CASE-METHOD APPROACH IN MASTER STUDIES: APPLICATION IN THE SUBJECT OF WASTES AND POLLUTED SOILS

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Abstract

In the interest of applying active learning methodologies, the students of the Wastes and Polluted Soils module of the Master's degrees in Civil Engineering of the University of Oviedo participated in an applied activity following the case-method approach. Through interdisciplinary working groups, students had to outline a preliminary design with proposals for the regeneration of the main abandoned industrial areas (brownfields) located along Nalon River basin (Asturias, Spain). The points to be addressed were: the environmental regeneration (including soil remediation techniques) of the site, the definition of the future land uses, and the technical and economic feasibility of the proposal. The different proposals were evaluated by an examination panel of subject matter experts. The results obtained revealed that the student's interest in the subject increased, probably due to the practical approach of the active methodology used. Additionally, a selected number of proposals were published in the form of a scientific article, thus developing the scientific thinking and writing skills of the students.

Keywords: Case-method, problem-based learning, civil engineering.

1 INTRODUCTION

The concept of problem-based learning (PBL) was initially implemented by Barrows and Tambly [1] at McMaster University (Ontario, Canada) Due to the theoretical-practical nature of a degree in medicine, it is essential for students to develop skills related to the case analysis and clinical diagnosis, thus the case-method proposed by Barrows [2]. He integrates the ‘clinical reasoning’ skills in the curriculum to help students to apply the knowledge in practice in the clinical setting [3].

The case-method is an active learning method focused on the research of the student into a real and specific problem, which is used as the basis for performing an inductive study [4]. In the case-method, real problematic situations are presented to the students. They are placed in the role of decision-makers and think on how they would solve the problem, thus the purpose of proposing the problem is to stimulate their thinking, and to develop and gain knowledge [5]. The application as a learning strategy lies in the fact that it does not present solutions, but specific data to reflect, analyze and discuss in groups the possible solutions to the problem that is presented. The specific problem proposed must be prepared to be understood, known and analyzed by the student. Thus, this method allows for the studying a specific subject over a period of time. The method is applicable to multiple areas of knowledge.

Therefore, the case-method is designed in such a way that active participation, cooperation and democratic dialogue among the students are encouraged. According to Asopa and Beye [6], the case-method has three fundamental pillars, namely 1) The active role of the students throughout the activity, 2) The cooperation among students and 3) The dialogue used as an essential tool to reach a common agreement and to make decisions jointly.

Overall, the case-method is widely used by higher education organizations since it promotes cognitive abilities, such as critical thinking, the synthesis of information, or the teamwork. Moreover, students usually show a positive perception of the methodology, as reported by multiple studies, covering a wide range of subjects from different knowledge disciplines [7 – 9].

Over the last few years, teaching engineering subjects are changing considerably due to technology advances, thus new learning methodologies are required. The application of the case-method strategy, widely used in the medical field, as it has been commented on above, is one of the ideal methods to transmit knowledge on engineering problems to the students.
In this work, a real case of study was proposed to the students from the Wastes and Polluted Soils module of the Master's degrees in Civil Engineering of the University of Oviedo. The main aim was to favor the transversal skills and to draw the students closer to professional activities.

2 METHODOLOGY

2.1 Applied Case-Method

In brief, the students worked in small groups to analyze, compare and contrast their individual solutions to the problems together with the solution proposed by others. Thus, the students train their collaborative work and decision-making skills and at the same time use their specific knowledge acquired during the course related to the subject, while gaining useful skills to their future professional practices.

The ensuing lines summarize the following steps:

- **Preliminary stage**: The study case was presented to the students by the professors of the subject, which included specific problems. For this purpose, a Technical Specifications Document was provided and an ideas competition was defined. The groups of students were formed randomly at this stage.

- **Opinion expression stage**: Each group was set to work individually and independently. Each member providing his or her opinion and impressions, while offering alternatives to the rest of the members of the group. Each student was encouraged to provide his or her own ideas.

- **Analysis stage**: It allowed for the integration of informative aspects through the consensus of the group. The stage was concluded when a synthesis was accepted by all the group members. Students built a scheme to simplify the idea and started seeking information to solve the problem.

- **Conceptualization stage**: It consisted on the formulation of operative concepts or specific action principles to be applied in similar situations.

- **Contrast stage**: Here we encouraged personal expression, the contrasting of opinions and the joint analysis among the students. The groups showed their proposals in the classroom to the professors, to the experts and to the other groups. The professors and experts assessed the solutions proposed by the students and discussed the best option.

2.2 Scope: The regeneration of the main abandoned industrial areas located along the Nalon river basin

The municipality of Langreo (Asturias, NW Spain, Fig. 1) is the main core of a region known as the Asturian Mining Basins. This area underwent high industrialization which dates back to the middle of the XIX century, mainly, because of coal exploitation. This mining resulted in the development of metallurgical activities, which attracted other companies which settled along Nalon River in the 1940s and 1950s. The rise of this basic industry caused a high economic and demographic growth, which lasted until 1985, when the downturn in the Asturian collieries resulted in a recession which has lasted until the present day.

![Figure 1 Situation of the municipality of Langreo. (ref. [10])](image)

As a consequence, Langreo began the XXI century in a process of urban shrinkage, which is now being undergone by other industrial cities in Europe. As a result, multiple industrial sites have been abandoned, involving important barriers for its urban development. Additionally, several environmental
problems of a different nature have arisen as a result of the industrial activity. The students were asked
to propose solutions to recover these abandoned localities aided by their professors through case-
method teaching.

For this case, students of the module Wastes and Polluted Soils, from the Master’s Degree in Civil
Engineering of the University of Oviedo, were divided into four interdisciplinary groups of 4 to 5 students
per group. The case study consisted of generating a series of proposals for the recovery and reutilization
of four brownfields located across the La Felguera city, in the Municipality of Langreo. All of them belong
to the Nalón River basin. The four brownfields were (Fig. 2): 1) Nitrastur factory; 2) Lada power station
coal storage area, whose closure is expected to come about in the next few years; 3) Felguera Melt;
and 4) Talleres del Conde. The challenges addressed for each of the brownfields were: 1) Their
environmental recovery, 2) prospective future uses, and 3) Technical and financial viability.

A committee made up of professors and experts from the Institute of Natural Resources and Territorial
Planning (INDUROT) evaluated the proposals of the students and chose the best one, incorporating
other contributions from the second-best group of students. Finally, these students had the opportunity
to elaborate a scientific-technical manuscript which was published in the journal Naturalia Cantabricae
[10]. All the groups were supervised and advised at each stage of the process. The final proposals for
each one of the brownfields are shown in the Results section.

Figure 2. Location of study areas. 1 – Nitrastur factory; 2 – Coal storage area;
3 – Felguera Melt; 4 – Talleres del Conde. (ref. [10])

3 RESULTS

3.1 Final proposals

This section shows the proposals for the restoration of the different areas of the Langreo river basin
which result from the case-method analysis performed by the students.

3.1.1 A final proposal for Nitrastur factory

Soil washing is a method whose technical and financial feasibility for Nitrastur has been demonstrated
[11]. The soil washing plant required for Nitrastur remediation would also serve to remediate the other
brownfields after a few adaptations. It will count on a feeding module, a pre-screening module, a mill,
wet grain-size separator by means vibrating screens, sample splitter and/or homogenizer, and a
mechanical water treatment module composed by an injector, pipes, and tanks, all being part of the
equipment. This system could separate particles larger than 70 μm and process up to 120 tons per hour.
Since it is required to remediate 270,000 m³, the capacity of the plant would be enough. According to the circular economy and due to the metals found in different studies in the pyrite cinders present in the area [12], part of them Cu, Zn or Pb, or even the precious ones, namely Au and Ag could be recovered and serve to finance the remediation costs.

Once the major part of the soil has been washed, phytoremediation is also proposed as a second remediation technique. The phytoremediation in Nitrastur has also been proved in previous studies [13]. Some suitable species would be Betula pubescens or Salix atrocinerea/caprea as woody species plants, or Dittrichia viscosa or Melilotus alba as herbaceous species, which would be optimal to accumulate As and other heavy metals. The duration of the complete remediation of this site is estimated to be between 3 to 5 years.

With regard to urban actions, once the remediation has been completed, the special aim is to build a technological node and a sports complex including a sports center, gymnasium, a football field, a basketball court and tennis/paddle courts and so on. The tech hub could be organized in the old cooling tower of the factory. The remaining soil could be used to fill a green area of dense vegetation, in such a way that the new park becomes one of the most attractive areas for the citizens. The transit areas will be made of concrete.

Finally, a system of Sustainable Drainage Systems (SUDS) would be also installed. Thus, green triangular or trapezoidal ditches will be located at the edges of the plots for water transport so that the surface runoff flows slowly across the park serving as a sustainable watering system.

3.1.2 Final proposal for Lada’s power station coal storage zone

Lada’s coal storage area is a flat area located alongside Nalón River and belongs to the homonymous coal-fired power station. This power plant opened in 1946 and is still in operation. In this case, soils do not present pollution apart from some coal dust atmospheric deposition. For this reason students did not propose any specific remediation actions here. Thus, the unique works suggested were the removal of the top 0.5 m of the soil, asphalt and/or concrete. The excavated material was suggested to be transported to an authorized landfill where the management of the waste could be carried out following legal standards.

Afterward, the environmental restoration would consist of encouraging the regeneration of a riparian forest as well as constructing an enlargement for the riverside path of La Felguera. This continuity would be achieved by the construction of several paths in such a way that these connect the fluvial sidewalk with the green areas which is to be created in Nitrastur area.

These actions would involve an important benefit for human health and a landscape improvement in the whole area, while intending a multifunctional perspective. Apart from recreational functions, other activities such as the establishment of information points on the history of the area or urban gardens seem ideal to be developed in this flat area. Finally, a river bathing zone has been also proposed.

3.1.3 Final proposal for Felguera Melt site

In this site, soil presents an anthropic filling formed by by-products from industrial activity concerning coal mining and metallurgy. Therefore, this soil may cause the affection of groundwater from the Nalón river alluvial strata.

Hence, remediation of the Felguera Melt soils is required. As a first step, the students proposed the dismantling of the old workshops of the company. Moreover, as no contamination was detected in the Construction and Demolition (C&D) waste, the students proposed its reuse as well as selling the scrap metal. For soil remediation, the students selected again the soil washing approach, making the most of the plant that would have been used previously for Nitrastur soil. Although the volumes of pollution are considered minor since the excavation depth rises just 1 m. The procedure of washing is analogous as the described for Nitrastur. The students estimated that about 43,000 m³ of the soil would be transported to the soil washing plant. After the washing, the cleaned soil would be reused to fill and homogenize the present plot, while the polluted fraction could be transported to appropriate dumps.

The main urban action proposed for this site by the students was the construction of an intermodal station to allow for the exchange between the train and bus services. This proposal arose from the idea of optimizing the rail network, a long-time standing demand in La Felguera. Furthermore, students also proposed the construction of a parking lot on the old railway track. For the construction of this space, green engineering methods were proposed, such as the use of pervious paving, specifically porous concrete, which has similar features to those described for the Nitrastur case. Finally, some space would
be reserved to the enlargement of the riverside path, including the environmental restoration of the riverbank, which would be part of the same project as the one suggested for the coal storage area.

3.1.4 Final proposal for Talleres del Conde site

Talleres del Conde is an abandoned metallurgical facility which was for years the only vertical pipeline industry in Spain. A power plant was also located in the site.

The site received remediation actions to eliminate the fiber-cement present in the ceiling of the warehouse. In this way, the fiber-cement is the main pollutant of the area. Apart from this, the site is also polluted by metals and metalloids, which are present as a consequence of the metallurgical activity. With regard to the asbestos, the remediation operations were not completely effective, and some debris remain irregularly dispersed on the site. For this reason, the students suggested that further asbestos remediation could be required. This material, which cannot be remediated by conventional soil washing, should be removed by an authorized certified company specialized in asbestos abatement. Despite all this, soil washing treatment was suggested for the removal of the inorganic contaminants, again at the same plant which was designed for the Nitrastur case.

For the urban activity, the main act would consist in rehabilitation of the two warehouses as a new fairground that would serve for the celebration of agrarian events. To do so, the first 0.5 m of soil would be substituted for a concrete deck. A part would be covered by an extensive green cover which would serve as SUDS, as those installed in Nitrastur, to pluvial water capture for the celebration of the events. In the perimeter area, a gravel band would be installed to retain the water surplus. Finally, it is recommended to add a firewall material to ensure the security against fires.

![Figure 3 Proposal for environmental regeneration and new uses of the industrial wastelands in the river axis of Langreo. (modified from ref. [10])](image)
3.2 Contribution of the activity to the development of the students

The most important point of the applied methodology is that the students face real cases in the activity which has several favorable several aspects for the students. The problem proposed is a real case that is described by a Technical Specifications Document and is provided to the students. Thus, the students come nearer to the professional career. In order to evaluate the success of the methodology, the subject pass rates have shown some improvement with regard to the previous years.

The performance of the ideas competition allows the students to develop transversal skills, such as team-work, resilience, and problem-solving. Nowadays, these competencies are being required on the labor market. Therefore, the transversal skills should be developed in the classroom. In fact, the team-work skill is highly promoted during the activity because of the necessity for this discipline in the majority of the jobs.

The multidisciplinary nature of the activity was also presented. The students should show their knowledge on the subject, but they also needed to use the learning of other subjects to complete the proposal successfully. The evaluation performed by an examination panel of experts favors the enrichment of the ideas presented by the students due to the experience of each member of the panel in the differences subjects.

The results of the survey of teacher education performed for the Wastes and Polluted Soils module revealed a mark of 9.1 over 10, while the average mark for the modules of the Master’s degree was only 7.6. This evaluation reveals that the students were interested in the activity. Furthermore, the students’ interest in the module content was also confirmed by the carrying out of several final works related to the subject of polluted soils, and the internship performed by students in the research group. The approximation to the scientific field through the elaboration of a scientific publication has led the students to estimate alternatives for career development. The impact of this publication was evaluated by the number of reads in ResearchGate, reaching a quantity of 135.

Finally, the local government revealed a great interest in the work performed by the students, which resulted in the fulfilling of a real project performed by INDUROT.

4 CONCLUSIONS

The application of the method-case methodology in engineering modules was revealed as a successful activity for the transversal skills development of the students. As the main conclusion, we can state that the methods applied help to train future professionals in civil engineering, who will be capable of finding the right solution to the particular problems arising and adapting it to a social and environmental context.

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REFERENCES


