscosity, surface tension and conductivity were performed using a PBL approach in the fall semester of the 2003/04 academic year at Kazim Karabekir Education Faculty of Atatürk University. Each experiment was done over a three week period. A total of 40 students, 18 male and 22 female, participated in the study. Students took the Physical Chemistry Laboratory Concept Test (PCLCT), Attitudes towards Chemistry Laboratory (ATCL) questionnaire and Science Process Skills Test (SPST) as pre and post-tests. In addition, the effectiveness of the PBL approach was also determined through four different scales; Scales Specific to Students' Views of PBL. A statistically significant difference between the students' academic achievement and scientific process skills at $p < 0.05$ level was found. No statistically significant difference was found at the students' attitude towards the physical chemistry laboratory. The results suggests that the PBL approach promoted critical thinking and problem-solving skills; active participation in the learning process including self-direction, identification of own learning needs, teamwork, creative discussion and learning from peers; and the integration and synthesis of a variety of knowledge.

## Introduction

What do students learn from a problem-based learning (PBL) exercise? That is, what and how much knowledge do students acquire? People who ask this question have frequently been trained in discipline-based education (traditional education). PBL, however, is an approach that focuses on problem analysis, self-directed learning and knowledge application (Schmidt, 1993).

*Corresponding author. Atatürk University, K. K. Education Faculty, Department of Chemistry Education, 25240, Erzurum Turkey. Email: ahmetgu@yahoo.com

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Today, PBL is a well-known alternative approach to traditional disciplinary-based professional educational programs in higher education. PBL was first implemented in medical education school programs at McMaster University in Canada about forty years ago (Barrows & Tamblyn, 1980), and later adapted for use in elementary and high school (e.g., Delisle, 1997). PBL is described by Barrows and Tamblyn (1980) as:

> … the learning that results from the process of working toward the understanding or resolution of a problem. The problem is encountered first in the learning process and serves as a focus or stimulus for the application of problem solving or reasoning skills, as well as for the search for or study of information or knowledge needed to understand the mechanisms responsible for the problem and how it might be resolved. (p. 18)

The key to effective teaching using a PBL approach is to present the students with interesting and challenging problems (Larive, 2004). In PBL, problems act as the stimulus and focus for student activity and learning (Boud & Feletti, 1991). Learning in this way is purposeful and self-motivating as the student learns while searching for solutions to the problems. Students are actively involved and learn in the context in which knowledge is to be used.

The guidelines for forming questions in PBL are summarized as:

- The problem should relate to the real world and be complex enough to require the students to cooperate with one another in order to complete the exercise.
- The problem should be interesting or controversial enough to draw students' interest. Ideas for problems may come from video clips of news programs or advertisements, research papers, newspaper articles, or some of the every day problems that come up on the campus and surrounding community.
- Learning objectives should be incorporated into the problem and include concepts that have been covered in previous classes so students can apply what they have learned to a real life situation. Those objectives can later be shared with the students after the problem is solved to help them check their self-evaluation (Duch *et al.*, 2001).

To examine the effect of PBL on problem-solving skills, Gallagher *et al.* (1992) tested students before and after they enrolled in an interdisciplinary PBL course and a comparison group of students. These tests focused on students' uses of the steps for solving problems in course exercises. They found differences between the two groups. The comparison group tended to skip 'problem finding' and move directly from 'fact finding' to implementation during the post-test. Conversely, PBL students showed a significant increase in including problem-finding steps in their problem-solving processes. These results suggest that the PBL course was effective in shaping students' problem-solving processes.

The learning process in PBL is considered to follow a sequence of interrelated steps. First, the scenario is presented to the students who then bring up their free associations in a 'brainstorm'. The result of the 'brainstorm' is arranged into a number of emerging themes and questions are posed in relation to each theme. The idea of the initial phase is to enable the students to clarify their preconceptions and

prejudices in relation to a particular topic. The clarification is accomplished as they scrutinize and discuss their associations, ideas and themes that have been generated in the 'brainstorming' process. The major goal of this process is to facilitate and support the identification of learning needs (Dahlgren & Öberg, 2001).

Bridges (1992, pp. 5–6) outlines the chief characteristics of PBL:

1. The starting point for learning is a problem (that is, a stimulus for which an individual lacks a ready response).
2. The problem is one that students are apt to face as future professionals.
3. The knowledge that students are expected to acquire during their professional training is organized around problems rather than the disciplines.
4. Students, individually and collectively, assume a major responsibility for their own instruction and learning.
5. Most of the learning occurs within the context of small groups rather than lectures.
6. Problem-based learning is also based on the idea that students in small groups decide what they need to study in order to solve the problem. After a group discussion, students study independently and meet again to share, compare and relate what they have found out about the problem.

PBL can help students to learn with complexity and understand that there are no straightforward answers to many problems (Savin-Baden, 2000). In addition, PBL offers students opportunities to learn in groups and to develop the presentation, negotiation and research skills that are very much called for in working life (Savin-Baden, 2000). Furthermore, according to Staudinger (1996), social interaction enhances problem solving in situations in which large amounts of knowledge and uncertainty related to procedure and outcome are involved.

The teacher guides by first modelling and coaching. Students then take on the responsibility of using the skills on their own. That is, teachers take on a facilitating and supporting role instead of behaving as experts who have 'right' answers to the problem. It is important to allow the students to make their own decisions about the directions that they will take in their investigations, what information they will need to locate, and how they will analyze and evaluate the information to understand and then resolve the problem (Chin & Chia, 2004).

It was interesting to contrast the attitude of students in the laboratory course with their experience in undergraduate research. Science educators have agreed that the development of a positive attitude toward science should be an important goal of science education (Salta & Tzougraki, 2004). Various studies have found a positive correlation between science attitudes and various achievement measures, although, in general, no strong relationship has been found (Cukrowska *et al.*, 1999). Even though the manipulations required by a research project might be tedious, most chemistry students find research invigorating and exciting because it explores an important problem for which the answer is unknown (Larive, 2004). PBL is an instructional approach that addresses many of the limitations of traditional methods by teaching important concepts in the context of solving real physical chemistry

problems. Although problem-based and cooperative learning approaches can also be applied in the classroom, either as a supplement to or in lieu of traditional lectures, the physical chemistry laboratory is an ideal environment to utilize PBL approaches. PBL laboratory experiences have the potential to provide motivation for students and to demonstrate how the science of physical and analytical chemistry is practised and why experiments must be performed properly (Larive, 2004). In addition, a practical problem-solving task was assigned to relate theory to practice and to reinforce the problem-solving skills in a laboratory setting (Shelton & Smith, 1998). However, the use of this approach is relatively new schools in Turkey, not much research has been done in science education and there is a shortage of research reported in chemistry laboratory courses used PBL approach.

Conventional teaching approaches are followed in most of the chemistry laboratory courses in Turkey. Instructors play dominant role in transferring the information and transfer the subject through didactic lectures and laboratory experiments, which mark conventional instructional strategy.

## The aim of the study

This study investigated effectiveness of a PBL approach in a physical chemistry laboratory course. The parameters investigated were students' attitudes towards the chemistry laboratory course, scientific process skills of students and their academic achievements.

## Methodology

### *The sample*

The subjects of the study were 40 third-year undergraduate students enrolled to a physical chemistry laboratory course in the Department of Chemistry Education in the fall semester of the 2003/04 academic year in the Kazim Karabekir Education Faculty in Atatürk University, Turkey. A one-group pre-test–post-test design was applied. In this design, a single group of subjects was given a pre-test, then the treatment, and then the post-test. The difference between pre-test to post-test scores was examined (McMillan & Schumacher, 1997, p. 324).

### *Data collection instruments*

*Physical Chemistry Laboratory Concept Test (PCLCT).* This test comprised a total of 40 questions, which were open-ended and parallel type. This test includes ten different questions for each experiment. These questions were applied before and after treatment. Five of the ten questions were asked as a pre-test for the each experiment (adsorption, viscosity, surface tension and conductivity, respectively) then the other questions were applied as post-test. The pre-test questions were based on the vital knowledge that students should know before starting the laboratory course while the

post-test questions were based on determining students' success in learning the concepts covered in the experiments. Prior to the start of the experiments, students took the part of the pre-test related to the particular experiment. When the experiment was completed, students were given the post-test questions related to the experiment. *PCLCT* was piloted with a group of students from the Department of Chemistry Education in Ataturk University who took the Physical Chemistry Laboratory-I course and modifications were made in terms of language and design of the test. The validity of the test was achieved by consulting chemistry professors and the researcher in this study. Two sample questions can be seen in Appendix 1.

*Science Process Skill Test (SPST).* The test used in this study was originally developed by Okey *et al.* (1982), translated and adapted into Turkish and the internal consistency (cronbach alpha coefficient) of the test was found to be 0.81 by Geban *et al.* (1992). Thirty-six items in this test cover all science areas, and include five subtests – identifying variables, identifying and stating hypotheses, operationally defining, designing investigations, and graphing and interpreting data (Geban *et al.*, 1992).

*Attitude towards Chemistry Laboratory (ATCL).* An attitude scale originally developed for Turkish chemistry students by Geban *et al.* (1994) was modified and used in order to measure the students' attitudes towards the chemistry laboratory course. The internal consistency (Cronbach alpha) of the ATCL was 0.77. Internal consistency is the most common type of reliability since it can be estimated from giving one form of a test once (McMillan & Schumacher, 1997). ATCL was composed of fifteen Likert type items on a five-point scale which ranged from strongly disagree to strongly agree. ATCL was administered as pre- and post-treatment.

*Scales Specific to Students' Views of PBL.* Four different scales were developed in order for the determination of students' views of PBL. These tests were: *Peer Evaluation Scale (PES),* in which students analyse their group-mates' performances during PBL treatment; *Self Evaluation Scale (SES),* in which students critique their performance during PBL sessions; *Tutor's Performance Evaluation Scale (TPES)*, in which students critique the tutor's performance during the PBL sessions; and *Students' Evaluation of PBL Scale (SEPBLS)*, in which students criticize the effectiveness of the PBL approach. All these scales included seven-to-twelve Likert type items on a three-point scale ranged from 1 (disagree), 2 (neutral) to 3 (agree), and also each scale had an open-ended part in order to give students a chance of writing their opinions. The PBL groups at the end of the trial filled in all these scales.

*Problem cases*

A crucial aspect of PBL is the actual design of the problem to be solved. PBL should enhance and promote the goal of a course, not serve as a digression in curriculum and

pedagogy. The problem should promote students' knowledge and skills that have been defined as intended course outcomes. In this study, four problem cases were developed covering different aspects of the laboratory experiments. The problem called 'Nilüfer Stream and Bursa Plain' is about adsorption, 'Automobile' related to viscosity, 'Detergents and Interesting Choice' intended to cover surface tension, and conductivity was covered with 'Weak Acid'. All problem cases were supported with a text that explains the cases. A sample problem scenario can be seen in Appendix 2.

*Grouping and stages of implementation*

Treatment was completed in forty-eight lecture hours (each 50 min) in twelve weeks (four lecture hours per week). Firstly students were informed about PBL and its proceedings. Then the students were grouped, five students in each group with a total of eight groups. Students were grouped by taking students' attitudes towards the laboratory course and scientific process skills scores, and gender into account.

The students went through six consecutive stages during the PBL trial: (1) presenting the problem case to the groups; (2) identification of problems to be investigated by the students; (3) carrying out scientific inquiry; (4) putting the information together; (5) doing the experiments; and (6) presenting the findings.

In stage 1, the problem was presented to the students in written form and they were asked to read the problem and encouraged to write their ideas. In stage 2, the students identified learning issues related to the problem and organized them around three focus questions (Gallagher *et al.*, 1995) using a 'Need-to-Know' worksheet. The questions were as follows: (a) What do you know? (b) What do you need to know? (c) How can you find out what you need to know? The students recorded their ideas and questions onto this worksheet regularly as a group. In this way, the Need-to-Know worksheets served as a central focus point for the unit and represented the continuing cycle of problem definition, information gathering, analysis and synthesis of information, and problem redefinition. In stage 3, the students gathered data to answer their own questions. Some looked up information from printed and electronic resources using both library research and the internet, and others consulted expert professionals. In stage (4), the students reported on what they had done, and prepared a report for the presentation to the classroom. In stage (5) they carried out the experiments and finally in stage (6), each group gave a 5–10 min oral presentation on what they found and what they had learned about their problem case. The students also submitted a group report that documented the group's findings and details of the inquiry process. The lecturer evaluated the groups based on criteria related to both the process and the products of the project work, including the oral presentation.

## Data Analysis

The data were analyzed using SPSS 11.5 (Statistical Package for Social Sciences). The significance level was set to 0.05 since it is the most used value in educational studies. Paired sample *t*-test and 'descriptive statistic analyze' were used in order to

find out the effect of the treatment (PBL) on students' learning related to the experiments in the physical chemistry laboratory course, students' scientific process skills, and students' attitudes towards laboratory, respectively.

## Results

### *Comparisons of PCLCT mean scores*

Descriptive statistics related to total mean scores of pre-test and post-test and t-test scores for all experiments are presented in Table 1. According to Table 1, all post-test scores are considerably higher than pre-test scores. For example, a paired sample *t*-test result also confirms that there is a statistically significant difference between students' total mean scores in the post-test ($t = -31.74$; $p < 0.05$). Similar results are obtained for the other experiments, surface tension experiments, viscosity experiments, conductivity experiments in terms of the pre and the post-test scores, respectively.

Because the focus of problem-based learning centres on a specific problem, academic achievement scores often favour traditional teaching methods when standardized test are used (Vernon & Blake, 1993). Lecturing is still efficient and has persisted as the traditional teaching method largely because it is familiar, easy, and how we learned (Duch *et al.*, 2001). However, PBL can be preferred especially in laboratory courses because it fosters the development of process skills (Duch *et al.*, 2001).

### *Comparison of SPST mean scores*

Descriptive statistics related to total mean scores of pre-test and post-test and *t*-test scores for SPST are presented in Table 2.

As can be seen from Table 2, mean scores for SPST changed from 68.12 to 72.49 for the pre and post-test respectively. Paired samples *t*-test results indicate that there

Table 1. Descriptive statistics for total scores of pre-test and post-test on the experiments

| | Descriptive Statistics | | | | Paired Samples t-test | | |
|---|---|---|---|---|---|---|---|
| Experiments | Test | *N* | Mean | Std. Dev. | *t* | *df* | Sig. (2-tailed) |
| Adsorption | Pre-test | 40 | 19.12 | 8.15 | −31.74 | 39 | 0.000* |
| | Post-test | 40 | 70.70 | 15.51 | | | |
| Surface tension | Pre-test | 40 | 11.15 | 8.62 | −33.74 | 39 | 0.000* |
| | Post-test | 40 | 73.07 | 15.57 | | | |
| Viscosity | Pre-test | 40 | 21.27 | 12.25 | −44.10 | 39 | 0.000* |
| | Post-test | 40 | 76.77 | 10.32 | | | |
| Conductivity | Pre-test | 40 | 15.37 | 9.01 | −40.96 | 39 | 0.000* |
| | Post-test | 40 | 70.67 | 11.64 | | | |

* $p < 0.05$

Table 2. Descriptive statistics for total scores of pre-test and post-test and *t*-test scores on SPST

| Descriptive Statistics | | | | Paired Samples *t*-test | | |
|---|---|---|---|---|---|---|
| Test | *N* | Mean | Std. Dev. | *t* | df | Sig. (2-tailed) |
| Pre-test | 40 | 68.12 | 9.94 | −4.66 | 39 | 0.000* |
| Post-test | 40 | 72.49 | 8.57 | | | |

* $p < 0.05$

is a statistically significant difference between pre and post-test SPST scores at 0.05 levels. As PBL promotes the use of scientific process skills at almost every stage of student work, this result is an expected one.

*Comparison of attitudes towards the chemistry laboratory course*

Students' attitudes towards the chemistry laboratory course were determined with the ATCL. Distribution of students' preferences for items on ATCL at pre-test and post-test are given in Figure 1 which shows that students' attitudes towards chemistry laboratory are quite positive both pre and post instruction. The total of "Agree" and "Strongly Agree" views for pre and post-tests are 70% and 73% respectively.

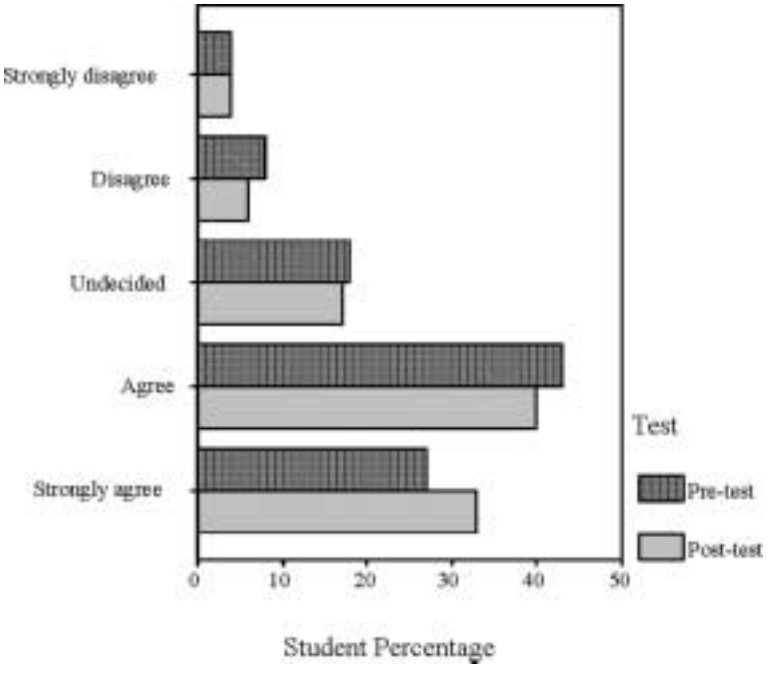


Figure 1. Distribution of students' preferences for questions on ATCL at pre-test and post-test

Therefore, this result indicates that PBL had no significant main effect on students' attitudes towards chemistry laboratory.

Research shows that the initial transition from a traditional to a PBL curriculum may be a difficult adjustment for students. The adjustment is difficult because students are concerned about content coverage in PBL environments (Dods, 1997; Lieux, 1996). Their concerns also relate to uncertainty about their grades (Woods, 1996). Another reason for students' frustrations might be the newness of students' roles in PBL and difficulty of attitude change.

*Students' views of PBL*

Four different scales were developed to determine students' views of PBL. These tests were: Peer Evaluation Scale (PES), Self Evaluation Scale (SES), Tutor's Performance Evaluation Scale (TPES) and Students' Evaluation of PBL Scale (SEPBLS), respectively. Table 3 shows the total mean scores of scales specific to students' self-evaluation of PBL. As seen from Table 3, all scores are close to the maximum indicating that students were happy with the PBL and liked the PBL approach.

In the following section students' responses given to the open-ended part of the scales used to gather students' views about PBL application. The views are categorised and given below. Each group of responses are also supported by original quotes taken from their writings.

Q: What do you think about the strength of PBL applications?

$R_1$: PBL encouraged us to investigate, and therefore, use library and Internet resources which made us to take the course more seriously and work intensively (40%).

*… it fosters investigation instead of expecting from the instructor to present us the knowledge. Once we reach a solution it motivated us and wanted to do new investigations.*

$R_2$: My ideas about the events of the daily life have changed. In this way I have a lot of knowledge about several subjects (42 %).

*… the given problems consist of events of the daily life. Actually, the events were our environment. The applications and investigations related to the events of daily life got my interest up.*

*… including some interesting problems from the daily life and to explore some solutions was amusing and instructive.*

$R_3$: To collaborate, to discuss some knowledge was useful (18 %).

*… the group work was very effective; we discussed together about the findings and reached result. This was very useful.*

Table 3. Total mean scores of scales specific to students' views of PBL

| Scales | *N* | Mean |
|---|---|---|
| PES (min 7–max 21) | 40 | 16.27 |
| SES (min 12–max 36) | 40 | 32.72 |
| TPES (min 10–max 30) | 40 | 27.83 |
| SEPBLS (min 10–max 30) | 40 | 24.76 |

Q: What do you think about the weaknesses of PBL applications?

$R_1$: Since PBL is based on investigation, Internet facilities and library must be readily available (36%).
*… more computers connected to the web are needed in the laboratory. I would prefer to find more books related to the investigations areas in the library*

$R_2$: There were some difficulties related to the group works (21 %).
*… I would rather study individually than work in a group. Some of our group mates, who didn't take over the responsibility, had delayed us reaching the results.*

$R_3$: The distributions of class hours must be re-considered (15 %).
*… I think that the given time* [four hours per week] *was enough. But the timetable which is prepared by us is suitable for work such as investigating and experimentation. I would prefer two hours twice per week than once time four hours per week.*

$R_4$: We would prefer teacher gives some information about the experiment (16%).
*… I think the teacher must enlighten us before starting the experiments and then they should ask our views. Also, they must provide us more resources such as books, journals, etc.*

$R_5$: The problems which are from daily life have effected our achievement (12 %).
*… we could not benefit from the problems which are from real life. This has negatively effected our achievement.*

The analysis of student responses suggests that PBL is a more rewarding and satisfying learning approach for students in practice-based programs. The evaluation highlights the ways in which students found their learning different, how they perceived themselves differently as students and the relationship of the learning process to their chemistry experiences. The issues discussed are: students' identification that the PBL approach promoted critical thinking and problem solving; active participation in the learning process including self-direction, identification of own learning needs, teamwork, creative discussion and learning from peers; and the integration and synthesis of a variety of knowledge. Students also found that this type of learning was realistic, fun and interesting (Cooke and Moyle, 2002).

The primary advantage of PBL is that students have the opportunity to apply problem-solving skills to the solution of meaningful problems related to real life. A tangential advantage is that observing the students' problem-solving approaches can give the instructor insight into the effectiveness of the initial laboratory orientation that preceded the PBL session. As students evaluate their progress, the instructor will have an opportunity to address problems and provide feedback to the students about their learning. PBL is potentially a useful tool for bringing meaning to the students' understanding of the value of problem solving as a lifelong learning process (Carder *et al.*, 2001).

Students found PBL immensely satisfying as it enabled them to problem-solve in situations, and provide rationales for reasoning and decision-making. Many reported that their learning during this time was exciting and stimulating and certainly promoted their critical thinking skills. The responses indicated that students believed that these skills were learnt and used through their engagement (identifying situations, testing hypotheses, and plans of treatment) with a problem situation that required them to synthesize knowledge and make critical decisions based on their

learning. These results also indicate that the students had developed the necessary skills, such as self-directed learning, critical analysis, literature researching and problem solving, to work through PBL (Cooke & Moyle, 2002).

## Conclusions and implications for teaching

The most important finding of this study can be summarized as follows:

- PBL learners have attained considerably higher scores after the introduction of PBL.
- PBL helped students to improve their scientific problem solving skills.
- Students' attitudes towards the physical chemistry laboratory course have not been changed significantly after PBL treatment, but they reported that PBL treatment was an effective type of teaching approach.
- Students reported that the scenarios are considered to provide a meaningful context for the concepts and principles that relate to future professional work.
- Learning in this way is purposeful and self-motivating as the student learns while searching for solutions to the problems. Students are actively involved and learn in the context in which knowledge is to be used.
- The analysis of the responses found that the problem-based learning approach promoted problem solving; active participation in the learning process including self-direction, identification of own learning needs, group work, creative discussion and learning from peers; and the integration and synthesis of a variety of knowledge.

It can be suggested that PBL has strong positive effects in promoting students' problem-solving skills and their ability to transfer these skills to real-world situations. We recognize that through the proper design of PBL environments that includes instruction facilitating the ability of students to develop expert-like mental models for solving problems, professors can adequately prepare students for both long- and short-term successes (Hung *et al.*, 2003).

Students found that the teacher's role in problem-based tutorials was more interactive and responsive to their needs. They also acknowledged that the teaching style helped them to develop critical thinking skills. The interactive style included questioning and challenging students, encouraging participation and contribution, prompting discussion (Cooke & Moyle, 2002).

The positive attributes of the course are that the students gain an appreciation of the way physical chemistry is practised. In addition, they found that the PBL strategies encouraged them to take control of their own learning experience by promoting their involvement, self-direction and the identification of learning needs (Cooke & Moyle, 2002). Although this problem-based learning course was designed for the benefit of our students, an interesting aspect of this approach is that it also provides an intellectually stimulating and rewarding experience for the graduate teaching assistants and faculty involved (Larive, 2004).

From the results, PBL provided an active, student-centred approach to learning encouraging the development of critical thinking and lifelong learning skills. What

sets PBL apart from other active learning techniques is its focus on self-directed learning, as a process in which learners take the initiative to define their learning needs, formulate goals, identify needed resources for learning, select and implement learning strategies, and evaluate the results. Descriptive reports from high school and college instructors in several disciplines describe students who are highly motivated to solve 'their' problem, and who effectively engage in real-life problem solving. This situation provides that the more is understood and retained by the student (Carder *et al.*, 2001). PBL involves the process of working towards the understanding or resolution of a problem (Barrows & Tamblyn, 1980). It is contextualized in small group teaching that develops considerable interpersonal communication. It improves motivation and increases collaboration between basic and laboratory disciplines.

The faculty role in PBL is the instructor must guide, probe and support students' initiatives, not lecture, direct or provide easy solutions. The degree to which a PBL course is student-directed versus teacher-directed is a decision that the faculty member must make based on the size of the class, the intellectual maturity level of the students, and the instructional goals of the course. When faculty incorporates PBL in their courses, they empower their students to take a responsible role in their learning and as a result, faculty must be ready to devolve some of their own authority in the classroom to their students (Duch, 1995).

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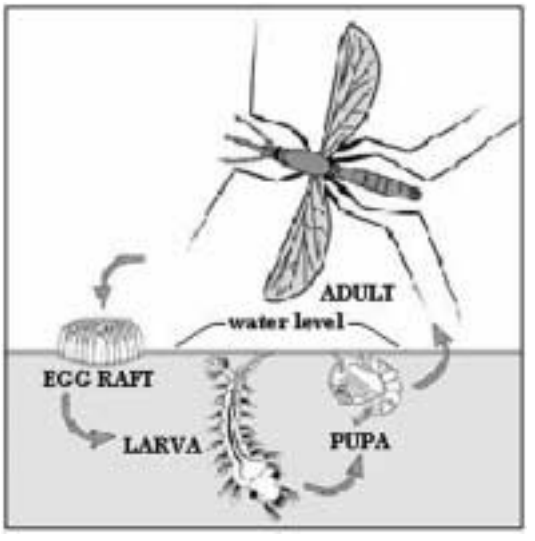
## Appendix 1. Two sample questions used in PCLCT

**First Question** (Post-test section for surface tension)




A mosquito is a member of the insect species and there are over 2500 different species in the world. Both the male and the female need water for hydration and survival. All mosquitoes need water to deposit their eggs. All larvae "wrigglers" need standing water to complete their development. But, when an insecticide is sprayed on the mosquitoes living the water, mosquitoes at all stages of development will die. What effect does insecticide have on the mosquitoes living the water? Please explain your responses.

**Second Question** (Pre-test section for adsorption)



**Content of Eucarbon**
180 mg vegetable coal
50 mg purified sulphur
105 mg senna leaf
25 mg extract of dry ravent
0.5 mg mint oil
0.5 mg fennel oil
Eucarbon is used to treat bloating, and stomach ache and intestinal problems. How does Eucarbon treat these symptoms? Please explain your responses.

## Appendix 2. Sample problem case used in PBL (viscosity session): automobile

### PART I

A car distributor in Turkey received a letter of complaint from a customer on 21st March 2003. Part of the letter appears below:

"I took my 2002 model X trademark (2.5 i V6) car for a service about 6 months ago. I was told that air and oil filters, engine (20W/50) and brake oils, spark plugs were

changed and a computerized check was carried out for possible faults. When I learned about the grades of oils used and parts changed, I said that these are not suitable for my car as climatologic conditions of Erzurum are harsh. It was argued that the grade of oils and the parts replaced are suitable for Erzurum conditions. The engine did not started smoothly in cold days throughout winter and approximately five months later, I noticed some unknown sounds coming from the engine. Initially I did not pay attention. But because of the persistence of the problem, I went to the same service station. They told me that the engine was worn four times more than normal and it would cost approximately three thousands New Turkish Lira to fix the engine again. Although I reminded them that my car was serviced five months ago in the same service and assured that there would be no problem, they said it is not their responsibility. In my opinion they used improper engine oil and it caused this wear. As you may understand, the cost of the repair should be paid by you.

I would be much appreciated if you could investigate the problem and pay the cost of wear in my car."

**PART II**

The car distributor contacted the service station and asked them to investigate the case and respond to them. The following letter was written by the service station.

"… the problem was investigated. The customer came to our service about five months ago and a routine service was carried out. The air and oil filters, engine and brake oils, spark plugs have been changed and a computerized check was carried out for possible faults. We wanted to also check cooling system of the car, but the customer did not want us to do this. The customer came to our service station again a week ago and reported that there is a problem in the car engine. We checked the car again and realized that the engine of the car was worn four times more than normal and reported to him that it will cost approximately three thousand NTL to fix the engine again. The customer argued that this is service station's fault and the service had to pay the cost. We did not accept this and he left our service saying that "I will complain you to the main distributor". We think that as he did not accept our offer for a full check, including the cooling system of the car, the customer should have the responsibility for the cost of damage in the car's engine."

If you were the distributor how would you answer the following questions to resolve the case?

- What questions do service staff have to answer in this investigation?
- What other information do you need to resolve the case?
- What kind of information should you collect?
- What kind of measurements do you need to take?