

CHAPTER 11: PROBLEM-BASED LEARNING

Assoc. Prof. Dr. Hidayet Tok
Zirve University, Faculty of Education

(Translated by Tülin Şenmerdan Uçar)

WHAT IS PROBLEM-BASED LEARNING?

In an age in which knowledge doubles every ten years and spreads too fast, it has become impossible for information to be memorized. This situation has brought to the forefront the individual who can use knowledge, question, think, discuss and solve problems and made it compulsory for him to be trained in this direction. The approach proposed for the education of such individuals is Problem-based Learning. Problem-based learning has taken its bases from John Dewey's views of "learning from experience".

Problem-based learning (PBL), which is a teaching method which tries to ensure that students learn by working in groups and in cooperation to research the real global problems, is known to have been pioneered and put into practice by The Faculty of Medicine, McMaster University of Ontario, Canada and used for the first time in the curriculum of Health Sciences in 1960's.¹ Since then, it has been a teaching approach used in many disciplines such as engineering, law and architecture. The use of problem-based learning in education began in 1980's. Why problem-based learning started to be used in education is because it was noticed that students could keep only little knowledge in their memory and were not able to use knowledge in other fields by transforming it when the traditional method was used.²

Problem-based learning constitutes one of the most important practices of the constructivist learning-teaching concept.³ Problem-based learning exposes students to a complicated situation or incident and encumbers them with the role of "possession of" the problem or of "responsibility for" the incident. Students define the real problem and learn whatever is necessary to work out a valid solution by means of research. Problem-based learning represents a learning based on experience, which calls for the active use of both the mind and skills of the individuals. Problem-based learning is an educational approach aiming to upskill students in learning how to learn and to increase their capacity for learning.⁴

Problem-based learning is an approach, which focuses on the problem, from teaching objectives to students' behaviour and from the method and technique to be used up to measurement and evaluation procedures. Consequently, first of all, the goals and behaviours need to be determined in such an approach. Subsequently, the methods and techniques to be used at the stage of problem solving will need setting.

While some educators consider problem-based learning as a teaching method, a great majority of them consider it an approach for a teaching and training program.⁵ Problem-based learning has evolved out of an extensive repertoire which searches how people will be able to obtain and transfer knowledge.

Watson and Matthews state that problem-based learning has three main characteristics⁶:

1. It is an organization of problem-based teaching. It has a totalitarian structure and emphasizes especially cognitive levels.
2. It has a structure facilitating the experiences in small groups, special education and active learning processes.

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3. It develops skills and motivation and maintains the skill for lifelong learning.

CHARACTERISTICS OF PROBLEM-BASED LEARNING

The Steps for the Practice of Problem-based Learning

Problem-based learning may include different steps of practice in the teaching of many disciplines. However, the basic steps for all problem-based learning practices in the literature are as follows:

1. Meeting the problem and defining it
2. Determining what one knows and what he needs to know and putting his thoughts into order
3. Gathering and sharing information
4. Producing potential solutions and hypotheses
5. Determining the learning issues
6. The application of the new knowledge to the problem and reevaluation
7. Identifying the best solution
8. Explaining the problem and its solution briefly
9. Evaluation and presentation of new learning⁷

The practice process of problem-based learning has been given in six steps in the diagram below.

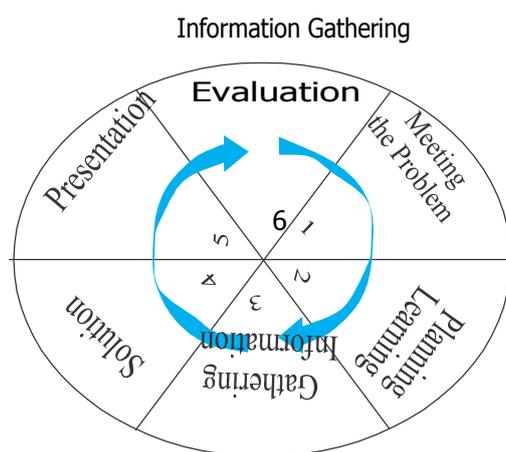


Diagram 1: Practice process of PBL

- I. Meeting the problem:* The tutor presents an ill-structured problem associated with real life to his students in small groups in a scenarized way. Students try to define the problem presented to them basing on their prior knowledge.
- II. Planning learning:* By exchanging views in groups, what is known about the problem is put into order and the points needed to be known are written down under the title "learning issues". Following a debate on potential solutions, the hypotheses produced are noted down. It is determined, benefiting from the guidance of the tutor as well, which information gathering method and resources will be needed for the solution and how they will be accessed. Plannings are carried out on each learning issue with attention paid to division of labour.
- III. Gathering information:* Information is gathered in an effort to access resources of information (library, internet, personal resources, etc.) Data needed is obtained via measurements carried out by means of methods (observation, experiment, etc.) intended for the solution to the problem.
- IV. Solution:* The data obtained is shared and interpreted. Potential solutions to the problem are discussed in groups and the best solution is determined.
- V. Presentation:* The solution identified for the problem situation is presented as a suggestion and explained to the other groups briefly. Views and criticisms about the suggestion are written down.

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VI. Evaluation: Students assess, from their points of view, the components of problem-based learning program and their performance during the process. Basing on learning products, the tutor carries out measurements and evaluations about the performance of his students.

The Role of the Tutor

The role of the tutor in problem-based learning approach is different from that of the traditional tutor. In problem-based learning, the tutor owns the role of a guide within the classroom and assists students in learning. He leads them about how to think and solve problems and directs their performance.

Roles of a tutor in problem-based learning can be listed like this⁸:

1. The tutor is motivated to spare time for the practice of problem-based learning, that is, PBL activities, deal closely with the performance of students, make them understand better and show that he gets pleasure from PBL activities.
2. He prepares true-life and well-designed problems and presents students with the problem situation using the media such as written scenarios, drawings, computer animations, video and tape-recorder.
3. He checks the accessibility of the resources such as books, periodicals and web, to which students can be directed for the PBL practices, and how practical they are for the work to be carried out.
4. He clearly identifies the goals, acquisitions, strategy and techniques in order to assess the learnings.
5. In PBL sessions, inexperienced students tend to forward their questions and information directly to the tutor. For this reason, the tutor keeps the groups under supervision and directs them to share what they know and their questions, if they have any, with the members of the group.
6. He addresses them questions to increase their comprehension to higher levels and to enable them to make in-depth analysis of the problem presented.
7. In order to create an atmosphere in which students share their views without getting possessed by the fear of being ridiculed, he guesses the ones who intend to ask a question but abstain, supports them and values their opinions.
8. He summarizes to the groups the positions they have reached so as to help them to check their work processes and to go ahead. He behaves impartially as far as possible while making this summary.
9. In cases groups have come to a point where they cannot go any further or in the decision-making processes of the ones who are not yet accustomed to PBL, he suggests some alternatives.
10. He monitors the PBL process of the groups. This is important in terms of both his place and the places of the groups within the process.
11. He includes questions for which he will be able to get the impressions of the students about the process both individually and as a group.
12. He gets free of the role of a sage and undertakes the role of a guide and a facilitator.

The Role of the Student

Problem-based learning is a student-centered approach. Therefore, the most important task lies within the student. In problem-based learning, the tutor and the student interchange their roles. In this method, the responsibilities of students in learning increase. Students move from a passive position to an active one. Students are persons who think, know and solve problems. The situation is that of a student who has turned into a tutor and of a tutor who has turned into a student, so to speak.

In problem-based learning, students are asked to learn as soon as possible how to succeed in self-directed learning. In this approach, the role, which students undertake in learning, has completely changed. Students who structure information actively have replaced passive receivers. Students working in groups need to organize their prior knowledge and define problem situations. Students should be inquisitive about things they do not understand, the design of a problem-solving plan and how to identify the resources needed.⁹

1. Analyzing the problem situation by comprehending the structure of the problem broadly.

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2. Developing practical solutions to the problem.
3. Undertaking a decision-making role in debates within the group.
4. Cooperating with the tutor and friends and determining the learning goals, which need researching for the solution to the problem.
5. Identifying the resources and strategies, which will be able to convey to the learning goals.
6. Assessing the conclusions one draws from the data obtained, that is, the learning products.
7. Checking both the learning goals and the learning media.
8. Presenting his opinions in a clear and understandable way in which the other group members can conceive.
9. Evaluating different views impartially.
10. Being aware of his roles and responsibilities individually.
11. Exhibiting behaviour of a type, which defends new ideas and situations and gets them across to the other members.
12. Congratulating and appreciating the other group members on account of their convenient suggestions leading to the solution.
13. Developing the knowledge infrastructure for the solution to the problem
14. Being able to set certain targets, which may be useful in using suitable research procedures and directing the group.
15. Carrying out observations and practices taking into consideration the processes used by the implementers of the field or the discipline related to the problem.
16. Becoming the instructor of each other by teaching what they have learned to the other group members.
17. Being courageous in focusing on a new problem and on its potential solution.
18. Getting into contact with the external world and other people so as to discover concepts and to use his abilities.
19. Approaching problems and their solutions with new and original ideas.
20. Being inquisitive during the process.
21. Giving positive input to constructive criticisms.
22. Joining group work on time and on a regular basis.
23. Assessing his and his friends' contribution to the group work in the course of it.
24. Finding out important resources for the solution to the problem and sharing them.
25. Turning the work into a report and presenting it to the class.

Problem situation

The use of problem situations constitutes an important part of the operation of problem-based learning process. Such problems are different from normal post-test problems and citations are made from daily life events during its preparation in order to attract students' attention. ¹⁰As is known, traditional problems are presented after the students are given the necessary information about the target concept. The content of the problem is simple and the problem is of a kind, which can easily be solved by the use of the information given in the content. Conversely, in problem-based learning approach, the student should access the information himself. In consequence, the tutor does not convey the information about the concept or concepts directly to the student. Problem situations are used to ensure that the student accesses information. The student encountering the problem does a research to solve it. Within this research process, he accesses the information he needs himself with the guidance of the tutor and uses it for the solution to the problem. The superiority of problem-based learning approach arises at this point. Individuals working with this approach are able to access information themselves and use it. ¹¹

The Characteristics of A Problem-based Learning Problem

The characteristics a PBL problem should involve can be listed as below¹²:

1. A quality problem should be able to attract the student's attention and stimulate all the students.
2. It should be reliable and there should be a relation between the problem situation and the real world.

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3. It should be meaningful and suitable for student's level of cognitive development and should provide an opportunity for interactions among students.
4. It should base on the student's current knowledge.
5. It should be ill-structured, that is to say,, it should have more than one way which will lead to the solution.
6. It should be authentic. In other words, problems should not be from outside of everyday life of students and exceedingly theoretic and should be selected from real world.
7. It should be ill defined, that is, questions should come to students' mind in order to cognize it when the problem is first heard.
8. It should support lifelong and self-directed learning.
9. It should be convenient for students to state their decisions at each stage.
10. As some problems will be solved as a group, it should be convenient for cooperation. It should have a feature that the group members can reduce it to sub problems.
11. It should be open-ended and not single-answer.
12. It should be associated with student's prior knowledge and be of a nature to support it. The problem should generate different points of view.
13. It should be able to motivate students to do researches so that they can have a more in-depth comprehension of the concepts they meet.
14. It should necessitate making judgements and decisions on the basis of knowledge and reason.
15. It should be complicated enough to necessitate the cooperation of all group members to work out a solution.
16. It should be debatable enough to draw all group members to a debate in the beginning.
17. It should cover the acquisitions of the lesson.
18. It should connect the students' prior knowledge with new concepts.
19. It should associate the students' new knowledge with the concepts in the other lessons or disciplines.
20. Students' cognitive abilities should be promoted from Bloom's lower cognitive level (knowledge and cognition) to a higher-level thinking (analysis, synthesis and evaluation).

Evaluation in Problem-based Learning

The concept of measurement and evaluation in problem-based learning approach is different from that of the traditional approach. Students are not only evaluated in proportion of the correct answers they have given to the questions in traditional measuring tools (written and oral examinations). Evaluation involves concluding about students' success basing on observation of their behaviour in the classroom as well as (written and oral) examination results in traditional measurement tools. ¹³

Evaluation methods in PBL are divided into two, as process-centered and product-centered and these methods are as follows: ¹⁴

Process-centered Evaluation Methods:

1. Classifications of tutors and of students' peers aimed at evaluating students
2. Students' evaluation of themselves
3. Nonirritating measurements (library records, articles checked, pupil tracking sheets)
4. Oral examinations and interviews
5. Observations
6. Student reports
7. Evaluation of problems
8. Performance evaluations (visual, verbal, audial and written presentations, graphics, demonstrations, mathematical analyses and portfolios)

Product-centered Evaluation Methods:

1. Student reports
2. Evaluations conducted by students
3. Multiple-choice examinations
4. Short-answer and gap-filling examinations

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5. Written examinations
6. Evaluations of portfolios

It is a key component in problem-based learning to give students the chance to evaluate their own learning and reflect it. With self-evaluating step, the students are enabled to compare their performances in achieving the goals they determine as a group when the problem begins. Self-evaluation enables students to develop their ability of monitoring their own learning outside the academic environment and helps them to achieve their goal to be life-long students as well. ¹⁵

In summary, in classes where a problem-based teaching strategy is applied, evaluations are carried out in the form of students' solving problems by using the knowledge they have obtained from lessons and their life experiences instead of paper and pencil tests. Since the responsibility for learning belongs to the student in the strategy for problem-based teaching, he should be able to conduct self-evaluation and the tutor should only act as a pathfinder and a guide.

Traditional Teaching Approach and Problem-based Learning

There exist profound differences between traditional teaching approaches and problem-based learning in regard to objective, role of the tutor and of the student and acquisition of knowledge. Some of these differences have been listed in table 2. ¹⁶

Table 2: Differences between traditional approach and problem-based learning

	Traditional Approach	PBL Approach
Objective	Enabling students to repeat the knowledge they have learned as it is when they are asked to.	Enabling students to construct their knowledge themselves to work out a solution to a problem situation.
Tutor's Role	<ol style="list-style-type: none"> 1.The tutor gives information and directs their thinking. 2.The tutor guides students into learning and evaluates them. 3.Learning materials are prepared and presented by the tutor. 	<ol style="list-style-type: none"> 1.The tutor, as a cognitive guide, exposes students to a problem situation. 2.The tutor, as a resource person, asks students questions, relates to students' world and directs their learning. 3.The tutor identifies the learning situations and students select the problems and learning materials.
Student's Role	<ol style="list-style-type: none"> 1.The student is passive. 2.As a follower, the student awaits the leadership and guidance of the tutor. 	<ol style="list-style-type: none"> 1.As problem solvers, students work out various solutions to problems they meet making use of the resources available. 2.As participants, students are active in the learning process and research the problem extensively.
Information	It is gathered, organized and presented to students by tutor.	Very little of the information is presented by the tutor. Most of it is gathered and constructed by students.

ADVANTAGES OF PROBLEM-BASED LEARNING

- 1. The lesson is student-centred rather than teacher-centred.** In a lesson grounded in a problem-based approach, the student determines what he knows or not about the existing problem. He continues learning by performing observations, experiments, practices, researches and analyses at the stage of acquiring new knowledge. The tutor guides his students into access to resources.
- 2. It develops self-inspection of students.** During the process of problem-based learning, the student can develop his self-inspection. Self-inspection is the student's adoption of some rules and obeying or enforcing them by himself without the need for external warnings. In short, student is given the opportunity to gain the ability for self-direction in problem solving.
- 3. It joins practice and theory.** The student gets the chance to transform the knowledge he has learned theoretically into practice with the help of PBL. Problem-based learning supports students in both joining their prior knowledge with new ones and developing their judgement skills in a certain disciplinary climate.
- 4. It maintains life-long learning.** Life-long learning is defined as continuous analysis, investigation and behaviour of search for knowledge in one's own field of specialization or in other fields of interest. The individual gaining the skill for problem-based learning can do an activity of search for knowledge and problem solving in his field of interest in any phase of his life.
- 5. It provides active learning.** It is aimed to gain students scientific processing skills such as making observations, classifications and measurements; using numbers; building up contact; making assumptions; collecting, recording and interpreting data; determining and controlling variables; making definitions; forming a hypothesis; making experiments and creating a model and using it at the end of the active learning process. ¹⁷
- 6. It gains group-working skills.** PBL focuses on earning students the skills of working in teams and in small groups. Lessons involving learnings in small groups have a more positive effect on students' academic successes, their pursuit of lessons and programs and their attitude to learning compared to traditional teaching.
- 7. It gains problem-solving skills.** Problems awaiting the next generation professionals will be from different disciplines and will call for new approaches and skills of solving complicated problems. To gain or strengthen students' skills of solving problems which are from their real world and which have a complicated nature is included within the aims PBL focuses on.
- 8. It increases science literacy.** Science literacy consists of establishing a connection with scientific facts, knowledge of concepts and theories, scientific thinking habits of mind, understanding the nature of science, mathematics, technology, the influence of technology on people and its role on communities.
- 9. It gains scientific process skills.** Most scientific programs, by excluding the most interesting application-oriented parts of the steps of scientific research process, focus on only a few steps. Yet, PBL has a nature motivating students to scientific thinking, which bears very close similarities to these steps.

The following are skills constituting main skills in scientific research process:

- Performing observations
- Making classifications
- Building up contact
- Making measurements
- Making predictions
- Drawing conclusions
- Identifying and controlling variables
- Forming hypotheses
- Interpreting data
- Producing definitions
- Making experiments

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- Forming models
- 10. It gains highly memorable knowledge.** Though, in some resources, PBL is stated to gain less knowledge when compared to other methods, there exist studies stating just the opposite and asserting that the knowledge gained by PBL is even more memorable.
 - 11. It gains metacognitive skills.** Metacognitive skills mean students' awareness of thinking and thinking processes of their own. Metacognitive skills, known to involve behaviour such as the ability to see an executive function in thinking, negotiating, expressing opinions about the problem situation, reviewing and recalling knowledge about the things told regarding the problem, forming hypotheses, determining what to observe, asking questions when necessary, questioning the meaning of the failures within the process by research and reviewing the new learning, are included within the goals students should achieve in PBL.
 - 12. It gains self-directed learning skills.** Self-directed learning is students' direction and planning of their learning activities by themselves. PBL approach enables students to develop their self-directed learning skills in order to achieve the goal expressed as "learning how to learn". Thus, students gain the attribute of carrying out their self-directed learning in the rest of their lives.
 - 13. It gains critical thinking skills.** Critical thinking is defined as identifying central topics and hypotheses in a debate, realizing important associations, drawing correct inferences, making conclusions from the data obtained, interpreting the conclusions, whether they are based on the data or not, and evaluating the prevailing opinions and evidence.¹⁸
 - 14. It gains cooperative learning skills.** Cooperative learning is cooperation of students as a team for a common goal, in other words, each student's learning what makes a cooperative learning activity valuable. PBL develops cooperative learning skills. By working in small groups, students compare their learnings with that of others..
 - 15. It facilitates high motivation and positive attitude.** In problem-based learning process, students are willing and enthusiastic about learning, because as they make personal investment in the results of their own researches, they go deeper in the learning job, which causes motivation to rise higher.¹⁹
 - 16. It gains communication skills.** Speaking to group members directly, using words they can understand, presenting clearly, asking nonjudgmental and open-ended questions properly, identifying the misunderstandings among group members and trying to settle them, expressing his feelings, understanding verbal and nonverbal behaviour and responding to them are among the communication skills involved in PBL.
 - 17. It gains higher-order thinking skills.** The main goal of PBL aiming to develop the higher-order thinking skills is to motivate students so as to ensure that they learn at higher levels of learning such as analysis, synthesis and evaluation instead of simple levels such as knowledge, comprehension and application from Bloom's levels of cognitive learning. In PBL, students are given the opportunity to gain higher-order thinking skills by means of well-designed problems.
 - 18. It constitutes a model for teacher candidates.** Lessons done through PBL approaches in which the student is active within the learning process and the tutor provides guidance instead of giving ready information, in this sense, have the quality of model applications which teacher candidates can take as examples.
 - 19. It increases skills in using information resources.** PBL, in addition to students' skills in finding, evaluating and using suitable learning resources, increases their skills in consulting personal resources and getting information as well.
 - 20. It develops decision-making ability.** PBL, by enabling students to get rid of indecisiveness and timidity, helps with their individual development.

LIMITATIONS OF PROBLEM-BASED LEARNING AND DIFFICULTIES IN PRACTICE

Besides many benefits of problem-based learning, there also exist studies touching on the limitations seen in practice. Limitations of PBL have been given below:

1. The most important problem with problem-based learning is the formation of the problem. The problem may sometimes not include the topic, or sometimes involve different topics.

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2. Direction of students who have continuously had lessons with the traditional approach to problem-based learning is likely to cause some problems.
3. It may take a long time to use such an approach in formal education. The length of time may cause the student to get bored or his motivation to lessen.
4. If the leadership skill of the tutor is poor, he may fall short in the direction of the class, which will cause the emergence of problems much more complicated than solving the problem.
5. It is quite difficult to evaluate learning in problem-based learning. It can also be difficult to evaluate all students in-group work objectively.
6. Teaching programs may not be suitable for problem-based learning, because the preparation of these programs has mostly been predicated on traditional teaching approach.
7. Students may be faced with resource constraints in problem-based learning, which prevents them from accessing information. What is more, it is almost impossible that the materials to be used should be developed by the student alone. ²⁰

The limitations of PBL can be stated in terms of tutor, student, nature of knowledge it earns, time and cost as well.

Difficulties Tutors Experience

Tutors, as they have moved from the role of a tutor transferring information in traditional environment to the role of a facilitating tutor who encourages his students, feel depreciated.²¹ Moreover, tutors who want to keep the control of the class in his hands and to do the lesson with students who are passive listeners feel uncomfortable with PBL environment. For tutors who have accustomed themselves to the role of transferring a body of knowledge to students, it is difficult to get used to their roles in PBL. ²² While, in traditional system, tutors perceive themselves as experts in their fields, they feel unconfident and disappointed since they cannot answer questions out of their fields, and they see themselves as instructors who are not experts in the field in PBL. The fear of not knowing and being unable to get accustomed causes great anxiety. High anxiety leads to avoiding PBL and in consequence, to resistance and refusal. Furthermore, as tutors need confirmation for the things they tell about in the traditional system, they demand lecture-based teaching method. ²³ Consequently, tutors are likely to have difficulty with changing their styles. Besides, if the tutor's leadership ability is inadequate, he may fall short in the management of the class, which will cause problems much more complicated than the solution to the problem.

The Difficulties Students Experience

A feeling of fear is likely to arise in students due to a different system. Because there is no stable curriculum and coursebook, they do not know (at least in the beginning) what they should learn. Additionally, the anxiety that each student will own different knowledge and skills prevails in them. They are confronted by a dilemma between their habits and the learning expected of them in PBL. ²⁴ Thinking and learning by means of problems is a situation they are not familiar with. Nevertheless, PBL may generally have some more disadvantages with students who are timid, lacking in self-confidence and exceedingly kind. In fact, students should ask questions continuously and do researches themselves to work out the answers for a successful PBL practice. Student-tutor relationships should be clearer and freer. Students should be free to criticize their tutors and make mistakes and learn owing to these mistakes.²⁵

The Nature of the Knowledge It Gains

It is stated, in some studies, that students gain less knowledge in PBL. Another criticism made is the emergence of a lack of gaining knowledge and focusing on problems, which make students, think of only limited subject content while students are aimed to gain higher order thinking skills in PBL. PBL students may not perform as well on multiple-choice tests as students taught by lecture-based method. However, researches carried out have brought to light that PBL students can keep knowledge in mind for a longer period of time. ²⁶

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Time One of the aspects of PBL, which is criticized most, is that such a practice needs much more time compared to the traditional lecture-based teaching.

Cost Another disadvantage of PBL is that it costs more in comparison to the traditional teaching based on lecture. Many factors are included in this cost calculation. Time spent by tutors and students, the personnel support required, rooms for the need of small groups for meetings and resources like library materials are among these factors. However, while a great number of students can be given lesson by one instructor only; there is a need for plenty of tutors for such a class in PBL. The support of teaching institutions regarding cost calculation is needed more in PBL compared to other teaching methods.

IDENTIFICATION OF THE PROBLEM SITUATION AND WRITING A SCENARIO

In problem-based learning, it is important to write scenarios relating to problems and to how they will be solved. After the topic to be dealt with is analyzed by students and tutors, the relevant problem, sub problems and scenarios associated with them are developed and researched. Students dwell on real life problems while preparing a problem on a topic related to lessons for science, math, social sciences, etc. The scenarios to be developed should involve real life examples. The aim of the problem or the scenarios dealt with is to get the student to the learning goals he is asked to obtain in certain periods of time. ²⁷

After this stage, the thing to be done is write down the problem situation. The scenarios should be organized in a way to explain the problem, designed in line with real life, be interesting and it should be able to produce a solution to the problem at the end of the period. Students, when they make efforts to solve the problem with scenarios, should meet situations for which they can find resources and be motivated and which have a field of practice.

In writing a scenario suitable for the problem, the teaching program is benefited from as the starting point. With the subject in the program analyzed thoroughly, main concepts, the existing knowledge about the subject, the topics which need to be known and where, how and with which methods this information will be obtained are determined by students. In the preparation of the scenarios, the tutor should carry out the necessary orientations for help. Otherwise, students are likely to deal with the subject too broadly or too constrictedly. It is very important to fully present the problem, which will be determined. Students should be asked to present their scenarios with a concrete product. The aim of the product to be presented should be explained accurately and the products should be suitable for the level of students. The scenarios can be written, oral, audial and visual.

Examples of Problems

Some examples of problems, which can be used in science, mathematics and social sciences education, have been given below:

1. Suppose, one day, while you were driving on the highway with your father, you saw a warning sign, read the warning "Slippery When Wet" and your father slowed down immediately after he saw this warning. Why?
2. Suppose you were spending your holiday by the sea and when you went out one morning, you saw many dead fish and some people picking them up to eat. How would you behave? Why?
3. Recently, you see that, in the detergent commercials broadcast on TV, commercials for lemon detergent are frequently advertised. Why, in your opinion, is lemon specially emphasized in detergent commercials? ²⁸
4. One day Ali was playing with a metal part he had found. He tried to compress the metal part in his hand to measure his strength against it, but did not succeed. His friend who was with him said that Ali would not be able to do this, as their teachers had mentioned solids was incompressible. Ali asserted that metal was compressible and decided to research this subject. Do you think solids can be compressed? Please explain.

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5. Karagoz shadow puppet play will be shown in our school. There exist 12 rows of chairs in tandem and 16 rows of chairs side by side in the school conference hall. It is you who should prepare the tickets for this play. How will you number the tickets in a way to enable the guests to find their seats in the easiest way?
6. There exist cardboards with the dimensions 8 cm by 8 cm in the stock of a sugar factory and the factory staff wants to make open-top sugar boxes out of these cardboards. However, the boxes should have maximum volume so that they will be economic. How would you design this if it were you?
7. We know that chess was first played in 570 A.D. in India. Word has it that, the Brahmani priest who invented this wanted to give the Shah a lesson. He meant to say "However important a man you are, you avail nothing without your men, your viziers and your soldiers. You cannot do any important work" . The Shah seemed pleased with the situation." All right, I liked your lesson. Make your wish", he said. Upon this, the priest, thinking that the Shah did not still learn his lesson that he was supposed to, said,"I want some wheat. I want you to give me one grain of wheat for the first square of the game I have invented, two grains for the second, four for the third. Thus, in each square, I want twice as many grains as I take in the previous square." "Make a calculation and do not give him even one grain more than he has deserved," the Shah told the people near him ironically. How, in your opinion, can we calculate the amount of wheat the priest will take?
8. Means of communication and especially mobile phones, of which use has recently grown rapidly, facilitate our lives. Technology, while it facilitates communication, on the other hand, exposes us to some unknowns. Base stations need to be made widespread for mobile phone coverage everywhere. The effects of base stations on our health have been among the unknowns for long, but these effects have now begun to be specified gradually. That this information is not positive is now a known fact. For instance, like the rise of the cases of cancer 7-10 years after the atomic bombing of Japan, health problems will break out all at once after years on people who live in places where base stations have been installed and also on those who use mobile phone so frequently. Base stations are devices which are generally white, box-shaped and four-meter high, installed on the roofs of buildings to expand the field of communication and which consist of two rod antennas and a dish antenna emitting microwave.
How have mobile phones affected communication recently? How can the increase in the use of mobile phones be evaluated? Which age has the use of mobile phones dropped to? Every how many metres do you think we can meet base stations on the roofs of apartment buildings? Do the use of mobile phones and the increase in the number of base stations constitute a problem? If so, state the problem.
9. Although not known exactly, the invention of glass is thought to date back 4000 years ago. Though glass is simply defined as "an amorphous object" in dictionaries, it can be as bright as diamond, as feverish as opal, as colourful as a rainbow, as light and delicate as a spider web or as big as a mirror weighing 20 tons, as fragile as an eggshell or as hard as steel. To tell the truth, glass is an "unusual" material. Envisioning a world without glass is the same as envisioning a world where there is no science and civilization. At the present time, science is far ahead of using a sandglass to measure time or evil eye bead for protection from bad spirits or evil eyes, which are believed to cause illnesses. Glass has, in every step of the science voyage, accompanied it. The most important disadvantage of glass used in every field today is that it can easily be broken. What is the reason why glass is easily breakable (with low endurance) compared to other solids? Please explain.
10. Sione and his family were making a living by hunting. For years, Sione and his family had been maintaining their lives by catching bats and the fish in coral reefs and by eating vegetables. However, in the last few years, Sione and his family began to sell the bats they hunted to dealers. The dealers were taking the bats they bought to the island of Guam. Sione heard that there were no bats left since the people living in Guam had hunted them excessively. Consequently, the people living in Guam had to pay a large amount of money for Samoa bats. Sione and his family became greed to earn a lot of money by selling bats. A reason for this was because they were unable to catch fish in their village anymore as fruitfully as they did before. The amount of the fish they caught was getting less gradually and some valuable species of fish seemed to disappear. Sione also knew that his family was worried about not selling enough fish in the

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marketplace. Sione knew that selling bats would earn them a lot of money, and thus they would be able to buy the food and clothing they needed. A few weeks ago, Sione's teacher had told the students in the class that many people hunted bats and that, for this reason, bats would become extinct. These words made Sione anxious as he always wished that there were enough bats for his family to hunt. Sione learned from his teachers that bats mattered for Samoa people from some other aspects too. Bats were drawing to the island the tourists spending plenty of money. They were playing an important role in the fertilization of many fruits Sione and his family ate. Sione went on hunting bats and selling them to dealers. However, one day, he saw that a signboard had been stuck up in the fruitful hunting ground, which said, "It is forbidden to hunt bats! If you kill or pick them up, you will be punished and dispossessed of them". Sione knew that the source of income for his family depended on bat hunting, but he also knew that he should not break the laws. Sione did not want the bats in Samoa to disappear as on the island of Guam.(Braus and Wood, 1993; 261-263)

Questions

1. Should Sione continue hunting bats?
2. Should he discuss the new law with his family?
3. What other ways can he try to bring money to his family?

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