SCIENTIFIC LITERACY, PROBLEM BASED LEARNING AND CITIZENSHIP: A SUGGESTION FOR GEOGRAPHY STUDIES TEACHING

Jerusa Vilhena de Moraes, Sonia Maria Vanzella Castellar
University of São Paulo, Brazil
E-mail: jevilhena@yahoo.com.br, smvc@usp.br

Abstract

In this paper we will present a part of our thesis: a proposal of problem based learning inside the Geography teaching as an alternative way to the scientific literacy and the citizenship. The research was developed under the context of Elementary School and the Middle School I and II teacher training, and it can contribute to a higher and wider reflection on propositions to the improvement of pedagogical practices and the learning of scientific concepts. This proposal can allow a link between practice and theory: help to organize classes, not just emphasizing the content, but the learning of some scientific concepts and, at the same time, the abilities and proceedings linked to different areas of knowledge. Scholars dealing with teaching (Lambros, 2002; Leite & Esteves, 2006, and others) have been showing that this methodology enable the students a more independent and meaningful learning of scientifical concepts, helping them to develop the competencies and abilities linked to the logical reasoning and cooperation. We will present two different cases to discuss if this methodology can allow an integrated learning process and if they contribute to an improvement of the teaching.
Key words: *problem based learning, geography teaching, teacher training, scientific literacy, citizenship.*

Introduction

The study of some of the data of international institutional evaluations, as in the case of PISA (Programme for International Student Assessment, which verifies the performance of 15 year old students as to their capacity for analysis, thinking and reflection on Literature, Mathematics and Sciences), shows us a not very encouraging reality and one which greatly concerns us. Schools, for various reasons, cannot provide the scientific education of their students; the students, in turn, leave school without knowing the specific content of disciplines, here including geographic school science, the theme we researched. These results can be seen in the great majority of countries which use evaluation as a way of verifying school performance.

In relation to Geography, PhD dissertations and theses identify that many students cannot establish the relationship between cartographic content and day to day experience (as in the case of spatial orientation), nor can they comprehend the content of Physical Geography integrated with Human (understand, for example, the relationship between agricultural production and the greater or lesser incidence of solar rays).

There are many factors to be taken into consideration, such as: educational policies, the initial qualification of teachers, the approach that each teacher takes daily to educational questions (how to deal with blockages and their and the student's learning difficulties for example), who develops the evaluations and the criteria associated to them, the dichotomy between academic and school geography among many others.

And so we may ask: is there anything that can be done to help the teachers work? What are the real possibilities? What can be done so that the student has a more integrated vision of science and scientific thinking, like exists? What are the proposals that can be presented to result in a greater linking between science and school? On what theoretical grounds are these based? Will these allow the spatial usage of the student, that is to say, that there can be perception of insertion in a space which is continually altered (Valcarcel, 2000)? How to help the teacher, in this case the Geography teacher, so that he or she can attain a more interdisciplinary outlook and know how to guide the student in developing scientific thinking in all its stages, such as the elaboration of hypotheses, the confrontation of data etc.?

We do not believe that there is one methodology that can resolve the problems mentioned in the opening paragraphs; the situation is too complex. That is why we need to develop systems approach in education. But there are some real measures, close to the everyday of the teacher which can be employed to make learning much more stimulating and teaching more coherent, aimed at helping to qualify individuals who will contribute to society, question values, raising hypotheses about what is happening to them and arguing scientifically. We believe that PBL methodology (Problem Based Learning) can contribute to solutions to the questions raised in this introduction, by allowing better expression of the concepts, perception by the student that society and nature walk side by side as much in the practical as in the theoretical approach to these concepts.

In this article, we will present an experience we had with this methodology during doctoral research.

The Educational Potencial of PBL

Currently, a large part of the stimuli linked to teaching comes from many areas, not only schools, the latter no longer being the only source for obtaining information and even knowledge; thus, it is essential that we think more and more of action, as much for the teacher as for the student, which lead to learning.

Rue (2003, p. 130) affirms that reflection on what students should know implies thinking not only in *knowing what,* but also *in knowing how and why* that is a contextualized knowledge that leads to the dominion of competences or of derived knowledge. The questions raised by this author are closely related to the use made of scientific knowledge in school and the relationship of this to teaching methodology. We know that there is much more about scientific thinking and scientific methodology in modern education, not only about knowledge and learning.

In relation to geographical knowledge, it is very important to think of practices that stimulate questioning in respect of a particular phenomenon. In this process, the student will have the opportunity to deal with science with the same involvement that a scientist's work requires: curiosity can be roused, knowledge can be problematic, there will be the possibility of going beyond what is known, the student will learn to argue based on the results being obtained, among other possible approaches.

We believe that PBL methodology can, through activities organized by the teacher, realize the potential for the scientific qualification of the individual in such a way as to make him capable of seeing himself in a determined place and time space, this place and time space within a geographically scientific point of view. Below, we will set out the reasons that have resulted in this sure, showing also what other potential the said methodology possesses.

A first idea is that, from a PBL perspective, learning does not take place with limits nor with the overlaying of isolated parts, but as a whole and in an interdisciplinary manner. From the point of view of Geography, it is very important that the students see this in the first place in an integrated form; linking the concepts of Physical and Human Geography and at the same time, attempt to work in an interdiscip-

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Volume 19, 2010

linary way from the earliest years of schooling, by means of the building up of a geographical rationale. Callai (2005, 245) justifies why activities linked to the development of geographical thought should be developed from the earliest years of schooling:

> Through Geography, in the lessons during the first years of basic schooling, we may find an interesting way in which to know the world, to recognize ourselves as citizens and to be active agents in the construction of the space in which we live. And our students need to learn to make geographical analyses. And to get to know their world and the place in which they live, so as to be able to understand the processes of social exclusion and the selectivity of spaces.

Callai's (2005) proposition takes us to the need to rethink the way in which we are teaching, in the sense of analyzing how the linking of Physical and Human Geography can be brought about. How can the students, within the perspective presented by the author, perceive that they are active agents of space? Do they know how to interpret this space? What instruments and knowledge (skills, attitudes or values) should we provide so that they can take advantage of their rights (nd also corresponding duties and responsibilities), once they see themselves as belonging to a specific place and time? In replying to these questions we come up against much larger questions which are the daily fare of the teacher, the student and the school.

We have observed that, in many schools, learning is still a passive activity; the teacher speaks, the student responds, techniques and scientific laws are only used to justify what is thought, the questions are formulated in evaluations with no context (neither during the learning process nor in the question itself), the students learn concepts and thereafter are unable to establish the relationship between them. Conceptual domination, which is the knowledge and how to use the concepts learned, (Ausubel, 1968), thus does not occur.

When PBL is utilized, the approximation of science to the student and the relationship thereby established with knowledge may take place in an integrated manner and linked to the stage at which the student is. That is, the student does not have to leave the school to understand the proximity of knowledge, nor need to wait for the ideal moment to intervene in a process. This can be verified in the outcomes and objectives of PBL, in how this takes place and comes about in practice. According to Hutchings & O'Rourke[1] (2004), PBL can be used for the following outcomes:

1) Acquire concepts that will help in the interpretation and understanding of phenomena. From this perspective, the student uses the knowledge to solve the problem. This is the primary perception of PBL: its usefulness in solving something;
2) Act professionally. In this perspective, the student develops strategies to resolve situations with which he will have to deal in the future. The focus in on the practicality of PBL, on that which it provides;
3) To have interdisciplinary knowledge. The teachers, when thinking of the contents to be learned, should think of work that allows the students to perceive the specific concepts of the disciplines and those which fit in. When the students face up to problems, they end up understanding that they need knowledge arising from diverse disciplines and they need to relate to this;
4) Possess trans-disciplinary knowledge (also skills as well as attitudes/values). The barriers that exist between the disciplines are questioned and tested, as a result of searching for solutions to the conflict. The students are stimulated to seek solutions to that which was questioned, looking for the concepts that are traditionally integrated in the different areas of knowledge (avoiding thus approaches which are frequently forced and result in leaving the student with superficial understanding, leaving aside concepts which are essential within each area of knowledge);
5) Know how to question. In this perspective, the students are encouraged to analyze the structures and question their viability. Competences are developed that allow evaluation of the knowledge obtained.

In all these outcomes we can perceive the importance that PBL confers on the taking of decisions by individuals, linked to conceptual learning. In other words, *the what, the how and for what* are processes

[1] This data can be found throughout the publication of Hutchings & O'Rourke, 2004.

that in our methodology, walk together. We can, based in this perspective, increment Know why, that is: do we have a problem as well as why do we need to solve it, why do we solve this problem in this way etc. In other words – what is the value of corresponding problem we are solving

Another characteristic common to these outcomes is that students are motivated to greater social interaction and to conceptual and attitudinal change, through informal observations which lead them to question certain practices that are commonly associated to problem solving, including the hypotheses that encourage solutions. As an example, we can cite those associated to concept learning linked to Physical Geography in the last years of Elementary School. Upon perceiving nature as a whole in which human and physical aspects relate to each other in space, the student will be better able to question if some measures taken by government organs on environmental questions (projects aimed at clearing river pollution, the practices of soil cultivation in a certain municipality etc) are beneficial or not for the population and the environment in which it lives.

The evaluation of work with PBL encompasses the analysis of the following items (Barell, 2007; Leite e Afonso, 2001):

1) presentation of the actual problem from real life;
2) organization of the students for learning and valuation.
3) follow-up that the students apply to the questions raised;
4) learning (concepts, skills, values etc.) obtained by the students.

With the analysis of these stages, we can see that PBL is much more associated to investigation and to a specific understanding as to how the knowledge should be constructed. The students raise questions, learn, formulate new questions, learn, hear other points of view, confront results, learn, work together, and learn (Barell, 2007, p. 3). This complete cycle is repeated in the face of new questions asked of the student or that they themselves raise. For Barell (Ibid., p. 3), PBL is defined as:

> an investigative process that answers questions, curiosities, doubts and uncertainties on the complex phenomena of life. A problem is any doubt, difficulty or uncertainty that invites or requires some sort of resolution. Student research is an essential part of PBL and of the problem solving process.

By reading certain reference works, such as Barell (2007), Lambros (2002) and Leite and Esteves (2006, 2007), we understand PBL to be a methodology that offers students a means of learning, developing abilities and attitudes which will be of value in professional life, in the curricular context. It is a method of teaching and learning (as well as upbringing or value education) which is based on a constructivist perspective, permitting the autonomous growth of the student and the exercise of his citizenship. In a more specific manner, we see PBL as a concept of the function that science should have in the school and in teaching itself. It is therefore, a way of understanding learning much more than a method of teaching (Barell, 2007; Boud & Feletti, 1997; Lambros, 2002).

We consider that learning is different from education. Today, is not enough only learning and so we need much more complex activity in school that is educational activity. This thinking of educational activity means specially organized gaining of life experience for life; furthermore, education involved more than learning and gaining knowledge and skills.

Thus, when working with problems is initiated, this must pass through some stages. The suggestion of the problem, understood as that which will unlock the knowledge to be researched, can originate from the student or the teacher; the problem to be worked should be real or seem to be real. Regardless of who initiates the process, it should always be borne in mind that it is the student who must construct the knowledge (about his or her life experience). This way of proceeding ensures that the experience lived in the school space is close to what happens in reality: first the problem appears, then the attempts to solve this with the scientific concept permeating this process, and not the opposite of this.

In life, elements of diverse sciences can be found in one sole problem. It is up to the teacher to identify these and guide the student to a possible solution, with the participation of specialists in the different areas linked to the problem. This does not mean that all the problems utilized by the teacher in the classroom should be interdisciplinary, nor that, being interdisciplinary, the teachers will always be there. On the contrary, at times a positive moment will be needed for one determined context, at times for another.

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Volume 19, 2010

In choosing a problem to be worked from the PBL perspective, authors such as Lambros (2002), Leite, Esteves (2005, 2006), Maufette, Kandlbinder & Soucisse (2004), Ross (1997) & West (1992) present some suggestions:

1) the problem should be short, well structured (or systemic);
2) the problem should permit a variety of activities to arrive at a solution;
3) should bring about change in the student (attitudinal and conceptual);
4) the teacher should reveal the learning educational objectives when presenting the problem;
5) the problem should be presented in a meaningful and provocative scenario, avoiding for example that quick answers are given to the problem – should these exist;
6) the problem can be associated to a question or theme; a situation which might be found in a professional context or life can be simulated;
7) if it is decided to work with a theme, this can be thought about in terms of greater or lesser problems which can arise from a general theme, in such a way as to facilitate conceptual, ideas and technique learning which the teacher judges to be important;
8) it can be presented by means of any didactic resource (such as for example, a poster, the reading of a fragment of a newspaper item, a scientific text, literary text etc.) and for all ages. What will vary is the degree of complexity. For Elementary School, for example, it is important that the problems be directed to the children's activities.

For good results to be obtained, we believe it is necessary that the problem is appropriate to the age of the students, so that they can work through all the stages of the solution, from the organizing of group working to the arrival at a possible solution. Related to this question is the importance of a clear presentation of the objectives, from the beginning of the process, that is to say the necessity of the student knowing what is expected of him or her.

In spite of this consideration, we have to emphasize that clear objectives are defined within the process of problem solving. We do not have clear objectives when we meet a problem, that is: objectives are clear only for traditional learning.

Contrary procedures can result in little advantage being gained from the potential of the methodology, and may adversely affect learning. If the problem is very small it will not cause work, in the sense that there will not be sufficient questions provoked to serve as a stimulus to conceptual learning; if the obstacle is very large, it could result in lack of motivation and giving up because the student will not feel capable of resolving the problem.

On the role of the teacher, the same authors who expounded on the conditions of the associates to the utilization of the problem suggest that:

1) the teacher will guide the learning at all stages: presentation of the problem, choice of the material to be consulted, organization of the ideas as presented by the student in the light of new information and doubts arising;
2) the teacher is the facilitator of the learning process, that is to say he leads but does not determine what is learnt;
3) the teacher will also instigate activities which will enable the exchange of information among members of the group, in such a way as to intensify the collaborative work;
4) in order that PBL develops to its maximum potential, it is essential that the teacher encourages collaborative work in large or small groups.

Learning through PBL from this perspective becomes much more interesting: the student can frame the problem from the starting point he considers relevant; the teacher, (when it is he who chooses the problem) may propose different and provocative situations, so that the student is motivated to work. The student will examine the problem, raise hypotheses or formulate definite research question, undertake research, compare his results constantly with others in his own group and with the entire class, think of possible solutions and in fact participate in the process of construction of knowledge.

Even in situations where the student is well prepared, there may be people who learn better in situations where they have to arrive at the answers by themselves, without the participation of the group, or people who develop better within mental schemes which they themselves structure for their learning.

In order for the potential of PBL to have an effect on the student, it is necessary constantly to verify if the scenario, the problem and the activities created around him are appropriate. Many of the difficulties may be solved by returning to what has been foreseen and to redirect the work.

In this sense, it is important to verify if the content to which the problem is linked is appropriate at that moment; if the problem permits its solving in school learning and how this occurs; if it is linked to the student's experiences; if it makes diverse solutions possible or is more restricted; if the students are able to obtain resources and what these are; if these resources are sufficient. If they are not, how can the teacher resolve this; if the teacher is helping as facilitator or tutor in the process; if the activity proposed by the teacher is appropriate and motivates the students; and finally, if the time foreseen needs to be adapted.

In an activity using PBL methodology, arriving at a response is not always of prime importance, but collective and an individual involvement throughout the solution process, how to interpret the questions, group information, schematize solutions, and know how to deal with different opinions. In this sense, group work is of fundamental value and importance. Because of this, it is necessary continually to verify how the students are organizing themselves into groups, so that there is involvement of everyone in the learning process, and so that the teacher has more instruments, appropriate and consistent with the methodology proposal.

In a general sense, a proposal of teaching and learning based on PBL permits the student to make what he is learning significant and makes it possible that he does not dwell on the learning of fragmented content. This is of the utmost importance when it is our intention to make the student a participating subject of the society in which he lives, and this regardless if what we are teaching is specific content in the area of Biology, Arts or Geography.

Even considering elements such as what the teacher should do in the classroom when dealing with this methodology, the approach proposed for working with the problem etc., there are many ways in which PBL can happen in a practical sense. In some groups, the teacher may spend more time on guidance on bibliographical searches, in other groups more time on the solution to a lesser problem.

Below, we present a proposal for intervention in a classroom by means of PBL, which was developed by teachers who work with students of 9 to 10 years old, that is the 3rd. Year of Elementary School. This proposal was carried out in the context of teacher training, and took place over a year and involved 22 teachers distributed over 5 groups (with 4 to 5 participants). This research is part of our doctoral thesis and we here present its application.

Example of Application

The proposal of work with PBL took place only when doubts in relation to work with the scientific concepts were better clarified. In this way, before beginning the discussion on PBL, we developed with the teachers' activities in which we discussed scientific literacy and the concepts of Geography in such a way they felt more comfortable in working with an unfamiliar methodology.

The classes thought up by the four teachers went through various adjustments in relation to the problem posed by them and which served as a starting point for the learning, as also in relation to the methodological and procedural direction of each class. Below we present in a chart the third version thought up by the teachers and which was used with the students:

Problem: Is there some area in the school where a vegetable garden can be made? Where and how can it be made?
Class 1: Observation of school grounds. Questions to be asked of the students: What is the land like? Is it flat or sloping? In what part of the school is there the greatest possibility of receiving sunlight? How can the irrigation system be made? Is there easy access to water in this locale? What types of plants are suitable to this soil?

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Volume 19, 2010

Class 2: Observe the clarity of the sun at the locale where the garden will be made. Build a Sun dial (in a tin filled with sand or clay, place a broom handle with a plastic bottle on the end). Place the Sun dial in the center of the land and, every hour, a group of students will verify the position of the Sun, making the necessary notes.
Class 3: Using the notes made in the previous class, encourage a discussion on the best position to plant the seeds, in accordance with the position of the Sun.
Class 4: Research the seeds and cuttings which will be adapted to the locale, due to the position of the Sun.
Class 5: Verify the type of ground. Undertake research on different types of ground and different types of fertilizers available in the market to improve the soil.
Class 6: Cleaning of the land and preparation of the soil with fertilizer.
Class 7: Preparation of beds and planting of seeds and cuttings.
Class 8: Observation of germination and plant growth.

Chart 1 – Proposal presented by teachers for 3rd. year – third version.

In terms of analysis, we note that the passage from the first to the second class takes place abruptly, so that it is not possible for the student to work with what was found in the circuit around the school to verify the best area for planting. We suggested that the teachers think as to how the students arrive at the conclusions to the questions in the first class and how the work of systemization of the class can be achieved, as in the case of the other classes.

For the teachers of this group, the work helped them to have a greater understanding of the concepts of the Geography of nature. We also consider that it helped them to lose their fear of geographical content and to know where to research, look for information and scientific bibliography.

As regards the PBL proposal, we verified that in all the development of the work, from the conception of what a problem is up to the solution, it was the group that best worked the strategies diagnosed by Hutchings & O'Rourke[2] (2004), as presented in the item Education Potential of PBL. The students utilized knowledge to solve a problem (where to build a vegetable garden and what products should be cultivated on the land); the teachers developed strategies for the students to investigate the situations with which they will deal in the future, amplifying the geographical concepts and permitting their integration (in linking for example, soil and society).

For these teachers, the work with PBL allowed them no longer to feel so insecure in situations where they don't dominate the content since, according to them, "they learned while investigating".

Brief Considerations

Our idea is that scientific literacy aimed at citizenship and starting from a problem, can make learning much more stimulating and significant, as much for the teachers as the student.

In a general sense, the understanding of science as a social product can be taught when you work with a historical perspective of the production of knowledge. The student for example learns different ideas, from long ago and current, about the human body and its functions; he learns of visions about material (the physical and chemical elements which are part of it) etc.

But what would be understanding within the scope of science, more specifically in the teaching of Geography, this vision that the student should construct scientific knowledge in such a way as to make him interact with the world from the starting point of a problem?

A common notion in the teaching of science is that the creation of explanatory models brings the student closer to what doing science is. From the point of view of Geography, we believe that this same procedure can be used. Thus, when the teacher initiates the content or systemization by making a maquette with the students, a panel, mental map, game, drawing or text, he is creating a model that will serve for the student to remember what he learned and simulate, by means of the model itself, the phenomena observed in reality.

[2] Deals with the actions that may be linked to the use of PBL in the classroom.

It is important that the teacher does not concentrate on only one model. On the contrary, throughout the year, the student should undergo multiple stages of creation, with different characteristics, forms of expression, taking into account also the distinct characteristics of the students.

We believe that learning will be effective if the subject is provided with the materials, the necessary instruments and the accomplishment of the indispensable mental operations (Meirieu, 1998 and Pozo, 1994). Thus, knowing the essential concepts of geographic science such as region, space, territory, nature, society, place and knowing how to apply them in extra-class situations (deduce information from data collected in reality, foresee a situation and interfere in it, draw conclusions etc.) are means and strategies for evaluating how the administration of teaching and learning are going.

In Elementary School for example, dominion of the geographic content linked to the concepts presented should take place starting from observations that the children make about the world in which they live. In this sense, the questions to be asked by themselves, with the help of colleagues and teachers, the hypotheses that are formulated or those that already exist should arise from the perception that the children have of the world and not the contrary, such that the concept is extracted from the content, so, that from this point the child is able to read and interpret the world (Callai, 2005; Castellar, 2000). For this age range, we have noticed from our experiences that the dominion of the concepts of place, society and nature is essential so that, at the end of Elementary School, the student will have the capacity to understand other concepts, which will be worked in Fundamental Teaching II.

One common sense idea is that in the application of a methodology like PBL the teacher doesn't work, since the focus is on the student. Our experience in this research and with teachers in Fundamental Teaching II verified exactly the opposite. There is much more work for the teacher when methodological preoccupations are accepted, because he must take into account possible responses from the students and how they might solve the problem presented based on the references chosen. Continuous evaluation of the development of each stage of the class is necessary.

As a methodological proposal, when thinking of didactic units based on the utilization of PBL, the teacher must think of the procedures which, in some ways, guarantee conceptual learning. This means planning the possible steps the students might take to learn a specific concept. Thus we can affirm that the elaboration of learning strategies, of age appropriate questions, of the content, and what is expected of the student (objectives), will make the difference in the treatment that the student will have in the classroom and in scientific understanding. This procedure will mean for example, that an activity will not be the mere application of formulas – as in the case of *puzzles* or even exercises – to arrive at a non-reflexive answer, without interaction and limited to concern in responding to a proposition.

With the problem being the starting point for learning, in depth evaluation, as foreseen by Leite & Esteves (2006), it is essential to think of procedures necessary for the learning to occur. The students will choose the manner of responding to the problem, based on research. Understanding learning in this way is to face the fact that knowledge itself is not predictable, immutable, nor safe, and therefore does not take for granted accurate answers.

This manner of understanding the process of teaching and of learning emphasizes action related to the procedures, often discarded in daily work. The advances in research on cognitive psychology show that, contrary to what used to be and still is thought, a student can organize his knowledge and learn starting as much from a general to a particular situation as vice-versa; going from theory to practice as much as vice-versa.

In conclusion, we believe and emphasize that this experience with PBL permits students and teachers to have a greater conceptual dominion and much more motivated learning, which stimulated the capacity to seek answers to the questions which were presented.

References

Ausubel, D. (1968). *Educational psychology: a cognitive view*. New York: Holt, Rinehart and Winston.

Barell, J. (2007). *Problem based learning* – an inquiry approach, 2nd ed. Thousand Oaks: Corwin.

Boud, D., Feletti, G. (1997). *The challenge of Problem based learning*. 2nd ed. London: Kogan Page.

Callai, Helena Copetti (2005). Aprender a ler o mundo: a Geografia nos anos iniciais do Ensino Fundamental. *Cadernos Cedes*, Campinas, Vol. 25, No. 66, p. 22–7247, maio/ago.

Castellar, S. M. V. (2005). Educação geográfica: a psicogenética e o conhecimento escolar. *Cadernos Cedes*, Campinas, v. 25, n. 66, p. 209–225.

Hutchings, W., O'Rourke, K. (2004). Medical Studies to Literary Studies: Adapting Problem-based Learning Processes for New Disciplines. In: Savin-Baden, M. and Wilkie, K. (Eds.). *Challenging Research into Problem-based Learning*. Buckingham: SRHE/Open University, 2004.

Lambros, A. (2002). *Problem based learning in k-8 classrooms – a teacher's guide to implementation*. Thousand Oaks: Corwin.

Lambros, A. (2002). *Problem based learning in Middle and High School classrooms – a teacher's guide to implementation*. Thousand Oaks: Corwin.

Leite, L., Afonso, A. (2001). Aprendizagem baseada na resolução de problemas. Características, organização e supervisão. *Boletín das Ciencias*, Ensinantes de Ciencias de Galícia (Enciga), n. 48, p. 253–260.

Leite, L., Esteves, E. (2006). Ensino orientado para a aprendizagem baseada na resolução de problemas na licenciatura em ensino de Física e Química. In: Congresso Internacional PBL, Lima, 2006. *Actas do Congresso Internacional PBL2006ABRP* (CD-Rom). Lima: Pontifícia Universidad Católica del Peru.

Leite, L., Esteves, E. (2007). Students' integration and teachers' differentiation: the role of PBL. In: Annual Conference Equity and Diversity in Teacher Education, 32, University of Wolverhampton, p. 25–29.

Meirieu, P. (1998). *Aprender... sim, mas como?* 7 ed. Porto Alegre: Artmed.

Pozo, J. I., Gonzalo, I. E Postigo, Y. (1994). *Las estrategias de aprendizaje como contenido procedimental*. Madrid: Memoria de investigación. Facultad de Psicología, Universidad Autónoma de Madrid.

Ross, B. (1997). Towards a framework for problem based curricula. In: Boud, D. and Feletti, G. *The challenge of PBL.* London: Kogan Page, p. 28–35.

Mauffette, Y., Kandlbinder, P., Soucisse, A. (2004). The problem in problem-based learning is the problems: But do they motivate students?. In: Savin-Baden, M. and Wilkie, K. (Eds.). *Challenging research in problem-based learning*. Maidenhead: Open University, p. 11–25.

Rué, J. (2004). *O que ensinar e por quê: elaboração e desenvolvimento de projetos de formação*. São Paulo: Moderna.

Valcárcel, J. O. (2000). *Los horizontes de la geografía*. 1 ed. Barcelona: Ariel.

West, S. (1992). PBL – a viable addition for secondary school science. *School Science Review*, No. 73 (265), p. 47–55.

Adviced by Ricardo Ricci Uvinha, University of São Paulo, Brazil

Jerusa Vilhena de Moraes Ph.D, Researcher, School of Education, University of São Paulo (FEUSP- Brazil), Department of Teaching Methodology and Compared Education, Street Manuel de Paiva, 89, Vila Marian, São Paulo, Brazil.
E-mail: jevilhena@yahoo.com.br
Website: http://www3.fe.usp.br/secoes/inst/folder/english.htm

Sonia Maria Vanzella Castellar Ph. D, Professor, School of Education, University of São Paulo (FEUSP- Brazil), Department of Teaching Methodology and Compared Education, Street Cardoso de Almeida, 480, ap.102. Perdizes, São Paulo, Brazil.
E-mail: smvc@usp.br
Website: http://www3.fe.usp.br/secoes/inst/folder/english.htm