Project Based Learning as Teaching Approach for Master Students

Iuliana LAZAR¹,
Ema FACIU²

¹Dr., Bucharest University, Bucharest, Romania,
iuliana.mihaela.lazar@drd.unibuc.ro

²Dr., Al. Vlahuta Technological School, Podu Turcului, Romania,
emafaciu@yahoo.com

Abstract: Human resources experts consider important for a young graduate to be well trained in the field of expertise and to have developed skills like problem-solving, communication, collaboration, responsibility, and self-direction. Project Based Learning (PBL) concord with the requests of the legal framework and studies showed that the method was successful in achieving them. In order to be efficient, PBL needs to respect a list of requirements, one of them being the realism of the themes. The paper presents the results of two projects which used the environmental protection issues as real-world context supported by interactive computer simulations. Subjects approached in two projects assessed the current state of quality of natural habitat and investigated the effect of building placement and orientation on the dispersion of traffic air pollutants. PBL was successfully used to effectively shape the learning environment for master students from a designated Applied Engineering program.

Keywords: *Higher education; Graduates Students; Online Collaborative Tools; Training Using Applied Methods.*

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1. Introduction

By definition, a project is a complex task that is based on challenging questions or problems and "*culminate in realistic products or presentations*" (Jones, Rasmussen, & Moffitt, 1997). Thus, the main goal of Project Based Learning (PBL) is to use projects in order to enhance both autonomous and collaborative learning in a real-world context (Bédard, Lison, Dalle, Côté, & Boutin, 2012; Lee, Blackwell, Drake, & Moran, 2014). In order to be effective, the interactive computer method relies highly on students' initiative, self-direction and, collaboration and communication skills (Mills & Treagust, 2004), but also provides the context and the tools to develop such competencies (Moran, 2007; Yeh, 2010). In the same time, human resources experts and managers consider of same importance for a young graduate to be well trained in the field of expertise and to have developed skills like: problem solving, communication, collaboration, responsibility, and self-direction, as well as be goal oriented and have media and IT&C competencies (Civzele & Turusheva, 2013; Lazar et al., 2013; Marques dos Santos, Teixeira Bonito, & Fernandes Guedes, 2013). In conclusion, the outcomes of an educational approach based on PBL concord with the requests of the economic environment and studies showed that the interactive computer method was successful in achieving them (Wurdinger, 2016).

In the last decades, the majority of national educational systems engaged on the path from a traditional approach focused on knowledge transfer, with most of the practical applications designed as tools for consolidating theories, to a competency development approach, targeting also skills like problem-solving, critical thinking, communication, collaboration, responsibility, self-direction, media and IT&C (Lee et al., 2014; Moran, 2007; Panisoara, Duta & Panisoara, 2015; Wurdinger, 2016; Yeh, 2010). Training programs for pre- and in-service teachers were developed focusing on the integration of active, interactive and collaborative teaching methods, and on the use of technology, computer-based and mobile, in all stages and levels of the educational process. But in the same time, in many cases, the national standards for assessment of teachers and/or students do not reflect the changes (Hodson, 1994; Osburg & Istrate, 2008; Yeh, 2010). While IT&C competencies, problem-solving, critical thinking and communication are covered by national tests, skills like collaboration, responsibility, self-direction and self-assessment, inquiring and challenging the established data, are not considered, thus teachers preferring to perform in a more traditional way in order to assure a high graduation

rate. The phenomenon was identified in our national educational system also (Faciú et al., 2014), and the lack of experience of students in the area of collaborative work, communication deficiencies and difficulties with the self-management, were perceived as potential limitations and risks that may occur in achieving educational goals when using PBL (Bédard et al., 2012).

Thomas (Thomas, 2000) proposed a list of five requirements in order to assess the efficiency of PBL exercises: 1. need to be central to the curriculum; 2. need to include a question or problem that drives students to meet the fundamental notions and principles of the discipline; 3. need to involve students in a productive study; 4. need to be significantly student-driven; 5. need to be realistic, to not contain hypothetical exercises. Considering the fifth requirement, the environmental issues from the community, with their multidisciplinary characteristic, may prove a suitable real-world context for projects in many disciplines (Blanchet-Cohen & Reilly, 2013; Martelli & Watson, 2016) from environmental related sciences to social sciences. In the same time, the results obtained through analysis of data from their own community, which may highlight real problems, can be used to increase environmental awareness and to shift students' attitude to active involvement (Hungerford & Volk, 1990; Wals, Brody, Dillon, & Stevenson, 2014).

Such an approach concords with the goals of Environmental Education (EE) stated by Hodson (Hodson, 1994), which are based on the declaration of 'Tbilisi Intergovernmental Conference on Environmental Education (FICE Subcommittee on Environmental Education, 1978). According to Hodson (Hodson, 1994), EE is structured into three major components: 1. is about the environment, its goal being environmental awareness; 2. is in and through the environment with the goal: environmental experience; 3. is for the environment, the final goal being environmental concern (Hodson, 1994). Using community's environment as a real-world context for PBL, the goals are about the environment, the activities to reach the goals happens in and through the environment, and the discussions and presentation of the results are conducted for the environment, raising the environmental issues identified during the analysis.

Two community's environmental issues: the historic effect of industrial discharges on the quality of a water ecosystem and the effect of building placement on traffic pollutants dispersion were used as real-world context for projects developed by a master student group from Environmental Engineering specialization. The projects aimed to: 1. assure students' professional development in a context as close as possible to the one required by the future employers; and 2. to increase their environmental

awareness as community members. The paper presents the PBL design of the themes and the validation; the intervention plan, using technology, proposed in order to surpass limitations and risks that may occur due to students' lack of skills; the discussion of the academic outcomes and the results of students' interviews considering their perception on the degree of readiness for entering the labor market; the community's environmental problems identified and the results of students' interviews considering their environmental awareness, experience and concern as both members of the community and as environmental engineers.

2. Project based learning design

2.1. Key Questions and Objectives

Two environmental issues specific to urban areas: 1. the historic effect of industrial discharges on the quality of the ecosystem from an artificial lake and 2. the effect of building placement from residential areas on traffic pollutants dispersion; were used as real-world context for two projects proposed to the students from the MSc specialization in Environmental Engineering (PMMIM). The projects run under the same Essential Question: How human activities affect the environment? were completed during the second and third semester and covered the learning units for the subjects: Environmental factors monitoring using GIS (GIS_Env) and Environmental monitoring using advanced techniques (Sp_Meth). MSc specializations have a three semester long, and the courses were finalized with a dissertation thesis at the end of the third semester. During two academic years, all subjects targeted in the project were taught along all three semesters: 1st and 2nd semesters were allocated to basic modules and the 3rd semester to advanced modules. A short description of the project's objectives is presented in Table 1.

For both projects, the activities were scheduled to be completed during the laboratory sessions allocated for the two study subjects, cumulating 4 hours per week. The targeted educational objectives were: O1. to implement the methods and the theoretical concepts learned during courses into a real-world context; O2. to review the curricula from the previous semester/semesters and from related disciplines; O3. to increase the students' degree of autonomy and self-management by conducting activities in a real-world context and preparing them for the labour market; O4. to increase students' environmental commitment and the degree of understanding in relation to their future role as environmental engineering specialists. The competencies targeted during the projects were: efficient use

of various measuring equipment (O1, O2), mapping and spatial analysis of environmental parameters (O1, O2), statistical analysis of data (O2), project management (O2, O3), communication and reasoning of results (O3, O4), self-management and self-assessment, collaboration, problem solving (O3), awareness and commitment to an environmental behavior as a member of the community (O4). Two environmental issues specific to urban areas: 1. the historic effect of industrial discharges on the quality of the ecosystem from an artificial lake and 2. the effect of building placement from residential areas on traffic pollutants dispersion; were used as real-world context for two projects proposed to the students from the MSc specialization in Environmental Engineering (PMMIM). The projects run under the same Essential Question: How human activities affect the environment? were completed during the second and third semester and covered the learning units for the subjects: Environmental factors monitoring using GIS (GIS_Env) and Environmental monitoring using advanced techniques (Sp_Meth). MSc specializations have a three semester long, and the courses were finalized with a dissertation thesis at the end of the third semester. During two academic years, all subjects targeted in the project were taught along all three semesters: 1st and 2nd semesters were allocated to basic modules and the 3rd semester to advanced modules. A short description of the project's objectives is presented in Table 1.

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Table 1. Presentation of projects research themes and the link of the key questions and objectives with the real-world context

Project Code	P1	P2
Project Title	Assessment of the current state of quality of the natural habitat from the artificial lake	Investigation of the effect of building placement and orientation on the dispersion of traffic air pollutants
Implementation Period	2 nd semester/10 weeks/nesting and breeding of the bird population	3 rd semester / 8 weeks /snowy winter
Real World Context	The lake, with an area of 29 ha, was built as a reservoir belonging to the energy system and to provide the water needed for the industrial units located in the area. In the same time, the treated wastewater was discharged into the lake in two locations from the right bank. Currently, the industrial units are closed, and the lake and its surroundings represent one of the largest green areas in the city, used by birds for nesting and wintering and by residents for leisure and recreation.	Most of the residential areas near high traffic routes consist of blocks of flats with four to eleven levels, with positioning along the street direction. This positioning may produce the <i>canyon effect</i> which determines the deposition of pollutant particles from the air to the soil. A characteristic of snow is its ability to capture particles of air pollutants during the fall. Once deposited on the soil it acts as a collector, studies showing levels of pollutants that are increasing in time.
Key Questions	<ul style="list-style-type: none"> • How evolves the surface of the natural habitat? • What is the current state of water quality? • Is any historic pollution manifested? To which extent? 	<ul style="list-style-type: none"> • How affects the position of the buildings the air pollutants dispersion? • How can discriminate between pollution sources using snow as an indicator?

Derived Research Objectives	1.To run a comparison analysis between the current map of the natural habitat and previous satellite images; 2.To analyze the variation of physical and chemical parameters values measured for water considering the quality standards; 3.To identify “hot spots” where historic pollution manifests.	1. To analyze the variation of physical and chemical parameters values measured for snow considering the distance from the traffic routes; 2. To identify the effect of building position on the dispersion of the air pollutants; 3. To discriminate between traffic and other pollution sources.
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2.2. Initial Assessment and Intervention Plan

To overpass possible risks and limitations due to students' lack of skills, a short six weeks project was run in the first semester in order to evaluate their ability to work collaboratively, to perform a correct self- and peer-assessment, to manage timelines and activities, to adapt to different learning environments, and also their abilities in using various mobile and online devices and tools for communication and collaboration. It consisted of three distinct phases incorporating field activities, laboratory activities and data analysis and interpretation, and culminated with a presentation of the results. Students' activities and skills were assessed by tutors using observation journals, scoring rubrics and progress monitoring checklists. The same evaluation sheets were given to the students in order to self-assess. The study was presented in detail elsewhere (Faciú et al., 2014), thus, in summary, a large percentage of students (85%) evaluated their acquired knowledge in the same domain of scores as their tutors, while half of them (54%) over or under evaluated their personal skills. Also, several management obstacles needed to be surpassed, mainly related to lack of communication and collaborative skills, lack of initiative and self-confidence, or poor self-management of some students. Overall, the majority of students proved to be proficient in using technology, and also adaptable and open to change, none of them manifesting a strong resistance, or refusing to perform the tasks.

Considering the results of the assessment, the intervention plan integrated technology in all students' activities related to communication, collaboration and progress monitoring. Thereby, enoeducation.ro online platform was used by students and tutors to post messages and comments, to upload their work files and results and to download tutorials and other

necessary materials. Teamwork was improved by using online collaborative tools like GoogleEarth and GoogleDocs, the links to the materials being shared with the other participants through email and enoeducation.ro platform. To assure a real-time interaction during field activities, tablets and smartphones with internet connection were used. Thus, it was possible not only to communicate but also to transfer field data to tutors and laboratory-based teams and to receive quick feedback on the accuracy of measurements. All the reflection journals, progress monitoring and self-assessment sheets were made available through online forms, much easier to be accessed and completed by students. These tools also allowed tutors a faster way to monitor students' activities and thus to intervene if necessary. The use of the interactive ceramic whiteboard facilitated the tutor-student conferences, brainstorming activities and presentations through: use of several files simultaneously opened on the screen, connection to the internet, possibility to make notes on and over the open files, possibility to save the annotated screens and to upload the files directly to enoeducation.ro platform.

2.3. Projects Development

Before starting the projects, a presentation of the objectives, of the desired outcomes and of forecasted impact on students' professional and personal capabilities was done, their participation in the project being based on volunteering. On both projects, seven PhD students acted as experts and performed demonstrations of the use of the equipment and specific software. Tutoring was assured by teaching staff involved in the two disciplines Environmental factors monitoring using GIS (GIS_Env) and Environmental monitoring using spectroscopic techniques (Sp_Meth). The activities took place during laboratory classes, 4 hours per week, the tasks being related to the curricula from the courses.

During second semester (the academic year 2013-2014), all 19 students enrolled to MSc specialization chose to participate to Assessment of the current state of quality of the natural habitat from the artificial lake project (P1). They formed six teams and performed the same tasks (sampling, georeferencing, measurements, analysis of data, report of results), but in different areas of the lake. In the end, a single report was presented embedding all six partial reports. While the framework of the project was given to the students, they had the liberty to negotiate their tasks and roles in the teams.

During the academic year 2014-2015 the MSc specialization Procedures and methods of measurement in Environmental Engineering

PMMIM was covered by 15 students. The participation in the project being volunteer-based, six students chose to involve in the project Investigation of the effect of building placement and orientation on the dispersion of traffic air pollutants (P2) and run the project related activities (sampling, georeferencing, measurements, analysis of data, report of results) according to the project timeline, two master students were granted internship stages at the Doctoral School of the university and worked with the PhD students on their research projects, and seven chose to attend the laboratory sessions according to the curricula-based schedule. To ease the references to the categories of students, they were coded as follows: project participants (PP1 to PP6), interns (IS1 and IS2) and the students that chose the curriculum-based approach (CB1 to CB7). To ensure an efficient implementation of projects tasks, PP and IS students could book the laboratories and the necessary equipment in other days, if available, according to the project timeline, while CB students attended to the laboratory sessions as planned through the curriculum-based schedule. Support materials (procedures, methods, tutorials) and references were posted in the group space on enoeducation.ro platform, to be available to all students; also, after each laboratory session or project task, all students needed to upload the results in the designated space on the educational platform, thus monitoring and peer-assessment was assured for all students. Together with PP students' presentations, the other two groups were requested to prepare and deliver a presentation and a short report about a curriculum sequence at choice, in this way, all students having the opportunity to exercise before thesis dissertation. It can be concluded that the same conditions and access to the same resources were granted to all students without regard to their learning path choice, equality of chances being ensured.

2.4. PBL Design Assessment

The list of requirements proposed by Thomas (Thomas, 2000) was used to evaluate the design of PBL experience. In order to be efficient, PBL exercises need to:

- Be centered on the curriculum - The projects' themes were chosen in accordance with the methods and procedures needed to be learnt by students. And, to be able to complete the activities of the projects, students needed to apply the concepts taught.
- Include a question or problem that drives students to meet (and fight with) the fundamental insights and principles of the discipline – Three open questions (P1 project) and respectively two (P2 project) were included

as key questions (Table 1), the path to find the responses driving students through the taught concepts. In the same time, to be able to respond, the students need to design their course through the project, to analyze and interpret the data and not only to sample and measure.

- Involve students in a productive study - In both cases the products of the projects were a short-written report and a presentation of results in front of the colleagues. During presentations and the following discussions, the students were encouraged to present not only the conclusions but also the struggles they encountered and the ways they overpassed them, to identify possible environmental problems resulting from the interpretation of data and to propose future actions.

- Be significantly student-driven – In both projects, the role of teaching staff resumed to tutoring and monitoring.

- Be realistic, to not contain hypothetical exercises – In both projects, the students went into the community to gather data about the community's environment, the results being interpreted in relation with the community's status.

- It can be concluded that both projects proposed met all PBL requirements.

2.5. Learning assessment

Due to the small number of participants, making it impossible to divide them into an experimental group and a control one, alternative methods were used like: comparison analysis with the grades and data recorded during the previous academic year from the same specialization (P1) and in-depth interview (P2).

2.5.1. P1 Project

For the P1 project, assessment of the acquired knowledge was done through a comparative analysis with the grades and data recorded during the previous academic year from the two specialization in the same fundamental domain. Considering the teaching-learning-assessment methods used during the targeted academic years, the two approaches of the educational process were defined as traditional (2012–2013) and experimental (2013–2014).

In the traditional approach methods like lectures and demonstrations prevailed, while the practical activities consisted of strictly pre-defined tasks performed in the laboratory individually or in groups. The technology used included projectors, laptops, measuring instruments, computer network and software applications dedicated to the spatial and statistical analysis of the

experimental data. The assessment aimed only the partial and final acquisition of scientific concepts and it was conducted using written tests.

The experimental educational approach included computer-aided instruction both in teaching and in the development of practical applications using ceramic whiteboards, tablets, online interactive and collaborative tools, project-based learning method. Students were free to project their activities within the groups and negotiate their duties. Complementary skills, like communication and collaboration, were also evaluated using observation sheets, as well as self-assessment and self-management rubrics, but the assessment of scientific knowledge was conducted through written tests, in the same manner as in the previous year. In addition, grading took into account only the results of the partial and final tests in order to be able to compare the results.

Grades for admission to a master level were used for the initial characterization of the traditional and experimental groups. The grades obtained during the specific exams at the targeted disciplines were used to assess the efficiency of the educational process.

Data analysis, descriptive statistics, and graphic representations were performed using the SPSS 20 software application.

Because the sample size is small (Table 2), comparative non-parametric tests were non completed.

Table 2. Descriptive statistics of admission grades

		No of students	Mean	Median	Min	Max
PMMIM	Traditional	15	8.6	8.4	8	9.6
	Experimental	19	8.16	8	7.56	9.5

It can be observed that in terms of educational level the experimental groups started at a lower level (Table 2, Figure 1).

From the representation of the examination grades in the case of the two approaches, traditional and experimental (Table 3, Figure 2), it can be observed that there is no significant difference between the two approaches in terms of results.

Figure 1. Histograms and normal curves of admission grades for PMMIM study groups

Figure 2. Histograms and normal curves of examination grades for Environmental factors monitoring using GIS (GIS_Env) and Environmental monitoring using spectroscopic techniques (Sp_Meth)

Table 3. Descriptive statistics of admission grades

		Mean	Median	Min	Max
GIS_Env	Traditional	8.58	9	5	10
	Experimental	8.42	9	6	10
Sp_Meth	Traditional	8.82	10	5	10
	Experimental	8.47	9	6	10

Even if the experimental group started their educational journey from a lower level than the traditional group, finishing at the same level, and also an increase of the minimum grade was observed for both subjects at the experimental group, it cannot be said that PBL approach had a beneficial influence on their learning process considering only the grades received through a traditional assessment. But even in this case, it can be stated that the radical change in teaching methodology did not lower the quality of the educational process.

2.5.2. P2 Project

Due to the small number of students at MSc specialization, and the even smaller number of students involved in the project, it was not possible to perform an analysis with test and control groups and questionnaires. In the literature, in-depth interview is considered a better method of learning assessment after participatory projects than questionnaires, because, during an interview unconsciousness learning surfaces, the students making their own connections between their project and other issues, in our case environment-related, suggesting a subdued level of learning awareness (Evans, 2008; Kuldass, Ismail, Hashim, & Bakar, 2013).

Three interviews were held: Interview 1 (I1) before starting the project, but after the students made their choice; (I2) at the end of the project, after the session of presentations; (I3) after the thesis dissertation. Participation at the interview was volunteer based, but the students were opened and accepted in a large number, nine of them responding in all three interviews: IS1, PP1, PP2, PP3, PP4, PP6, CB1, CB2, CB4.

The questions asked during the interviews followed three main directions: 1. Understanding of course materials (I2, I3); 2. Feelings regarding their degree of preparedness for integration on the labor market (I1, I2, I3); 3. Understanding their role in the community as environmental monitoring experts (I1, I2, I3). A fourth direction was related to 4. Their

experiences and opinions regarding their participation in the projects (P1 and P2) and its benefits, or lack of (I1, I2, I3). The codes, and subsequently the themes and patterns, were derived bottom-up by the researchers' analysis of the data. Interpretations were based on an examination process, searching for reoccurring themes of and types of learning gained from the projects or activated by them (Braun & Clarke, 2006).

Analyzing the responses from direction 1. Understanding of course materials questions, it can be concluded that all PP students considered that the project contributed significantly to meaningful learning, the real-world context helping them to understand better when and why certain methods and procedures are applied. Also, it was observed during the master thesis presentations and following discussions with the examining committee that the PP students mastered very well the concepts used in their thesis and that they proved easier access to concepts learned during courses but not used in the thesis. Here are some of the responses:

- PP3 during I2: During the project, not only that I learned how to use certain equipment or to run a certain method of analysis, but because the activities were linked between them, I understood why I am doing what I am doing. It all had sense. ... Designing my thesis was easy.

- PP3 during I3: I am very pleased with my grade. I did not use spectroscopic techniques for data gathering [Sp_Meth subject], I took my data from a public database, but I mastered the spatial distribution [GIS_Env subject] and my interpretation of results was appreciated. ... and when they start to ask me questions about sampling and conservation [not used by the student in the thesis because a public database was used] I remembered from the lake project, and it was all good...

- PP5 during I2: When I saw that the timeline of the project [P2 project] is different than the laboratory activities schedule, I was afraid that we will not cover all the spectroscopic methods, and my thesis uses them heavily. But it was better this way, I used them in a context and not just to exercise. ... I already know how to structure my thesis.

- IS1 during I3: I covered all the concepts working with PhD students, helping them with their research. I did this mostly outside the laboratory classes, like my colleagues from the project. I saw how the methods were integrated into their research, and I experienced more than [was included] in the curricula, which was a huge plus. ... But at the end of the semester, I felt somehow puzzled because I jumped from project to project and each of them used different methods. I did not have an overall picture and when I started to design my thesis I struggled.

- CB3 during I3: I appreciated their [PP students] confidence when presenting and answering. Even the timid ones stud up. I chose not to participate in this project because I knew [from P1 project] that I will need to present my findings at each [tutor-student] conference. And I feel awkward when speaking in public. It was a mistake.

The use of enoeducation.ro platform by all students as a common space was perceived positive by both PP and CB students, the first had a new resource of information to question, the second witnessed to all discussions and both had the possibility to view the uploaded materials. Here are some of the responses:

- PP5 during I2: I used the [curricula-based] schedule [from the platform] as a checklist to be sure that we are covering [during project activities] all the [spectroscopic] methods.

- PP1 during I2: Once I was alone in the GIS lab [not during laboratory schedule] doing my task and I had an error. I did not find an explanation in the tutorials or help and no one near to ask. I posted on the platform and [CB2 student] told me how to eliminate it. They encountered the same error during lab and [CB2 student] explained to me why it happened.

- CB1 during I2: I was online once, and I saw a desperate message [from PP1] about the same error I had [during laboratory session]. I post the steps to eliminate the error. The professor explained to us, but I am not a professor. I do not know how much of my explanation [PP1] understood, but I am sure that it became crystal clear for me.

- CB4 during I3: I used to follow the posts they [PP students and tutors] put on the platform and to view their conferences recordings. I admit that there were some concepts I understood better after that. It was a good thing that they did not restrict access.

- Students' reports and presentations also indicated that they had learned about the spectral and the spatial analysis methods, procedures and functions used for environmental factors monitoring. This conclusion was confirmed by the grades obtained at the final exam: master thesis dissertation (Table 6).

- From 15 students, three did not deliver the thesis, therefore, they did not participate in the same session with their peers. All three were from the CB category: CB5-7. The other 12 students passed the exam, their grades being shown in Table 4. The mean, the minimum and the maximum for each category were marked.

Table 4. Students' final grades by category

PP – MEAN: 9.08		IS – MEAN: 9.63		CB – MEAN: 8.81	
PP1	8.5	IS1	9.5	CB1	8.25
PP2	9.5	IS2	9.75	CB2	9.5
PP3	9.25			CB3	7.75
PP4	9.5			CB4	9.75
PP5	9.25				
PP6	8.5				

3. Results

3.1. Interview Results Considering Students' Feelings Regarding Their Degree of Preparedness for Integration on the Labor Market

First interview (I1) showed that students' choice regarding participation on the P2 project was strongly influenced by students' perception regarding their professional skills and the employers' requirements. Four of the PP students never worked in the environmental sciences field and perceived the project as an opportunity to experience. The other two (PP2 and PP4) work in different environmental related organizations and perceived the project as an opportunity to evolve in other directions. Also, the students who chose not to participate in the P2 project reasoned their decision in relation to their current or future job requirements. Here are some of the responses:

- PP1 during I1: It is very hard to find an internship in the field and the employers are reluctant when you say that you do not have experience. I intend to put both projects in my resume as professional experience ... [because] last year project [P1 project] showed to me how an ecological assessment should be made. I will have what to talk about during the interview.

- PP2 during I1: I chose this specialization because of the GIS course. ... I already do at my job sampling, measurements and reports, but only statistics. I want to integrate spatial analysis also. ... The last year project [P1 project] was useful; I hope this one will be too.

- PP4 during I1: our monitoring projects [at the workplace] are related mainly with natural protected areas. An analysis of the urban environment sounds very interesting. I am curious about what will find.

- CB2 during I1: I already structured my thesis on [theme of research not related to the subjects covered by the project] and the project will not help me very much. I work in a lab [at the workplace], and I prefer to stay in the lab to experience other equipment than ours.

- CB1 during I1: I don't believe that a project is of too much relevance for an employer. I'm searching for an internship.

All students considered that both projects provided a job-related environment for practice. While students who were not working in the environmental monitoring field appreciated the integrated approach linking the curriculum with the logic of complete monitoring activity, the more experienced students praised the possibility to experience other fields of expertise. Here are some of the answers:

- PP3 during I2: The projects [P1 and P2] had very different themes, we applied different techniques and referred different concepts ... but during this project [P2] I realized that they had the same structure ... I was practicing the monitoring ... I am more confident now that I will be able to adapt to my future job requirements.

- CB2 during I3: I learned the stages of a monitoring process, but it was interesting to experience it from start to end [P1 project] ... I work in a lab doing laboratory analysis, others are doing field measurements and sampling, and others are doing the interpretation of data ... but we are a big organization ... if I will need to change my workplace I will be able to complete the whole process.

- PP4 during I3: The field [environmental monitoring] is huge, you can work with a lot of equipment, and it is impossible to know everything ... it is important to understand the process, to be flexible and willing to learn.

3.2. Correlation between PBL key questions and educational goals

While reaching the goals of the projects and answering the key questions, some environmental risks were identified (EE goal - environmental awareness), students found explanations (EE goal - environmental experience) and proposed possible solutions or developed a new key question for future research (EE goal - environmental concern) (Hodson, 1994). In Table 5 a synthesis is presented.

Table 5. Examples of correlation between projects key questions and EE goals through students' results

Key questions	Environmental awareness	Environmental experience	Environmental concern
P1 - Assessment of the current state of quality of the natural habitat from the artificial lake			
How evolves the surface of the natural habitat?	In time the surface of the natural habitat increased with the result: the bird population was increased. Because the lake is not a protected area, what are the risks for the fauna and how the economy of the lake area will be affected?	Students experienced the environment directly through measurements, observations and comparative analysis of various types of maps. The increase of surface was explained by the silting process, the direction of expansion being influenced by the underwater currents.	In some parts the vegetation islands became connected with the shores, wandering dogs being able to reach the birds' nests. Also, the rowing channel was narrowed affecting the business. Solution: to design and implement an intervention plan which will maintain the natural habitat in an optimum extension without affecting the established businesses and will improve the security of wild fauna.
P2 - Investigation of the effect of building placement and orientation on the dispersion of traffic air pollutants			
How affects the position of the buildings the air pollutants dispersion?	The position of buildings along the streets favours pollutants deposition on the ground in the immediate vicinity of buildings. Because the ground in urban areas is covered mainly with	Students experienced the environment directly through sampling, field measurements, observations and comparison analysis of distribution maps. The air currents dispersing	In order to reduce the health risk, in short term students proposed as solutions: to increase the number of trees from the city, to select the new trees considering their ability to retain

	artificial materials and not with soil and vegetation, pollutant particles can be easily scattered by air currents becoming a threat to population health.	pollutants are broken by buildings and the particles fall on the ground. The distribution maps showed clear differences between concentrations.	pollutant particles, development of an awareness campaign addressed to local council and domestic owners to increase and maintain the green cover of the soil. In long term, to redesign urban planning policy and to find economic solutions to implement green covers for the walls of buildings.
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It can be concluded that using the nearby environment and its problems as a real-world context for PBL proved to be an efficient resource for environmental education also. In the same time, considering the community's environmental issues increased students' degree of awareness and motivation for action. This was reflected in their interview answers also:

- IS2 during I1: Each summer I spend two weeks planting trees in areas affected by deforestation. I started after I witnessed a landslide ... I admit that I was not that willing to do this before ... direct experience with environmental problems is the best way of achieving motivation and implication.

- CB1 during I2: When [we were] discussing the lake environmental status [P1 project] I felt sorry for the swans and the ducks, but to be honest, I was not willing to start a campaign ... yes, if someone would have asked my help, I would give my help ... but now, after listening to my colleagues presenting their results, I am the duck, I am the one affected by the human population. I want to be involved, I want to do something, and I will do something.

- PP4 during I3: ...we'll work on environmental monitoring, that means we'll not only experience the environment, but also the peoples and businesses responsible for its degradation. You need to be highly motivated in order to stand up in front of them. ... These projects made us realize our importance and the possible impact of our work.

4. Discussions and conclusions

The projects presented in the article were based on two community environmental problems, often recorded in urban areas: the historic effect of industrial discharges on the quality of a water ecosystem and the effect of building placement on traffic pollutants dispersion. Their goal was not only to assure students' professional development in a context as close as possible to the one required by future employers but also to increase their environmental awareness as community members. Considering the fifth requirement of PBL exercises: need to be realistic, to not contain hypothetical exercises (Thomas, 2000), the choice of an environmental issue from the community as the real-world context for projects developed by environmental engineering students seems a logic decision. But to understand, to explain and to solve an environmental problem need a multidisciplinary perspective, thus, becoming central to the curriculum in many subjects from physics, chemistry, biology, geography, economy, social studies, and computer science.

Teamwork used online collaborative tools and an educational platform for interactive computer simulations. The problems proposed were solved by students using knowledge taught in Environmental factors monitoring using GIS and Environmental monitoring using spectroscopic techniques subjects. Ongoing and summative learning assessment was run using observation sheets, as well as self-assessment and self-management rubrics and showed a good understanding of the concepts. Written tests were also used as an assessment of scientific knowledge acquired, in the same manner as in the traditional approach of the subjects. Comparison of the grades obtained by the study group and the students from the previous year taught in the traditional manner, showed that the radical change in teaching methodology did not lower the quality of the educational process.

The development of complementary skills (communication, collaborative, self-management, self-assessment) was assured and monitored through various collaborative online tools, considering students' degree of adaptability to new technologies. The final presentations and the interview responses showed that students who participate in both projects were more confident and proved easier access to concepts learned during courses but not used in the thesis. Also, they considered that both projects provided a job-related environment for practice.

Using the local environment as a real-world context for PBL, transformed the projects proposed in projects about the environment, which were developed in and through the environment and the discussions and

solutions found were for the environment. Thus, the key questions of the project became the link to the environmental education goals: environmental awareness, environmental experience and environmental concern. All interviewed students appreciated that direct experience with the environment affected positively their degree of awareness. Also, they differentiated between the risks from the community, with a possible direct effect on inhabitants, and the environmental risks located elsewhere, highlighting the profound impact of the direct experience.

In conclusion, community's environmental problems can be approached in various subjects and disciplines when used as real-world context for PBL, assuring not only the scientific and personal development of students but also their degree of awareness and motivation for action in the community is increased through direct experience. A better understanding of how students motivated by improves performance was highlighted. Due to the multidisciplinary characteristics of natural science related processes, the design can be replicated in other subjects also.

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