

WCES 2014

Problem-Based Learning - An Efficient Learning Strategy In The Science Lessons Context

Gabriel Gorghiu^{a*}, Luminița Mihaela Drăghicescu^b, Sorin Cristea^c, Ana-Maria Petrescu^b,
Laura Monica Gorghiu^d

^a Faculty of Electrical Engineering, Electronics and Information Technology, Valahia University Targoviste, 18-24 Unirii Blvd., 130082 Targoviste, Romania

^b Teacher Training Department, Valahia University Targoviste, 5 Moldovei str., 130093 Targoviste, Romania

^c Faculty of Psychology and Educational Sciences, University of Bucharest, 90 Panduri Blvd., 050663 Bucharest, Romania

^d Faculty of Sciences and Arts, Valahia University Targoviste, 18-24 Unirii Blvd., 130082 Targoviste, Romania

Abstract

The research conducted in recent years illustrates that traditional teaching generates a real passivity among students, who are placed in the position of ready-made knowledge consumers, their only effort being oriented to secure and, subsequently, reproduce the knowledge in the context of evaluation tests. Traditional teaching practices may not have a learning effect than a superficial one, which result come as inconsistent and possible to be used only in immediate instructional contexts. In this sense, *problem-based learning (PBL)* - often known as *inquiry-based learning* - represents an effective way of working with students who may thus be helped to build basic skills in various domains or curricular areas. Generally, the method involves a central question (problem), proposed and explained by the teacher, with the students working cooperatively and deciding for the proper strategy with the view to solve the problem. The paper presents the results of the implementation in the classroom of 17 Modules which involve *problem-based learning* paradigm. The Modules were created by teachers enrolled in the continuous professional development programme named "*PROFILES - Education through Sciences*", organized in the frame of the Seventh Framework Programme "*PROFILES - Professional Reflection Oriented Focus on Inquiry-based Learning and Education through Science*". The feedback collected from teachers and students was positive, with important achievements in students' understanding of Science concepts, but also in taking ownership of their learning.

© 2015 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Selection and peer-review under responsibility of the Organizing Committee of WCES 2014

Keywords: Problem-based learning, learning skills, classroom implementation, CPD programme, Education through Sciences, PROFILES project

* Gabriel Gorghiu. Tel.: +40-245-217683
E-mail address: ggorghiu@yahoo.com

1. Introduction

Focusing on the educational process, the key competences represent, both for theoreticians and practitioners involved in the Romanian educational system, a reference point in the demarche of structuring / reorganization / rethinking of the educational politics, and generally of the instructive-educative process. The formation of key competences, susceptible to be used and transferred in different concrete situations is - according to European Union documents - the mission of the contemporary school. From the competences nominees in *The European framework of key competences for lifelong learning*, we retain, as being relevant for the theme submitted for analysis, *the competence of learning how to learn* and *the basic competence in mathematics, sciences and technology*. *The capacity to solve problems* is representative both for *the competence of learning how to learn* and for *the basic competences in mathematics, sciences and technology*, important being, in this sense, the identification of the adequate modalities of their development. One of the manners proved to be efficient in this sense is *PBL - Problem Based Learning*. The application of *PBL* in the teaching-learning process is a necessary demarche, if we understand, as teachers, that in order to permanently have chances of adaptation, of integration in the world the pupils they live or they will live, our pupils must constantly develop and valorize *the competence of learning how to learn*. Especially for Science education, we must eliminate the pedagogical practices centered on the formalized and excessively generalized presentation, and promote the teaching-learning models axed on action, experimentation, investigation and problems solving.

2. Problem Based Learning - an access path to competences. What is PBL?

In the previously described context, the *Problem Based Learning* may be considered, even *a priori*, an efficient modality through which pupils may be helped to acquire basic competences in Sciences, and in other curricular areas or fields. The researches made in the last couple of years underlined once more the fact that the traditional teaching (sometimes based excessively on expositive methods) generate passivity among pupils, who are “placed” in the hypostasis of being mere consumers of already fabricated knowledge, their only effort being that to acknowledge, to memorize them (often in a mechanic manner) and subsequently to reproduce them in an evaluative context. Obviously such teaching practices cannot have as effect, but a “surface”, shallow learning, the results of which are inconsistent and usable only in immediate instructional contexts. The formation of the pupils’ scientific spirit, and of the learning abilities for the entire life, implicate „(...) a change of the type of intellectual activity, of the method used by the one who learns; and, of course, a problem of teaching, of exercise in an activity of knowledge which is sort of specific for the scientific one, which to offer the possibility of making a sort of „science apprenticeship” or „a discovery apprenticeship”, to behave like a „pupil-researcher”, who is able to look at the reality with a researcher’s eye, that is to ask questions (to raise problems), to formulate hypothesis, to imagine strategies; to engage in an activity of searching, testing, trying, investigation, rediscovery of what he is supposed „to know”” (Cerghit, 2002, 80). The teaching practices activated by teachers must thus be „thought”, selected and used according to their capacity to trigger an authentic learning, based on understanding, on the mechanisms of logic thinking. The expert-teacher builds his/her didactic demarche respecting the principles of the pedagogic constructivism and constantly reporting at the pupils’ age and individual psychological particularities. He/she creates a learning environment in which pupils can valorize their own knowledge, even if they are acquired in non-formal or informal contexts, they can verify the validity, they can confront them with those of other colleagues, they can share them to others; an experiential learning environment, based on action, scientific investigation, experimentation, on the discovery of new truths which will be the generating source of restructurings in previously built cognitive structures. In a society troubled by change, in which the problems encountered in school, family, at the working place etc., are diverse and they succeed with rapidity, one of the educational process’ priorities is to instrument pupils with the ability to face the problematic situations they confront with, thus to solve problems.

A *problem* „is most frequently associated with the barrier, the obstacle, the question mark, the theoretical or practical difficulty, the cognitive lacuna - all of them intervened while thinking -, which must be removed, surpassed, solved” (Zlate, 2006, 316).

The way of problems solving supposes first of all that the pupils to identify and to define a problem, to acquire specific investigative methods of the solving process (algorithmic and heuristic strategies) and, at the same time, to be able to make arguments.

Zlate (2006) opined that the main solving processes, with which the pupils must be familiarized, are:

- The interpretation of the situation or the presentation of the problem;
- The elaboration of objectives and planning;
- Memorization of the critical events;
- Evaluation of the actions' results.

Hoskins and Fredriksson, (Hoskins & Fredriksson, 2008) appreciate that the problem solving may be understood in different manners. It can be considered a general competence which includes the capacity to combine different abilities and may be perceived as a specific domain, conjugating knowledge and skills

"*The problems solving* is the ability of an individual to use the cognitive processes in confronting and solving real situations, trans-disciplinary, in which solution is not obvious and the fields of alphabetization or the curricular areas which might be regarded/applied do not imply a single domain like mathematics, science or reading " (PISA, 2003, p. 156; apud Hoskins & Fredriksson, 2008).

In our opinion, *the capacity to solve problems* is subsumed to *the competence of learning how to learn*, but it is not reduced to the capacity to simply solve a single type of problems - for instance Physics or Chemistry problems -, and it also represent the capacity to identify obstacles which intervene during learning and to "construct"/identify the optimal/efficient manner in which there can be surpassed those barriers, by valorizing and effectively applying different strategies. *Problems solving* is thus transferable/transversal capacity, susceptible of being used in different instructional contexts, in various disciplines and, generally, in life contexts. In *problems based learning*, Diana Wood appreciate that pupils will have as starting point a problem and, according to it, they will define their own learning objectives. After identifying the problem, the pupils study independently, trying to discover knowledge, the strategies with which they can solve the respective problem. In working groups, they confront ideas, the solving techniques, they share with each other the acquired knowledge, refining and perfecting them. Thus PBL does not suppose the mere problem solving, but it is rather a strategy which has a considerable contribution at enriching and fathoming understanding (Wood, 2003, p. 328). *Problems based learning*, appreciated Duch, is an instruction method which consists in the utilization of the "real world" problems like a necessary context, in order for the pupils "to learn" the critical thinking and the abilities of problems solving and to assimilate the essential concepts for the various study disciplines. Practicing *PBL*, the pupils acquire learning skills throughout life, which include the capacity to identify and to use adequate learning resources. In the scientific literature, next to the collocations *problems based learning* or *problems centered learning*, frequently encountered is also the collocation *solving problems learning*. The model of "problems solving" regards the observation of an opened problem from everyday life, having a „real finality" (Leahu, 2006). The steps of solving a problem are based on a proactive learning strategy, on the pupils' acquisitions, their knowledge and competences, developing with every solving step. *Problem based learning* may implicate individual and group activities, stimulating and inciting curiosity, intrinsic motivation, self-guided study and personal and group reflection. The problem which serves as initiation source for learning may be furnished by the teacher or proposed by pupils. Being a problem based on real life, the pupils will be motivated to implicate effectively in its accurate analysis and definition, in understanding its nature, the necessity of its solving etc. Valorizing their previous experience, they will frame it in an adequate theoretical cadre, where they will try to enlarge/extend, if it doesn't furnish all the possible solutions or solving strategies. Acting in this manner, the deductive demarche is abandoned in the favor of the inductive one, the pupils thus "discovering", by independent study, what the teacher would have transmitted in an already processed form, but with small chances to be internalized, included in their own cognitive structures. *PBL* creates a learning environment in which the teacher plays the role of coach for the pupils thought, he/she guides them in the activity of problem investigation / research, facilitating the pupils' learning and "advancing" towards superior levels of understanding.

3. Problem Based Learning - steps and practical aspects

The PBL model proposed by Wood is based on the elaboration of a scenario which includes 7 steps (Wood, 2003):

Step 1 - there are identified and clarified the unfamiliar terms which are presented in the scenario; a writer (pupil) lists the terms which remain unexplained, after discussions;

Step 2 - there is/are defined the problem/problems which are to be discussed; the pupils may have different opinions about them, but all the opinions must be considered; it is registered/made a list of problems about which everybody expressed their agreement / all the pupils agree;

Step 3 - it is organized a brainstorming session in order to discuss about the problem(s), suggesting the possible explanations based on the previous knowledge; there will be valorized all the pupils' acquisitions and it is identified the area / field of incomplete knowledge; the writer registers all discussions;

Step 4 - it is made a retrospective view on the steps 2 and 3 and are valorized the explanations for the elaboration of provisory solutions; the writer organizes explanations and restructures them, if necessary;

Step 5 - there are formulated the learning objectives; the group reaches a consensus on those objectives; the teacher makes sure that the learning objectives are achievable, relevant and adequate;

Step 6 - independent study (all pupils collect information regarding every learning objective);

Step 7 - the group disseminates the results of the independent study (the pupils identify their learning resources and share with the others the obtained results); the teacher controls the manner in which the learning was produced and may evaluate the group.

No matter which is the applied model, we should observe the following *definitive aspects for PBL*, which demonstrate its efficaciousness and its superiority face to the teaching practices based on expositive methods, on the delivery of a finished „product”, often far from the pupils interests and too abstract, conceptualized, far from real life and its tumult of problems:

1. Learning is centered on pupil: the pupils are implicated in every step of the didactic demarche, from the listing of learning objectives, to the evaluation of results; there are respected their age and individual psychological particularities.

2. Learning is accomplished in a stimulating environment: the pupils have access to various sources, relevant for the investigated problem, which facilitate understanding and ensures a successful finalization of tasks.

3. Learning is relevant: because it has as marker problems from real life and ends with acquisitions which will effectively serve pupils in different contexts.

4. Learning is active and experiential: pupils are implicated in a demarche of searching, investigation, research, experimenting, after which they develop both their cognitive structures and the competences.

5. Learning is logical: it is based especially on the understanding and of the complex operations of thought.

6. Learning valorizes the pupils' previous experience; all pupils are active, valorized.

7. The collaborative learning is promoted, so that pupils may learn from one another, making a useful exchange of information and experience.

8. Learning is efficient: the achieved acquisitions belong to pupils like a definitive good, being obtained through personal activity, with a quite elevated indicator of voluntary and intellectual effort.

9. Learning is authentic: it implies not only cognitive strategies, but also meta-cognitive, ensuring the development of key competences.

10. Learning is integrative: the pupils combine, valorize, associate and compare data, information, specific results for the different study disciplines.

4. Results and Discussions

The students' feedback - after classroom implementation of 17 modules that involve PBL - is presented in the following paragraphs. The modules were designed for upper secondary education by the Science teachers enrolled in the continuous professional development programme entitled “*PROFILES - Education through Sciences*”, organized in the frame of the Seventh Framework Programme “*PROFILES - Professional Reflection Oriented Focus on Inquiry-based Learning and Education through Science*” (<http://www.profiles-project.eu/>, <http://profiles.ssai.valahia.ro>). The

students' feedback was based on the filling in the assessment questionnaire of the *Motivational Learning Environment - MoLE* - designed in the frame of the same project (Bolte, 2006). As Figure 1a shows, when we asked students to indicate how often they have the opportunity to submit to teachers suggestions on different topics discussed in Science lessons we found that most respondents believe that only sometimes do this. The figure presents the comparison between students' answers to the questionnaires implemented before and after the PROFILES modules implementation. Those results lead us to draw the attention of teachers on the quality of the communication with students during Science lessons and beyond. The student should be approached as a partner of teacher in training activities, as an active participant heavily involved in this process. This will lead to the development of a broad range of learning and innovation skills regarding creativity and innovation, critical thinking and problem solving, communication and collaboration. We must emphasize that students responses have evolved positively after applying instructional strategies promoted by the project PROFILES strategies based just on the above skills. From the perspective of an ideal training situation (like Figure 1b illustrates), it can be seen that most students consider as important the ability to send the teacher suggestions on related topics, in Science classes. This confirms the students' need to be actively involved in their own training, which in the context of contemporary society cannot be the same for everyone, but should be customized to the needs of individual learners.

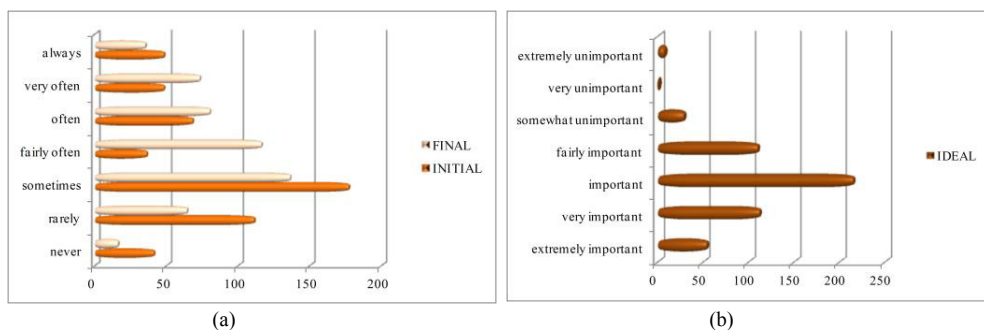


Fig. 1. Students' feedback to the questions: (a) "Please indicate how often you get the opportunity to make suggestions to the teacher in lessons in the above subject" before and after the PROFILES Modules implementation; (b) "For me, in lessons of the above subject I should get the opportunity to make suggestions to the teacher" in the ideal situation from the student's point of view.

Similar to the data presented in the previous item, Figure 2a shows the structure and student responses on the frequency of how often the teacher gives them the opportunity to ask questions on related topics, in Science classes. The fact that most students appreciate that only occasionally has the opportunity to ask questions of the teacher can be linked to several causes such as: teaching style of the teacher, the number of hours allocated by discipline curriculum, the density of the mandatory content contained in curricula, student personality etc. Beyond these cases, each teacher must pay attention to the feed-back received from the students, in order to be able to adjust effectively the training process. At the ideal level (Figure 2b), most of the students consider important or very important the opportunity to ask teachers various questions about different topics in Science lessons. This confirms once again the skills profile of the contemporary student that cannot be satisfied with simply receiving status information, but must learn the power tool to learn through active involvement in the process.

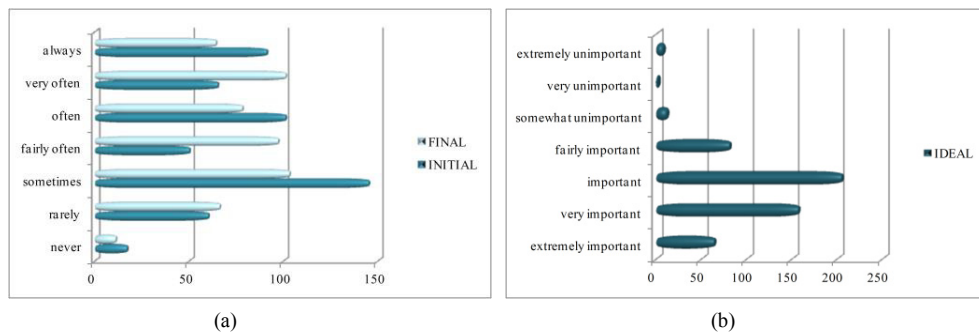


Fig. 2. Students' feedback to the questions: (a) "Please indicate how often you get the opportunity to ask questions in lessons in the above subject" before and after the PROFILES Modules implementation; (b) "For me, in lessons of the above subject I should get the opportunity to ask questions" in the ideal situation from the student's point of view.

5. Conclusions

As PBL represents an educational method that uses *real world* problems like an important context, in order for the pupils to think critical and to achieve skills for solving the proposed problem, the results obtained in the frame of PROFILES project emphasized that the quality of the communication between teacher and students is very important, the teacher being perceived as a partner, as an active participant, during the training activities. More, the teachers have to pay more attention to the feed-back received from the students, in order to control and adjust properly the training process.

Acknowledgements

This work was funded through the Seventh Framework Programme "**PROFILES - Professional Reflection Oriented Focus on Inquiry-based Learning and Education through Science**" No. 5.2.2.1 - SiS-2010-2.2.1, Grant Agreement No. 266589, *Supporting and coordinating actions on innovative methods in Science education: teacher training on inquiry based teaching methods on a large scale in Europe*. The support offered by the European Commission in the fields of research and innovation, through the project mentioned above, is gratefully acknowledged.

References

- Bolte, C. (2006). As Good as It Gets: The MoLE-Instrument for the Evaluation of Science Instruction. *The Annual Meeting of the National Association for the Research on Science Education (NARST)*. San Francisco, USA: Polyscript.
- Cerghit, I. (2002). *Sisteme de instruire alternative și complementare. Structuri, stiluri și strategii*. București: Editura Aramis.
- Duch, B. J. (1995). What is Problem-Based Learning? Newsletter of the Center for Teaching Effectiveness. <http://www.udel.edu/pbl/cte/jan95-what.html>. Retrieved at December the 16th, 2013.
- Hoskins, B., Fredriksson, U. (2008). European Commission, Joint Research Centre, Institute for the Protection and Security of the Citizen. Centre for Research on Lifelong Learning (CRELL). Luxembourg: Office for Official Publications of the European Communities © European Communities.
- Leahu, I. (2006). *Didactica fizicii - Modele de proiectare curriculară*. București: Editura Didactica și Pedagogica.
- Wood, D. F. (2003). *Problem based learning*, p. 328, <http://www.bmj.com/content/326/7384/328.full?sid=b30b11a7-7b41-49a9-8121-6002413ca1ec>. Retrieved at December the 16th, 2013.
- Zlate, M. (2006). *Psihologia mecanismelor cognitive*. Iași: Editura Polirom.
- *** PROFILES Consortium. (2010). FP7 Negotiation Guidance Notes - Coordination and Support Actions. Annex I - Description of Work. Unpublished.
- *** The European framework of key competences for lifelong learning, <http://www.tvet.ro/index.php/educatie-si-formare-profesionala-in-europa/instrumente-europene-pentru-invatarea-pe-tot-parcursul-vietii/cadrul-european-de-referinta-al-competenelor-cheie-pentru-invatarea-pe-tot-parcursul-vietii.html#5>. Retrieved at December the 16th, 2013.