PROBLEM BASED LEARNING VS CHALLENGE BASED LEARNING IN GEODETIC ENGINEERING

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***Abstract**: In this article we propose a comparative approach of what Challenge Based Learning vs Problem Based Learning means, as well as examples of the possibilities already applied in the Geodetic Engineering Domain, at master's and doctorate level. The CBL concept is analyzed from the perspective of creating a real link with market actors, public or private entities. The strong and weak points of CBL are identified from this perspective. A feasible work flow is identified, which leads to a win-win collaboration between universities and relevant actors.*

***Keywords:** CBL, PBL, Geodesy, PhD thesis, MSc thesis, Challenge Based Learning, Problem Based Learning*

1. Introduction

Currently, not only technology, but also learning and research methods are transforming and evolving rapidly. Notions such as Traditional Learning (TL), Problem-Based Learning (PBL), Challenge-Based Learning (CBL) appeared over time. They also change the approach paradigm in higher education in general and in engineering higher education in particular. [1] In the in the Framework of Education 4.0, CBL is an important approach, involving methods of innovation in learning. [2][3]For example, GIS is seen as a useful tool for applying CBL in interdisciplinary research. [4]

Analyzing the concepts presented in many specialized works [1][6], it becomes obvious that the attention of teaching staff in higher education must be directed not only to the technical content that is teached to the students, but also to the way in which this is achieved, to the techniques of "teaching them to learn". [7][8][9] In fact, the Challenge Based Learning educational trend, which is part of the broader spectrum of Experiential Learning. [10]

2. Problem-Based Learning vs Challenge-Based Learning

According to [11], CBL resides in three major stages, the first of these stages being the involvement stage, which is based on a major idea, usually a real problem, which can be solved in several ways, being important not only for the student , but also for the community. We can thus mention environmental issues, transport, sustainable development, green energy, intelligent spatial planning, smart city, digital twin, etc. The people involved, i.e. the coordinating professor(s), the student(s) and the external partners work together to define the

major question from which to start the research. In this way, the question is transformed into a call to action to thoroughly analyze the subject in order to identify a solution.

The second stage is the investigation of the current state, in which the main goal is to create a solid base to develop real, applicable and sustainable solutions. Additional knowledge needed to solve the challenge must also be identified. There are needed resources and activities necessary to obtain additional knowledge, such as: simulations, experiments, projects, problem sets, research. The current state analysis phase concludes with a synthesis of that relevant information found.

The third stage is the development and implementation of the solution, the results being implicitly evaluated in this way. It is the moment when the accumulated knowledge is applied practically and disseminated to develop a solution. [11]Two main sub-stages are thus completed, the first being the design and the second the implementation of the solution. In the design cycle, new questions usually arise that can lead to further research. In the final stage, the solution is tested in a real context and evaluated according to the impact it has on the initial challenge.

In figure 1 and 2 are emphasized the PBL, respectively CBL approaches.[10][13][14]

Fig. 1. Problem Based Learning

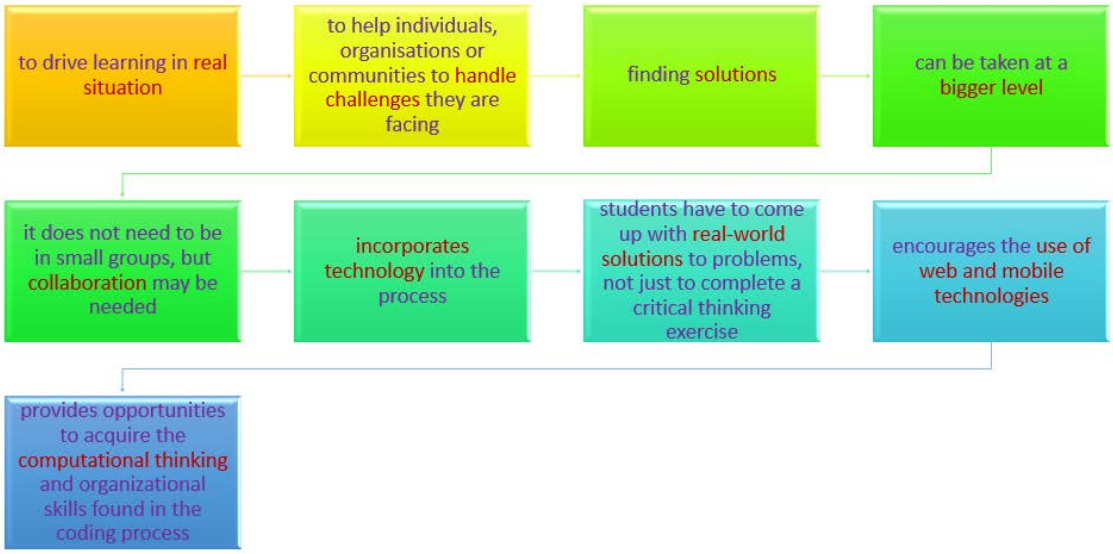

Fig. 2. Challenge Based Learning Approach

Fig. 3. PBL vs CBL (adapted from [15])

3. CBL applied in MSc Dissertation Thesis or PhD Thesis

In this article we want to mention some examples regarding the elaboration of dissertations and doctoral theses using this technique. Among the challenges that arise are the student's openness and desire for knowledge and self-improvement, but also the receptivity to the ideas that the coordinator suggests during the elaboration of the work. In figure 4 is highlighted the framework of CBL approach in PhD Thesis.

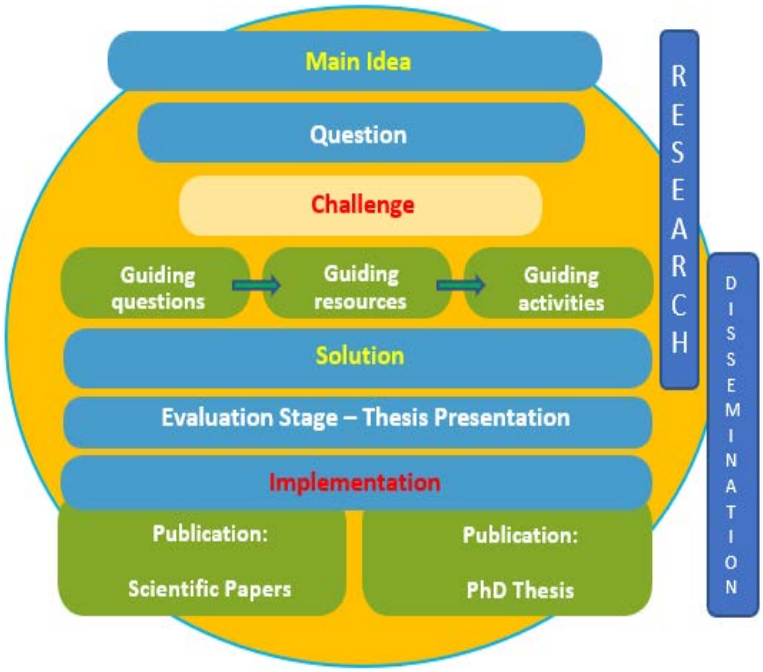

Fig. 4. CBL Approach in PhD Thesis Development

In fact, CBL is increasingly being used in higher education in projects, being a process of discussion and research, so everyone is a Learner, existing a paradigm like Teacher/Learner and Learner/Teacher. [11]

During the development of the work, the students are identifying a selection of workable questions for their project, documenting with commonly accessible technology and using the technology to implement solutions and to publish results. [16]

An important phase is presenting of the findings and reflections not just to their class but also to their community, to the specialized commission, but also the dissemination on a large scale, through scientific articles and even through the publication of the work

The thesis coordinator has a particularly important role, acting as a mentor to help answer questions and providing examples. In figure 5 are identified the CBL advantages and in figure 6 the CBL main steps, from the student and the professor involvment viewpoint.

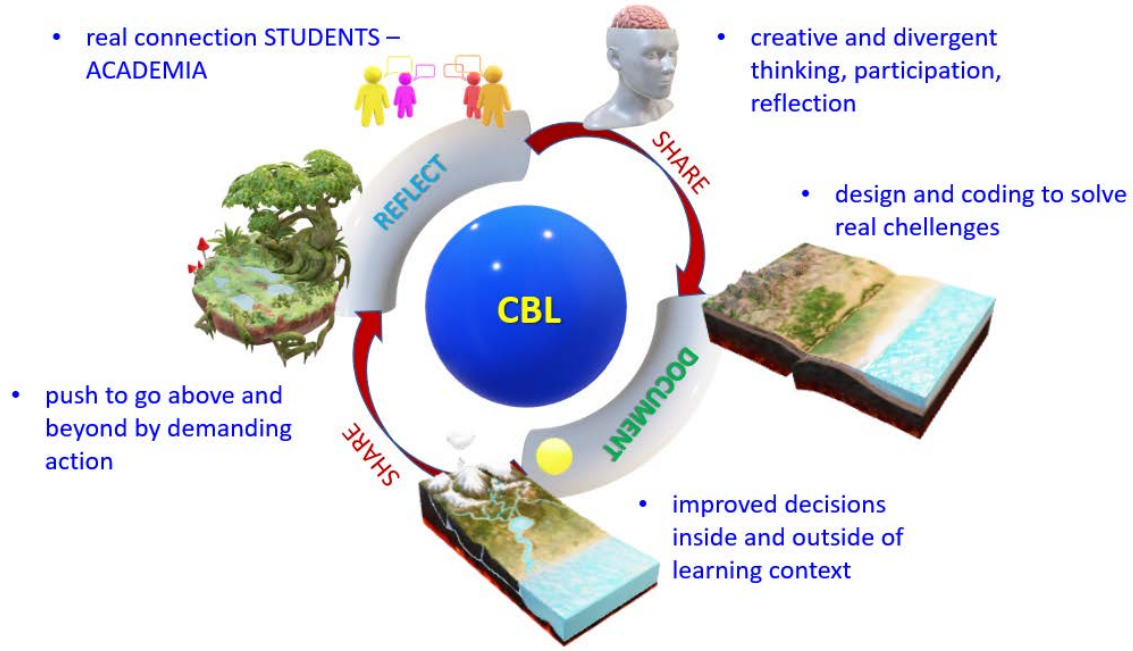

Fig. 5. CBL Advantages

Main Steps	Student Involved	Professor Involved
Review theoretical background	x	x
Exploring the challenge	x	x
Understanding the challenge • Meet the challenge • Know/ Need to know • Explore the possibilities	x	x
Guiding for solving the challenge • Questions • Resources • Activities	x	x
Analyze the existing solutions (if any) • Gather information • Shate information • Test possible solutions	x	-
Developing and implementing a solution • Best fit solution • Present the solution	x	-
Conclusions for the challenge	x	-
Continuous feedback	-	x

Fig. 6. CBL Main Steps

4. Case Studies in Geodetic Engineering

All these conceptual elements have been successfully applied in recent years in the process of developing dissertations and doctoral theses. It is important to mention that these examples were considered for analysis from the point of view of the topic and the approach of the student and the coordinator, that is CBL, and not from the point of view of some case studies within an article focused on the scientific solution.

The first example is CBL based on GIS and Remote Sensing, a dissertation thesis having as a CBL theme to analyze of coastline changes. The student approach consisted in identifying Mamaia Area & Sacalin Island changes using GIS technology and satellite images, focused on the following steps: image processing, bands combining, classification of the satellite images content, analysis and interpretation of coastlines, assessment of changes in coastlines, animated highlighting of changes. In figure 7 are shown the main results.

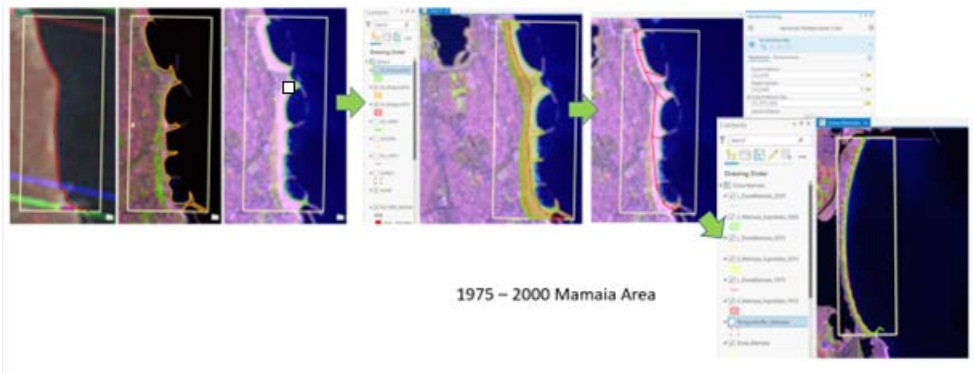

Fig. 7. Mamaia Area [17]

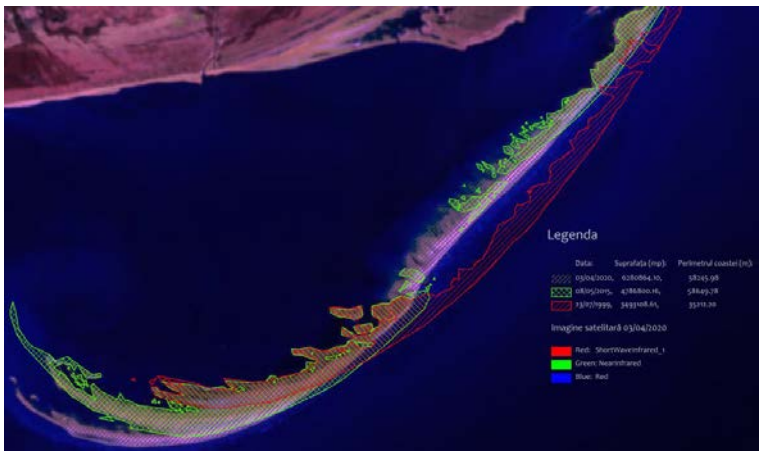

Fig. 8. 1999-2020 Sacalin Island [17]

The second example is CBL based on GIS and Remote Sensing (MSc Level), with a CBL theme: determination of floodplains and determination of urban footprint. The student approach consisted in automatization based on Sentinel-1 SAR. (figure 9 and 10)

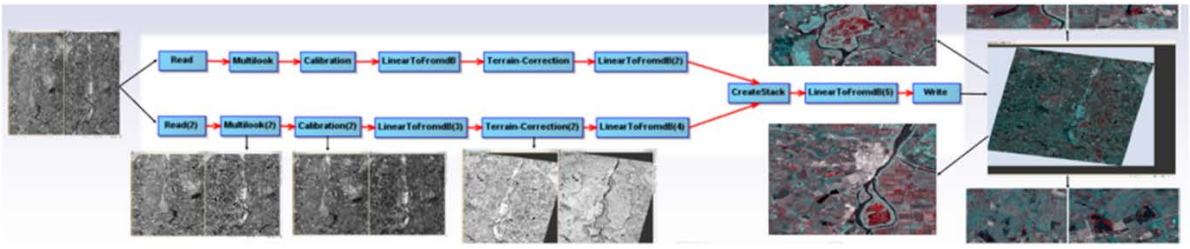

Fig. 9. Automatization Workflow for floodplains [18]

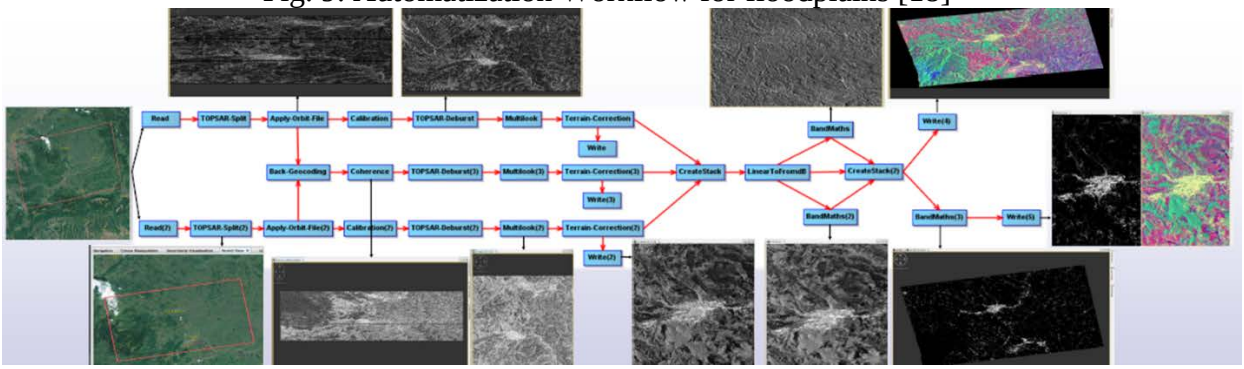

Fig. 10. Automatization Workflow for determination of urban footprint [18]

The third example is CBL applied in monitoring static tested construction subjected to vertical or horizontal bending that causes deformation of the structural elements of construction, such as beams, columns, plates. (figure 11)

Fig. 11. Student approach: analyzing classic technologies and new technologies for geodetic collecting, processing and representation of data [19]

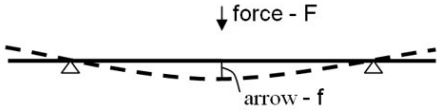

Fig. 12. Vertical bending (arrow) that causes deformation of the bridge structural elements [19]

Student approach consisted in analyzing classic technologies and new technologies for geodetic collecting, processing and representation of data. Development of laser scanning technology for geodetic measurements, was used to measure objects and obtain results. Determining the arrow from laser scanning data by creating sections (fig. 13) with the same origin, through the two point clouds was the solution chosen to solve the problem.

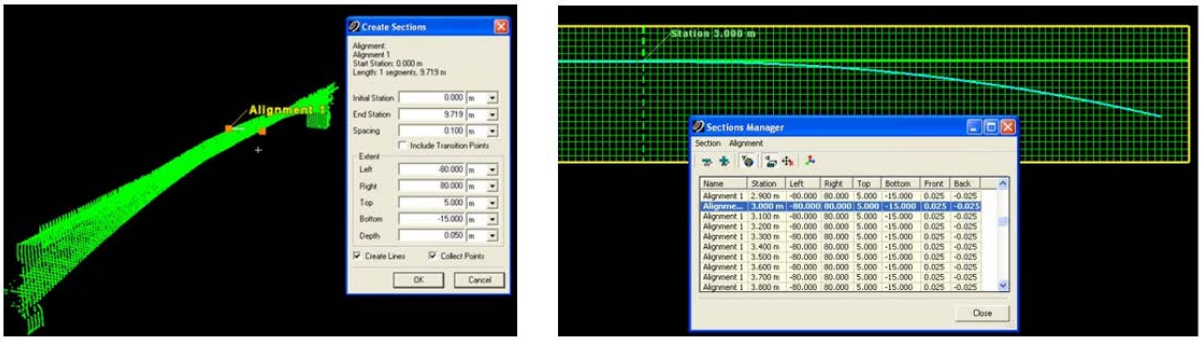

Fig. 13. Creating and viewing sections [19]

The fourth example is focused on AI (Artificial Inteliggence) and ML (Machine Learning) as tools for CBL (PhD Level). First theme consisted in extracting data from orthorectified images –image semantic segmentation using ML algorithms.

First case study was conducted by testing the semantic image segmentation capabilities of both ML-type algorithms and deep artificial neural networks. The processing was run on the central processing unit, without the ability to run on the GPU, which made the classification process difficult. [20] The following classification scheme was used: buildings, vegetation, roads and land and the supervised classifiers tested in ArcGIS Pro were: Maximum Likelihood (probabilistic classifier), Random Trees (ensemble classifier) and Support Vector Machine (SVM). Even though the semantic segmentation quality indicators were close, SVM generated the best results. The classification quality was increased by introducing the digital surface model as a classification attribute, achieving 92% accuracy and 98% completeness. (figure 14)

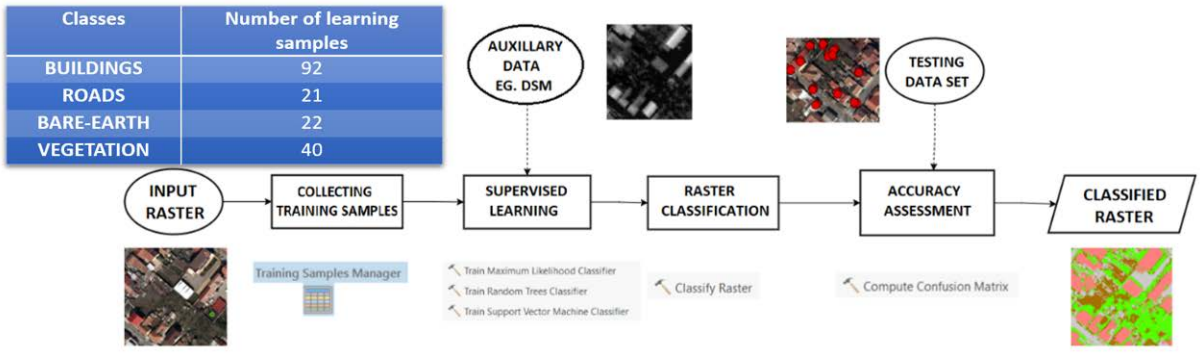

Fig. 14. Extracting data from orthorectified images –image semantic segmentation using ML algorithms - Tests on a subset of the orthophoto for the city of Arad [20]

Second case study was extracting data from orthorectified images - image semantic segmentation based on DNNs (Deep Neural Networks).

For semantic segmentation using deep neural networks, the U-Net network (based on FCN- Fully convolutional networks) with the structural model ResNet34 (Residual Networks) and ResNet50 was used. In this situation, the classification was carried out only for the building class, obtaining a precision of 90% and a completeness of 63% (ResNet34). (figure 15)

The next step after preparing the image was to create the training samples, digitizing the outline of 138 roofs, using the Label Objects for Deep Learning tool. These samples, were transformed into typical ANN format with the Export Training Data tool. The result was composed of 52 images with 3 spectral bands and the size of 256x256 pixels. [20] ANN extracted 556 features, with an average of 10 features/image.

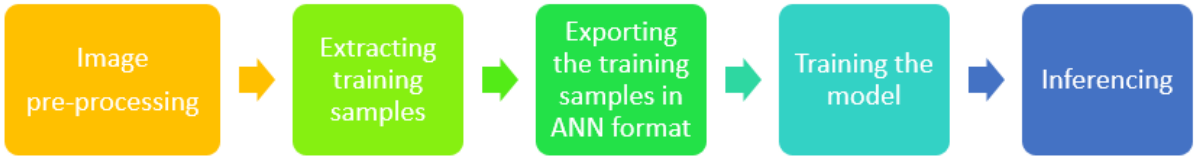

Fig. 15. Processing Workflow [20]

The fifth example of CBL is composed by a case study of GIS BIM Approach. CBL theme was GIS, BIM, CAD intergation for urban planning.

Student approach consisted in an integrated workflow in ArcGIS Pro, Revit, CityEngine [21], as following:

- Modeling a BIM from measurements (Autodesk Revit)
- Exporting the BIM created in a format that allows interoperability with GIS software (IFC);
- Data transformation from IFC format to .shp/geodatabase (FME) format;
- Integrating the resulting data into a GIS software (Esri ArcGIS Pro);
- 3D modeling of the same construction in Esri CityEngine;
- Comparison of the obtained results. (figure 16)

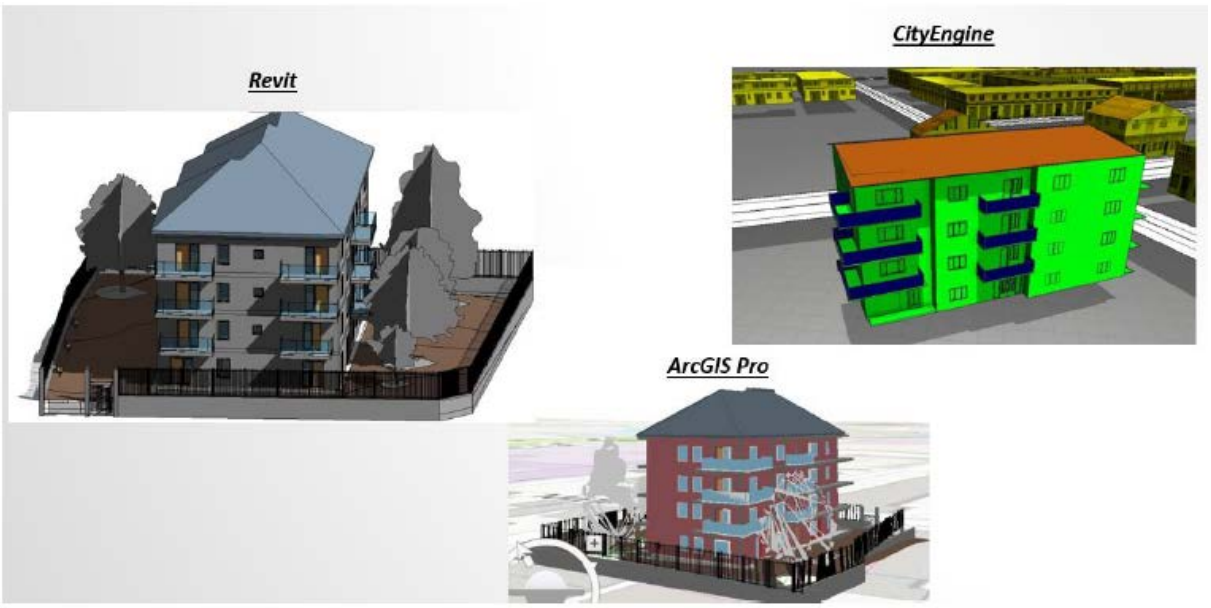

Fig. 16. Different Results [21]

Taking into account the experience from these case studies, initiated and developed in a similar context to CBL, the ideas presented in table 1 and in figures 17 and 18 can be synthesized.

Table 1. PBL vs CBL by Criteria

approach/ viewpoint	PBL	CBL
Learning	• new information through self learning using designed problems • the knowledge is applied to solve the problem	• work with scientific coordinator and experts on real-world problems • a deeper knowledge is developed • finding a new knowledge and the necessary tools or resources
Target	• relevant problematic situation, often fictional, for which a real solution is not needed	• an open, relevant, problematic situation, which requires a real solution
Solution	• focused more on the learning processes than the products of the solutions	• it requires to create a solution resulting in a concrete action
Workflow	• testing abilities to reason • applying the knowledge to be evaluated	• analyzing, designing, developing the best solution in order to tackle the challenge in a way they and other people can see and measure
Coordinator's role	• facilitator, guide, tutor or professional adviser	• coach, co-researcher and designer

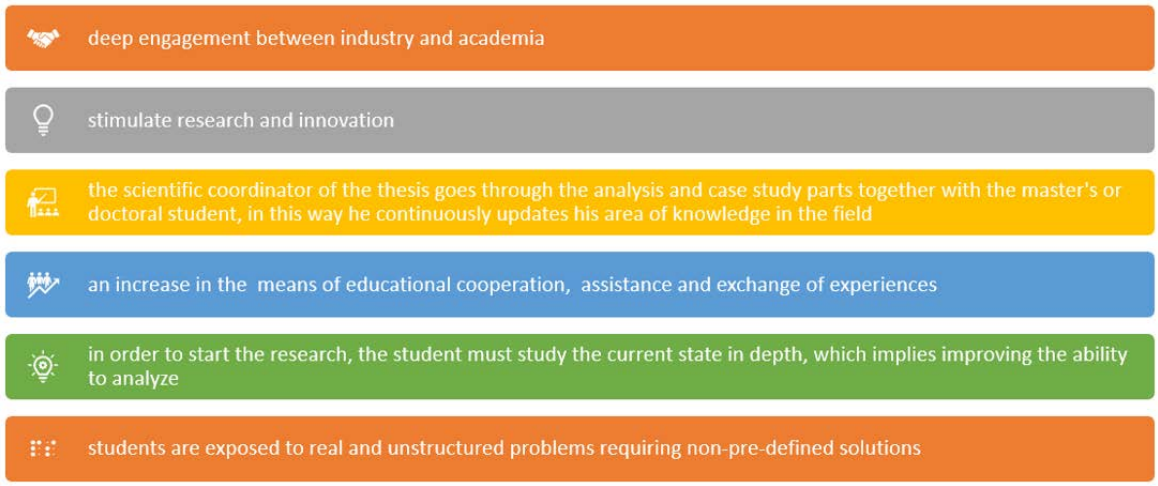

Fig. 17. CBL Strenghts

Fig. 18. CBL Weaknesses

5. Conclusions

The usefulness of CBL resides in the fact that solutions to real problems can only be identified through an interdisciplinary approach, especially in the case of engineering. Correlation and the integrated application of notions related to different disciplines are absolutely necessary skills in the present context. This is especially felt when the master's graduates are at the time of preparing the dissertation thesis, or when the doctoral students have to prepare the PhD thesis. The themes of these works, established with the coordinating professors must necessarily be focused on a real applicability, to assume a coherent research, based on technology, which will then be materialized in a case study that can be applied further.

However, students cannot be supported without a real collaboration between public institutions, the private and the academic environment, which we highlighted in figure 19, by creating a possible integrated flow that can be applied in this sense, as a win-win solution for all actors involved.

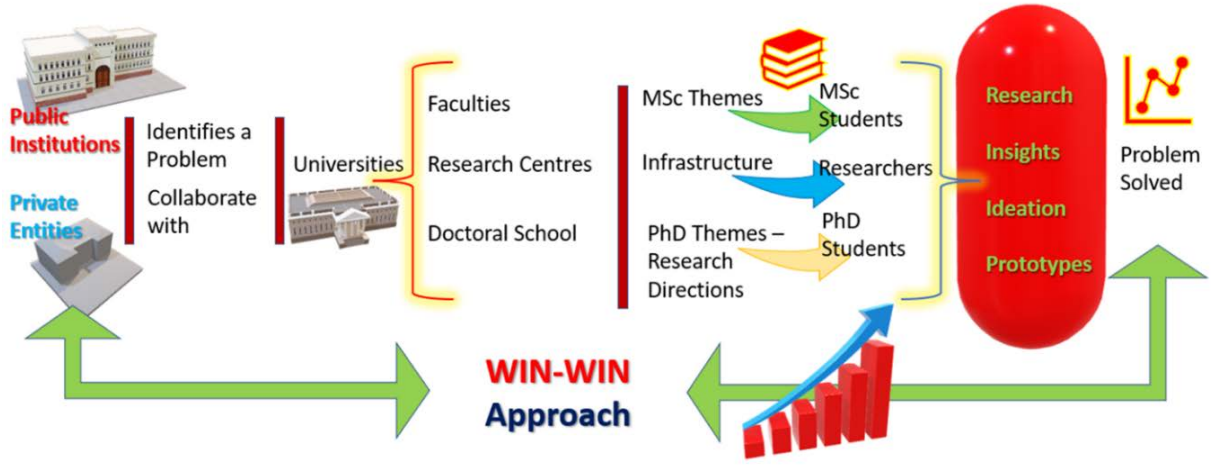

Fig. 19. CBL – A Real Link between Public or Private Actors and University Research – Proposed Workflow

The examples presented in this article clearly show that the graduates of a study cycle need to have current knowledge, mostly acquired through effort and individual determination. It is therefore also necessary to be prepared for working in multidisciplinary teams during the years of study, so that the future graduates have the ability to identify both the necessary knowledge when looking for a practical solution to a real problem, as well as to apply this knowledge. This shows that one of the major conclusions that emerge constantly is the growing importance of developing self-direction and learning organization skills, in order to successfully integrate interdisciplinary notions.

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