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Problem-Based Learning: An Approach to Chemical Engineering Education within the EHEA

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1. Introduction to Problem-Based Learning: Definition, origins and evolution

Problem-based learning (PBL) is an approach to structuring the curriculum which has derived in an educational technique that confronts the students with problems from practice, providing a stimulus for learning.

PBL was originated and introduced in the undergraduate learning processes in North America more than 30 years ago, in order to improve the exhausting pattern of basis science lectures, and clinical teaching programmes in medical science. With the help of the information technologies PBL has become a very efficient learning method. Medical Faculty at the McMaster University in Canada introduced the tutorial process, not only as specific instructional method (Barrows & Tamblyn, 1980) but also to promote student-centred multidisciplinary education as a basis for a lifelong learning in professional practice (Neufeld & Barrows, 1974), incorporating a wide range of instructional new methods and strategies, which was the forerunner of the PBL tutorial (Bussigel et al., 1988). Harvard Medical School, with their PBL tutorials, lectures, conferences and clinical sessions integrating teaching and learning around weekly themes is also a good and old example of application of PBL (Tosteson et al., 1994).

As it was previously commented, PBL was first established in Medical Science, however, many teachers of other sciences such as biology, biochemistry, chemistry and physics, from North America became attracted by these techniques and were adapting the contents and training programs for teachers for the correct application in different subjects. However, for many instructors and teachers the adoption of PBL as a mode of instruction was a change not undertaken lightly, and the implantation of PBL took more time than expected, not only due to the teachers but also to the students. Nowadays faculties and educational institutions throughout United States, Australia and Europe have adopted PBL as a valid learning offer for both students and teachers.

PBL is being used thinking that learning is more effective when the students are actively involved, learning in the context in which the knowledge is going to be used. The problems should act as a stimulus for the student activity, focused the students' learning in a professional practice (Engel, 2008). For this reason PBL is a pedagogical very useful strategy for the teaching-learning process within the European Higher Education Area (EHEA).

2. PBL characteristics and models

There are several authors that set PBL in the context of an approach to learning rather than a teaching technique, framing PBL as a means of developing learning for capability rather than learning for acquiring knowledge (Engel, 2008). Other authors such as Barrows associate PBL with a particular strategy, based on small groups with a supportive tutor, doing this method consistent with adult learning principles and able to be applied in undergraduate studies (Barrows, 1986). PBL should develop the following abilities:

- To think critically and be able to analyze and solve complex, real-world problems.
- To find evaluate, and use appropriate learning resources.
- To work cooperatively in teams and small groups.
- To show versatile and effective communication skills, both written and verbal.
- To use content knowledge and intellectual skills acquired at the undergraduate studies, to become continual learners.

Normally, the process of a problem-based instruction should have the following scheme (Duch et al., 2001):

- Presentation of a problem to the students. The students begin then to work in permanent groups and they must organize their ideas and previous knowledge related to the problem and attempt to define the broad nature of the problem.
- Discussion sessions in which the students pose questions (learning issues) indicating the aspects of the problem that the students do not understand. These learning issues help in the generation of discussion about the problem.
- Ranking, in order of importance the generated learning issues. Assignation of the team tasks, and discussion with the teacher about the tasks, resources for the search and the learning issues.
- Exploration of the learning issues by the students, integration of their knowledge in the problem context. Summarization of the knowledge and connection of the new and old concepts about the problem. Definition of new and more accurate, learning issues and solution, if possible, of the problem.

One of the main problems of PBL is that the model is not generally applicable to many typical undergraduate courses for a variety of reasons, such as class size. Thus, several models of problem-based instructions have been used by different faculties and undergraduate institutions. The most important models in PBL are (Dutch et al., 2001):

- *Medical School Model*, in which students are assigned to groups of eight to ten, and to each group is assigned a faculty member who plays the role of tutor, while the students work through a case of problem. This is a very student-centered model with almost no formal class time and only group meetings, to discuss the materials and problems. This model requires small classes and in some cases additional tutors to the regular teacher of the subject.
- *Floating Facilitator Model*, this is an applicable model in large size classes and when there is no possibility to have an individual tutor for each group. Thus, this method limits the size of each group to four or five students (Johnson et al., 1991) in order to improve the participation of each of them. In this model only a portion of class

time is for individual group discussions and the teacher acts as the "floating facilitator" moving between groups asking questions and supervising the students' understanding. Debates, presentation of project results or problem solutions and flash presentations are also possible sessions of this model.

- *Peer Tutor Model*, in this model undergraduate peer or near-pear tutors are utilized to check and assure the correct work and discussions of each group. The introduction of peer tutors enhances the positive aspects of group learning, serving as a role model in the PBL process for inexperienced students, looking for conceptual understandings and serving as the teacher's window into the groups, informing what is working well and what not. Feedback of peer tutors is very informative and important for the teachers, helping them to improve their models.
- *Large Class Models*, these must be more teacher-centred than the others. Large class models can also use undergraduate peer tutors or graduate assistants as floating facilitators for group supporting and assisting purposes. In large groups, teachers need to design additional structures into group activities during class times. The teacher should act as a discussion leader trying to promote discussion of the groups into teacher' generated questions, rank learning issues and report results for each group, and ask probing questions. This method is based on the Floating Facilitator Method; however, there is a need to limit the time that groups spend in individual group discussions with the teacher, in order to save time.

3. Design good PBL problems

Normally, the writing process of PBL problems may be quite difficult, resulting in a time consuming challenge that may frustrate the authors. However, this is not the principal problem in the writing and designing process, the most important characteristic of PBL problems must be their clarity for the students and the adaption of complex materials to the student level. But not only the elaboration and presentation of the problem is important, other things such as concept knowledge, the students' need for the acquisition of knowledge, and application of the acquired concept in the real life are some of the important features of PBLs that teachers should have into account in the design and writing of good PBL problems. For a correct design of a PBL problem the following characteristics are required (Dutch et al., 2001):

- An effective PBL problem must motivate the students for a deeper understanding of the proposed concepts. It should relate the subject matter to the real world as much as possible, placing the problem in a familiar context for the student.
- Problems should require the students to make decisions or judgments based on facts and information. Not all the information given in the problem needs to be relevant for the solution, and the problems should be designed with multiple stages to work step by step.
- Problems should be complex enough to assure that cooperation of all the members of the group will be necessary for the final solution. The length and complexity of the problem must be such that students realize that the individual work is not a good strategy for the final solution, and that it requires a cooperative learning and group discussions.

- The initial question in the first stage of a problem should be based on previous knowledge of the student and should be controversial in order to initialize students discussion about the topic, trying to keep the group together.
- The concepts and contents objectives of the subject must be included in the PBL problems, trying to bind previous knowledge with new concepts and connect with concepts of other subjects in the degree. The problems should also enhance many general competences and skills such as their planning and time management, problem-solving and capacity of analysis and synthesis.

4. Working groups in PBL

PBL is based on collaborative work, a group of students must work toward common objectives, this helps in the detriment of the student isolation (Seymour & Hewitt, 1997). Thus, activities that promote a collaborative learning are always very welcome in the teaching-learning process (Michaelson & Black, 1994). Many teachers that choose PBL as an education technique in their courses, recommend the formation of the groups at the very early stage of the course, if possible in the first day of class, explaining to the students the reason because using groups is a good strategy for PBL. In addition, it is recommended to promote some interesting activities for the groups in the first day, such as writing the group biography, completing a learning style survey, and propose mental games that require the skilful use of the group.

However, the formation of the different working groups is very complicated. The groups should be heterogeneous, in order to expose students to new ideas and distribute assets and liabilities (Michaelson & Black, 1994). Formation of such groups can be either randomly (with the risk that the group finally is not so heterogeneous) or based on information provided by the students such as special skills, desired grade in the course, course and work schedules. It is desired that minority students should not be isolated in groups, in order to reduce the possibility of discounting their ideas and thinking.

One way to promote participation in the group and distribute responsibility is the assignation of roles that should be rotating within the PBL and the course. This is also a very reasonable way for monitoring groups, because the assignation of group roles, let the teacher to follow the degree of assimilation of the task and responsibility by the student. Commonly assigned roles of responsibility are (Dutch et al., 2001):

- *Discussion leader*, who maintains the full participation of the group members.
- *Recorder*, who records task assignments, unresolved issues, data and proposes dates for group meetings.
- *Reporter*, who reports during the discussions and writes the final decided assignments.
- *Accuracy coach*, who checks the group understanding and tries to find resources for searching.

The main problem of the working groups is the existence of conflicts within the group, the teacher should communicate clearly that each student is responsible for monitoring the correct functioning of the group as well as discussions, assignments and reports. However, the teacher should also make it clear to students that he will help and assist them in dealing with group conflicts being the one that has the final decision about each possible conflict.

5. Assessment strategies in PBL

A wide variety of approaches to assessment for PBL have been reported within the last years, however, this is one of the most difficult parts of PBL methods. Many of the methods are focused on the learning process while some other are centred on the learning outcomes.
Process-oriented assessment methods are focused on communication skills, acceptance of responsibility for learning, appropriate use of learning resources and development of problem-solving skills.
From these assessment methods, the following are the most commonly used (Dutch et al., 2001):

- *Tutor, peer and self-ratings*, assess a broad range of skills, including effort, self-directed learning, group cooperation and communication skills.
- *Unobtrusive measures*, which are based on the process of learning (Webb et al., 1966) checking the information resources and searches.
- *Learning exercises*, which are posed for students to complete. Classical examples such as the "triple jump exercise" (Painvin et al., 1979) in which the students are faced with a problem situation and they discuss the problem and their learning needs with an oral examiner who rates problem-solving skills, self-directed learning skills and knowledge of the problem area.

Outcome-oriented assessment methods, are emphasized in learning outcomes, self-directed learning skills coupled with differences in general ability result in marked variations in learning outcomes which must be assessed using some of the following methods:

- *Multiple-choice exams*, although they were rejected in the first stages of implantation of PBL (Newble et al., 1979 and West et al., 1985) currently are being used more commonly due to their efficiency in the requirement of the application of the knowledge in the problem-solving situations (Case & Swanson, 1996) and in detecting the problems and shortcomings in the learning outcomes.
- *Short-answer tests*, which are normally being used for the assessment of learning outcomes in PBL, when they are well designed.

6. A PBL example in Chemical Engineering Education: General Chemistry

6.1 Introduction

This sample problem pretends to be an interesting starting point for Chemical Engineering students in the knowledge of polymers of high importance in the chemistry industry. This PBL is designed for students of the first or second year for the subject "General Chemistry" of the Chemical Engineering degree.
Concepts as monomer, polymer, polymerization reactions, leaching of monomers, side-effects, and other interesting concepts for chemical engineerings will be handled and acquired by the students during this activity.
This PBL will also help the students in the development of generic competences such as planning and time management, oral and written communication, information management skills increasing the ability to retrieve and analyse information from different sources, teamwork and problem-solving.

6.2 Objectives

- Development of the capacity for applying knowledge in real situations.
- Improvement of problem-solving, capacity for analysis and synthesis and rational application of the knowledge.
- Development of the teamwork competence, with an active participation and collaboration in the team, using constructively the viewpoints of other colleagues .
- To have an overview of the current polymer industry as well as of the benefits and potential dangers of the use of these substances in the quotidian life.

6.3 Problem formulation and questions

From the beginning of March 2009, a very well known American gas and Chemical company is refusing to distribute one of the polymers of the "type 7" plastics (other plastics than polyolefins and PVC). This company requires its customers to guarantee that this substance will not be used for the manufacture of containers, bottles, cups and other things used for the children's food products. In addition, the six largest American companies which commercialize baby bottles, decided to stop the use of this polymer for the framing of their products.

These decisions in the American polymer industry have been caused by the fact that there are some suspicions, based on scientific studies, which determine that the use of these polymers in containers, bottles, cups and other things used for food products, may be risky for the human health, especially for children. The health risks associated to the use of this polymer are brain malformations, permanent changes to genital tract, and changes in breast tissue, activation of determined cells or hormones and carcinogens, early puberty, longer estrus and decline in testicular testosterone.

These side-effects associated to the use of this polymer have been measured in studies of rats and are still under investigations, however, the proposed health risks have not yet been observed in humans.

Questions to be solved

1. Which polymer is the responsible of these industrial and health decisions?
2. Is the polymer by itself the cause of the associated health problems?
3. Do temperature and content of the bottle/container have any influence in the associated health problems?
4. What concentration of substance is considered as the lowest limit for observed adverse effect? What does it mean?
5. Which are the advantages and disadvantages of the use of this polymer in baby bottles?

6. Which is the industrial process for the manufacturing of this polymer?
7. Which is the chemical mechanism of formation of this polymer?
8. How can we know if the use of this polymer for baby bottles or similar products is safe or not? Is possible the substitution of this polymer with a safer one?

6.4 Methodology

Identification of the learning needs (1 session: 1 hour in the classroom)

Individually, the student must analyze the problem, trying to find the reasons that origin this problem and its corresponding consequences.

Afterwards, the work teams will be assigned and these groups will analyze the problem trying to give a brief possible explanation that lead to the subsequent problem-solving.

The work teams will identify their previous knowledge in the topic of the problem, as well as the deficiencies of the chemical processes or concepts associated to the proposed problem, in order to find a way to search information and bibliography on the topic.

The working group will identify the necessary additional data to solve the problem.

Finally, the working team will design a working plan for the information search with the assigned tasks for each member of the group. A copy of this planning will be given to the teacher.

Information search (2 sessions: 1 hour independently and 1 hour with the teacher)

Following the working plan and according to the learning needs, each member of the working groups will use the available information sources (such as books, scientific journals, web pages, …) to get the necessary and adequate information.

A meeting with all the group members will be carried out in order to evaluate the appropriateness of the obtained information about the problem. The group will decide if the information is enough and adequate and if not an additional working plan will be design in order to cover the weaker parts of the problem.

In a second session with the teacher, all the groups, separately, will discuss with the teacher about the selected documentation which will be used for the problem-solving. The working plan will also be discussed and commented with the teacher in order to overcome the observed problems. In addition, the group can ask the teacher the necessary data for the correct solving of the problem.

Study of the collected information

Individually, the students will analyze and study all the selected information about the problem and the data on the topic given by the teacher (in case that they were necessary) in order to begin with the problem-solving process.

Students' strategy for the didactic solving of the questions 1-7 (1 session: 1 hour in the classroom)

The work team will analyze and study again the problem, in a "brain storming" session, in which the final aim is the debate, proposal and comparison of the different ways of each of the members for the problem-solving.

With all the proposed ideas and concepts the questions 1-7 of the PBL will be solved and answered. An inform with the answers and explanations for each question will be given to the teacher.

Students' strategy for the didactic solving of the question 8 (2 sessions: 2 hours independently and 1 hour with the teacher)

For the solving of question 8 of the problem, the students will elaborate an action plan and, individually, will collect information about the different polymers used for baby-bottles and food storage that are available in the current market in their country and in other countries.
Subsequently, the work team will elaborate a list of the different polymers used for those purposes and will evaluate the composition and possible side effects of the polymers.
Individually, each member of the group will then search in the information sources the analyses that are being carried out currently for the determination of the toxicity of substances.
Afterwards, the work group will decide the different tests to be carried out to determine the toxicity of the polymers or their components.
In a second session with the teacher, all the groups, separately, will discuss with the teacher about the collected information and about the proposed final answer for this last question.
Finally the work group will elaborate an inform with the solving to the question 8 of this PBL.
Presentation and debate (1 session: 1 hour in the classroom)
All the groups will give to the teacher a written inform with the solution to question 8.
Subsequently a spokesperson (chosen by the teacher) will present to all the students of the groups the proposed solution to question 8 of the problem (in a presentation of about 10 minutes and 2-3 slides).
After the presentation the teacher will open and moderate the discussion time in which all the students of all the different groups can ask, discuss and debate freely about the proposed solution to the problem.
Self-evaluation and peers' evaluation (1 session: 1 hour in the classroom)
All the students will fill, individually, a self-evaluation questionnaire about their activity and participation in the problem-solving, finalizing with a global mark about their work.
Subsequently, each work group will meet again in order to discuss about the marks that each student has given himself. The final mark will be modified (if necessary) after consensus with their peers.

6.5 Evaluation

An evaluation process will be carried out collecting information of each phase and activity of the problem-solving. The teamwork (60% of the final mark) and individual work (40% of the final mark) will be assessed.
Related to the teamwork, these items will be taken into consideration:

- Design and performance of the working plan for the information search
- Quality of the collected information
- Written inform with the answer to the questions 1-7 of the problem
- Written inform with the answer to the question 8 of the problem
- Public presentation and questions

Related to the individual work, these items will be taken into consideration:

- Personal behaviour in the teamwork activities. This item will be evaluated triangularly by the teacher, the student (self-evaluation) and the peers.

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7. A PBL example in Chemical Engineering Education: Instrumental Analysis

7.1 . Introduction

This PBL example pretends to be a useful tool for Chemical Engineering students in the knowledge of a quotidian problem such as environmental pollution, especially, in emergent polluting agents. This PBL is designed for students of the second year for the subject "Instrumental Analysis" of the Chemical Engineering degree. The problematic of the water treatment that presents a new type of polluting agents, like drugs, effects of their presence, methods for their detection and treatment are interesting concepts that chemical engineers students will handle and acquire during this activity. This PBL will also help the students in the development of generic competences such as planning and time management, oral and written communication, information management, work in group.

7.2 Objectives

a) Development of the capacity for applying knowledge in real situations.
b) Improvement of problem-solving, capacity for analysis and synthesis and rational application of the knowledge.
c) Development of the teamwork competence, with an active participation and collaboration in the team, using constructively the viewpoints of other colleagues.
d) To understand the importance of the right treatment and elimination of useless medicines.

7.3 Problem formulation and questions

The presence of pharmaceutical residues in the environment is one of the main problems that irrupted in the last years. Many of these residues, come from urban waste waters, garbage dumps and drug remainders (from exceeding drugs or by the own drug excretion non assimilated by the human body). These substances end up introducing themselves in the environment and the waters, many of the times through effluents of urban plants. Several investigations have shown that, generally, these pharmaceutical substances are not eliminated in water treatments and they are not biodegradable in the environment and may, therefore, finish in tap waters.

A company of water treatment that supplies potable water to several villages needs to know the quality of the water, in order to assure its safe consumption. This company also wants to quantify the presence of these drugs in the effluents generated by these villages. For these purposes, the company carries out a series of different water analysis from samples taken in different places and at different times throughout the year. The results that were obtained in these analyses are given in Table 1:

		Concentration (ng/L)			
Sample	**Month**	**Salicylic acid**	**Naproxen**	**Diclorofenac-Na**	**Ibuprofen**
River	August	300	25	Not detectable	100
	December	500	35	50	150
Dam in high mountain	August	8	Not detectable	Not detectable	Not detectable
	December	10	Not detectable	Not detectable	Not detectable
Lake	August	20	10	5	75
	December	220	15	35	120
Effluent in town A	August	550	300	60	220
	December	970	1500	390	260
Effluent in town B	August	2000	1500	190	460
	December	9000	2000	490	1000
Industrial Effluent	August	100	Not detectable	Not detectable	75
	December	8000	100	50	6500

Table 1. Dates of toxicity expressed as amount of drug obtained in the analysis of surface water samples and effluents of different populations at different times throughout the year.

After analyzing the obtained results, differences in the drug content were observed. Thus, the type of drug, the location of the sample and the period of the year in which the analysis was carried out, were some of the observed changes.

Questions to be solved

1. Identify possible contamination sources of the water samples
2. What relationship can exist between the detected drug levels and the dates of the measurements?
3. What relationship can exist between the detected drugs levels and the place where the samples were taken?
4. What problems may cause to the population the consumption of the analyzed samples?
5. What possible treatments may be carried out for the correct purification of the water?
6. Which current analysis methods are able to detect the presence of this type of drugs in the environment?
7. What changes or improvements need to be adopted to decrease the presence of these agents in the environment.

8. Design an analytical methodology for the drug detection in real water samples.

7.4 Methodology

Identification of the learning needs (1 session: 1 hour in the classroom)

Individually, the student must analyse the problem, trying to find the reasons that origin this problem and its corresponding consequences.

Afterwards, the work teams will be assigned and these groups will analyze the problem trying to give a brief possible explanation that leads to the subsequent problem-solving.

The work teams will identify their previous knowledge in the topic of the problem, as well as the deficiencies of the concepts associated to the proposed problem, in order to find a way to search information and bibliography on the topic.

The working group will identify the necessary additional data to solve the problem.

Finally, the working team will design a working plan for the information search with the assigned tasks for each member of the group. A copy of this planning will be given to the teacher.

Information search (2 sessions: 1 hour independently and 1 hour with the teacher)

Following the working plan and according to the learning needs, each member of the working groups will use the available information sources (such as books, scientific journals, web pages, …) to get the necessary and adequate information.

A meeting with all the group members will be carried out in order to evaluate the appropriateness of the obtained information about the problem. The group will decide if the information is enough and adequate and if not an additional working plan will be design in order to cover the weaker parts of the problem.

In a second session with the teacher, all the groups, separately, will discuss with the teacher about the selected documentation which will be used for the problem-solving. The working plan will also be discussed and commented with the teacher in order overcome the observed problems. In addition, the group can ask the teacher the necessary data for the correct solving of the problem.

Study of the collected information

Individually, the students will analyze and study all the selected information about the problem and the data on the topic given by the teacher (in case that they were necessary) in order to begin with the problem-solving process.

Students' strategy for the didactic solving of the questions 1-7 (1 session: 1 hour in the classroom)

The work team will analyze and study again the problem, in a "brain storming" session, in which the final aim is the debate, proposal and comparison of the different ways of each of the members for the problem-solving.

With all the proposed ideas and concepts the questions 1-7 of the PBL will be solved and answered. An inform with the answers and explanations for each question will be given to the teacher.

Students' strategy for the didactic solving of the question 8 (2 sessions: 2 hours independently and 1 hour with the teacher)

In order to solve question 8, the students will have to settle down an action plan and, in an individual way, they will collect scientific information from publications, instrumental related to the analytical methodology and techniques that can be used for the drug detection in environmental samples.

The control of the information search process will be carried out by the teacher with each work group.
Finally, in a group meeting outside the classroom, the group will elaborate a report giving the solution to question 8 of the problem.
Presentation and debate (1 session: 1 hour in the classroom)
All the groups will give to the teacher a written inform with the solution to question 8.
Subsequently a spokesperson (chosen by the teacher) will present to all the students of the groups the proposed solution to question 8 of the problem (in a presentation of about 10 minutes and 2-3 slides).
After the presentation the teacher will open and moderate the discussion time in which all the students of all the different groups can ask, discuss and debate freely about the proposed solution to the problem.
Self-evaluation and peers' evaluation (1 session: 1 hour in the classroom)
All the students will fill, individually, a self-evaluation questionnaire about their activity and participation in the problem-solving, finalizing with a global mark about their work.
Subsequently, each work group will meet again in order to discuss about the marks that each student has given himself. The final mark will be modified (if necessary) after consensus with their peers.

7.5 Evaluation

An evaluation process will be carried out collecting information of each phase and activity of the problem-solving. The teamwork (60% of the final mark) and individual work (40% of the final mark) will be assessed.
Related to the teamwork, these items will be taken into consideration:

- Design and performance of the working plan for the information search
- Quality of the collected information
- Written inform with the answer to questions 1-7 of the problem
- Written inform with the answer to question 8 of the problem
- Public presentation and questions

Related to the individual work, these items will be taken into consideration:

- Personal behaviour in the teamwork activities. This item will be evaluated triangularly by the teacher, the student (self-evaluation) and the peers.

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8. Conclusion

Problem-Based Learning (PBL) is one of the most commonly used teaching - learning methods in Higher Education institutions in recent years. PBL is a very useful "active learning" pedagogical strategy for the teaching-learning process within the European Higher Education Area (EHEA). With this educational technique, conventional learning process is reversed. Firstly, the problem with incomplete information is presented to the students, which must identify the missing data, concepts and theoretical knowledge required to overcome the problem. Subsequently, the students have to search the necessary information, and, try to solve successfully the problem.

The main outcome of this learning process is that students work in small collaborative groups, taking together decisions and responsibilities. Normally, teachers take the role of "facilitators" helping the students through the learning steps. The primary distinction of PBL with other student-centred learning methods is that it focuses on introducing concepts to students by challenging them to solve a real world problem. Thus, PBL uses problems to motivate, focus, and initiate student learning.

In this chapter an introduction to PBL methodology including information about the origins, characteristics, evolution and methodology used in PBL has been reported, including the different characteristics needed for the design of good problems. In addition, two different examples of PBL on general chemistry and instrumental analysis for chemical engineering students have been proposed and discussed.

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The widespread deployment and use of Information Technologies (IT) has paved the way for change in many fields of our societies. The Internet, mobile computing, social networks and many other advances in human communications have become essential to promote and boost education, technology and industry. On the education side, the new challenges related with the integration of IT technologies into all aspects of learning require revising the traditional educational paradigms that have prevailed for the last centuries. Additionally, the globalization of education and student mobility requirements are favoring a fluid interchange of tools, methodologies and evaluation strategies, which promote innovation at an accelerated pace. Curricular revisions are also taking place to achieved a more specialized education that is able to responds to the society's requirements in terms of professional training. In this process, guaranteeing quality has also become a critical issue. On the industrial and technological side, the focus on ecological developments is essential to achieve a sustainable degree of prosperity, and all efforts to promote greener societies are welcome. In this book we gather knowledge and experiences of different authors on all these topics, hoping to offer the reader a wider view of the revolution taking place within and without our educational centers. In summary, we believe that this book makes an important contribution to the fields of education and technology in these times of great change, offering a mean for experts in the different areas to share valuable experiences and points of view that we hope are enriching to the reader. Enjoy the book!

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