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Evaluating potentialities and constrains of Problem Based Learning curriculum: research methodology

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Abstract

This paper presents a research design to evaluate Problem Based Learning (PBL) curriculum potentialities and constrains for future changes. PBL literature lacks examples of how to evaluate and analyse established PBL learning environments to address new challenges posed. The research design encloses three methodological approaches to investigate three interrelated research questions. Phase one, a literature review; aims develop a theoretical and analytical framework. The second phase aims to investigate examples of practices that combine PBL and Education for Sustainable Development (ESD) in the curriculum and a mean to choose cases for further case study (third phase).

Keywords: Problem Based Learning curriculum; research design

1. Introduction

Problem Based Learning (PBL) is a teaching and learning approach where solving a problem drives the learning process. Having its origin in the 60's, PBL spread fast and several examples and its practice can be found around the world, from the compulsory education to higher education, from medicine to engineering and science. PBL is claimed as being one of the most innovative approaches, developing deep learning and competencies for professional life (Dochy et *al*., 2003; Dolmans *et al*., 2005)

PBL is used in professional educational disciplines as mentioned, and normally its practice is associated with curriculum change to address new challenges, like for example, engineering education to integrate Education for Sustainable Development (ESD) in the curriculum. On the other hand, one of the learning approaches claimed to integrate ESD in engineering education is PBL through, for example, the development of key competencies. However there is a lack of studies regarding in which ways PBL facilitate such curricular integration, by providing a systematic evaluation of the PBL curriculum and its potentialities to integrate sustainability aspects (Savin-Baden & Howell, 2004; Ferrer-Balas & Muler, 2005; Kolmos *et al*., 2009; Guerra 2012).

This paper presents a research design that aims to investigate the potentialities and constrains of PBL curriculum to face new challenges, like the integration of ESD in engineering curriculum.

Figure 1 presents the overview of the research design, presenting the three research questions followed by the main methodological approaches and objectives.

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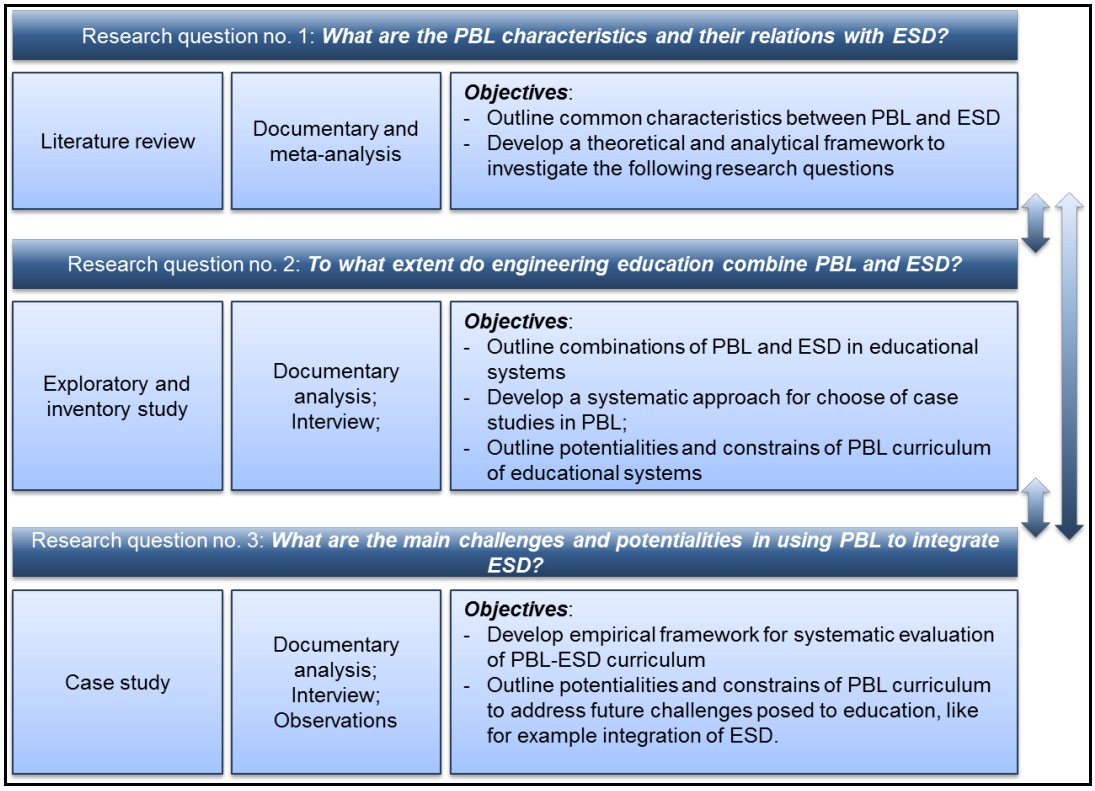

Figure 1. Overview of the research design: main research questions and methodologies

The research design has a qualitative approach and encloses three phases. In the three following sections I present each one of the phases of the research design, and their interconnections. In the third section I present some considerations of the contributions of the paper.

2. Literature review (Problem Based Learning as point of departure for the research design)

The literature review constitutes the point of departure to investigate the first research question (Figure 1). The purpose of the literature review is to provide a theoretical foundation of the alignment between PBL theory and ESD principles, and contribute for the development of a theoretical framework for data collection and analysis in the research.

Figure 2 presents the main themes literature review cover: PBL, ESD and Engineering Education. By pointing the common principles, elements and characteristics from PBL and ESD, I argue for a theoretical framework that provides the analytical elements for data collection and analysis in the research design. It is also important to stress the flexibility of the framework, due to its development in theory, which allows exploring combinations between PBL and ESD for other professional area. This framework takes into consideration the nature and the specificities of context and type of education (e.g. engineering education) where PBL is used as learning approach.

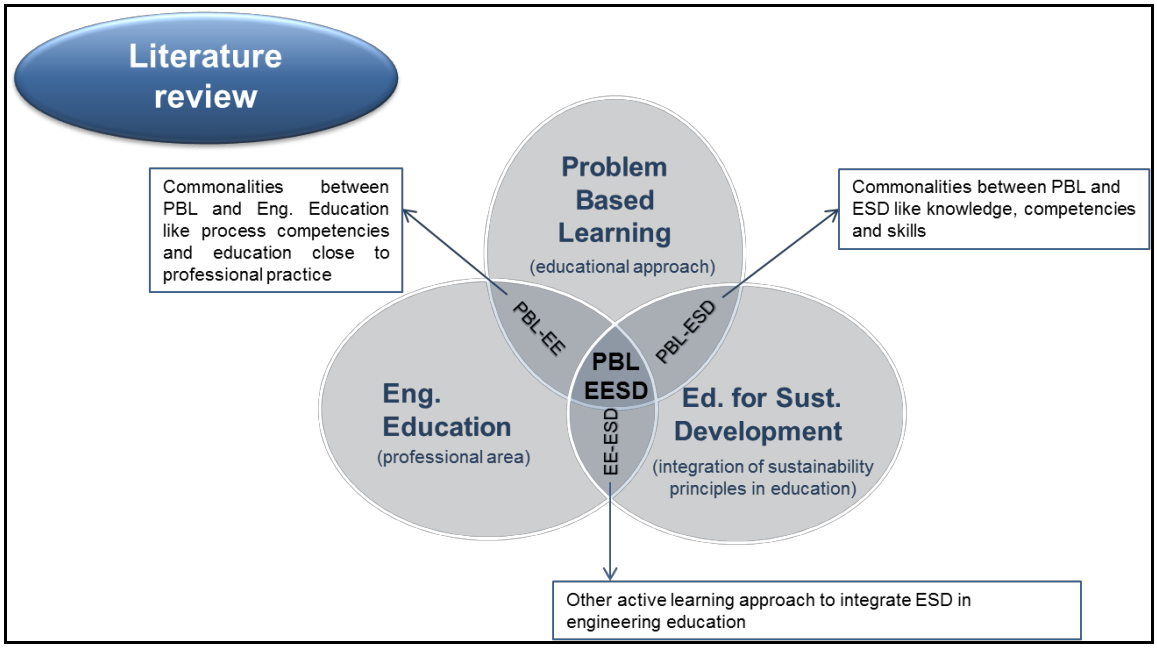

Figure 2. Overview of literature review, its phases and contributions for the research design

PBL can be seen as a learning philosophy, methodology, and/ or learning strategy. In a PBL environment, group of students analyse, formulate and solve a problem from a given real situation, which sets the start of the learning process. As a student-centred learning approach, it is up to students to, for example: (i) set a plan to solve the problem; (ii) to formulate the expected outcomes within the curriculum framework; (iii) the resources needed (e.g. bibliographic, human, facilities, etc.); (iv) assess their learning progression. Students find themselves actively involved in a learning process where they develop and apply different cognitive tasks, take responsibility for their own learning, development of several skills and competencies for life (e.g. critical thinking, long life learning, self-directed learning) (Savin-Baden & Howell, 2004; Kolmos *et al*., 2009)

PBL is a dynamic and multi variable environment, with different dimensions like: problems; knowledge; facilitators' role; students' role; assessment; learning; etc. The combination of different dimensions originates different approaches to PBL, resulting in the achievement of different learning outcomes. These dimensions provide indicators of what characterize the learning environment and the order of the learning outcomes achieve. For example the type of problem formulated, less structured; leads to the development of more complex competencies, like for example different levels of critical thinking, and different types of knowledge (Biggs, 2003; Kolmos *et al*., 2009; Jonassen, 2011).

Sterling (1996) argues that ESD should be: contextual; innovative and constructive; focused and infusive; holistic and human scale; integrative; process oriented and empowering; critical; balancing; systemic and connective; ethical; purposive; inclusive and lifelong. This is also some of the characteristics claimed to be developed in a PBL learning environment. With overlap of the elements from both worlds (PBL and ESD), it is not only possible to develop an analytical framework to evaluate the PBL curriculum, and its potentialities and constrains to integrate ESD, but also to go with the depth of the competencies developed (Table 1) (Steineman, 2003; Steiner, 2010; Jonassen, 2011).

Table 1. PBL and ESD principles

PBL elements for ESD	
Dimensions	**Categories**
Problems (Savin & Baden & Howell 2004; Jonassen, 2011)	Structured/ ill-structured; Concrete/ abstract; Practical / conceptual; Qualitative/ quantitative
Knowledge (McCormick 1997, 2004; OECD, 2000; Anderson et al., 2001; Savin-Baden & Howell 2004; Qvortrup, 2006; Kolmos et al, 2009)	Factual & Conceptual; Procedural; Metacognitive; Personal & evolutionary
Disciplinarity (Savin-Baden & Howell 2004; Davies & Devlin 2007; Bolitho & McDonnell, 2010; Borrego & Cutler 2010)	Disciplinary; Cross/ multidisciplinary; Interdisciplinary; Transdisciplinary
Criticality	Epistemological;

(Mogensen 1997; Savin-Baden & Howell 2004)	Transformative; Dialectic; Holistic
Process competencies (Sterling, 1994, 2004; Engineering Education for Sustainable Development 2004; Savin-Baden & Howell 2004; Bourn & Neal, 2008; Kolmos et al. 2009)	Problem analysis & solving Communication Collaboration Creativity and innovation
Curriculum organization (Savin-Baden & Howell 2004; Kolmos et al. 2009)	Lectures Cases Projects
Others (Sterling 1994; Bourn & Neal, 2008)	Ethics and professional responsibility
Sustainability aspects (Global Report Initiative, 2006-2011)	Environment Society Labour practices and decent work Human Rights Product responsibility Economic

The outcome of the literature review is summed up in Table 1, which presents the PBL-ESD dimensions and categories for analysis in different PBL curricula, and their interplays in practice.

3. Exploratory and inventory study

The exploratory aims to investigate the research question*: To what extent does engineering education combine PBL and ESD?*, and aims to point best examples where PBL is used to integrate ESD in engineering education. The study encloses two parts: an exploratory study followed by an inventory study (Figure 3).

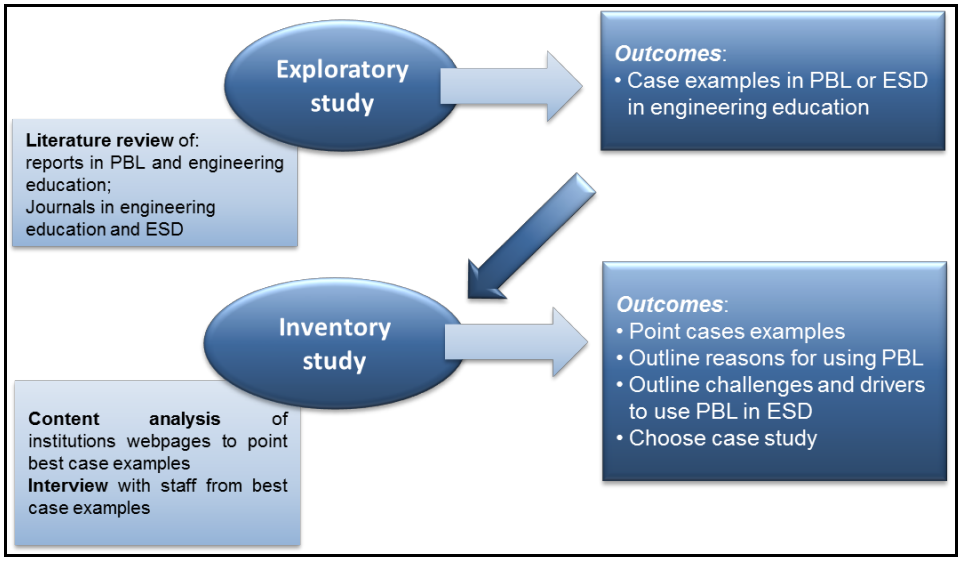

Figure 3. Overview of the research design to investigate the second research question

The exploratory study takes it part of departure in the literature review of engineering education reports, journals within area of engineering education, sustainability and PBL. Such publications report examples of PBL practice, especially in engineering education, integration ESD. For content analysis it can be used in the following indicators: problem based learning, case study, project organized learning, sustainability, sustainable development, environmental education, which correspond the dimensions presented in Table 1.

In the inventory part of the study, the institutions resulting from the exploratory study will be analysed in their homepages, programmes and syllabus. The aim is to point and select institutions that have an explicit presence of PBL and ESD in engineering education and consider them as case examples.

The content analysis is followed by interviews with practitioners from the case examples. The interview is poorly structured with open questions and aims to collect data concerning the challenges of using PBL to integrate ESD, and reasons for using it (Figure 3). These cases examples can be further used as cases for case study research, where their choice is not randomly but information-oriented (Flyvbjerg, 2006).

4. Case Study: evaluating PBL curriculum

In the case study research it is aimed to investigate the following research question: *What are the main challenges and potentialities in using PBL to integrate education for sustainable development (ESD)?*, and aims to understand, in real context, the potentialities and constrains of PBL approach to integrate ESD. The data collection targets the: (i) ESD presence in the programme (e.g. ESD principles, sustainability aspects …); (ii) curriculum organization (e.g. project organized, case study; assessment; curriculum development ...); (iii) PBL process (process competencies; challenges, problem formulation, group formation…); (iv) ESD and learning process (e.g. students motivations and perceptions; staff motivation and perceptions; etc.).

The three methods, and respective instruments, for data collection in the case study are: documentary analysis; interview and observation (Figure 4). All the data are analysed through content analysis by using the theoretical framework explained in section 2 of this paper.

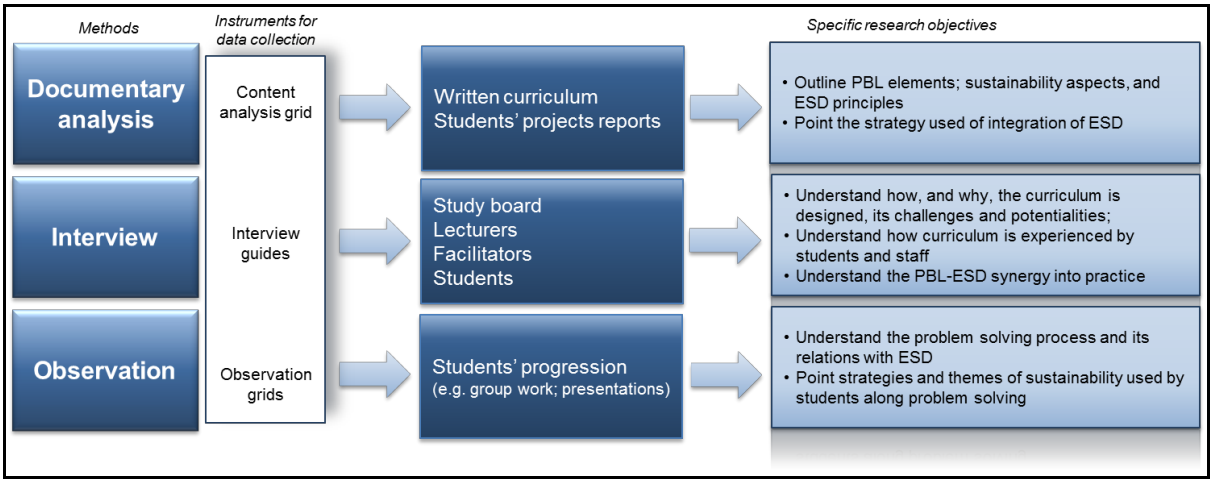

Figure 4. Overview of methods, instruments and specific research objectives for the case study research.

The data collection can be preceded as follow:

1. Documentary analysis of the curricula, which will point programmes organized around problems and with ESD presence. For this purpose, it can use the PBL dimensions and categories and sustainability aspects, presented in Table 1, as units for coding. The outcome will be mainly the development of PBL-ESD profile.
2. The same process can be used, for example, in the analysis of the students' written reports of the solving process.
3. Once the PBL-ESD profile is done, it is possible to formulate more specific questions to add to a pre-defined interview script in order to understand how this curriculum is designed and experienced by staff and students, and also to validate the PBL-ESD profile developed.
4. The interview process may include all the actors involved in the learning process (lecturers, facilitators, students) but also those who are responsible for the curriculum design (study board members). The interviews' script are constructed accordingly with the theoretical inputs from the literature review, but can be completed with more specific questions resulting from the documentary analysis.
5. The observation is non-participant, and aims to understand the learning process students are involved in, which moments characterize the solving process, where and how ESD is integrated. And like the content analysis grid developed for documentary analysis, also the observational grid contains the PBL and sustainability indicators which result from the literature review (Table 1).

The instruments for data collection and analysis have their base in the theoretical, and analytical, framework developed on the first phase on the study which allows: i) collecting systematically data from different objects/ subjects of study; ii) triangulate data from several sources; iii) collect comparable data in different type of case studies (single-case, multi-case study and/ or embedded multi units of analysis) (Creswell, 2003; Yin, 2009).

5. Final considerations

In this section I make some final considerations and reflections concerning, for example, the research design, its weaknesses and strengths.

The research design presented in this paper is qualitative, and takes its point of departure in PBL and ESD theories, with their general and abstract concepts, to case study research, with their real context of PBL practice. However the research design may go other ways. For example, the first research question formulated could start with exploratory study where PBL and ESD practice could be characterized in its elements. In this scenario, theory would support the data analysis and its interpretation, and would be more difficult to argue for generalization. On the other hand, the exploratory study could lead to some new concepts, principles, and good practices that are not yet place in the PBL landscape. Another weakness of this alternative approach is the choice of how to make the exploratory study, could this exploratory case chosen be a good example of using PBL to integrate ESD in engineering education. Of course it can be argued that there are several examples of such combinations in practice, and not necessary restricted to engineering education, but in any of the cases literature always provides good examples of practice with empirical work supporting it. That is one of the aims to be pursued with the exploratory approach (research questions number two) in the research design presented in this paper, what Flyvbjerg (2006) calls as strategic choice of case (Figure 5).

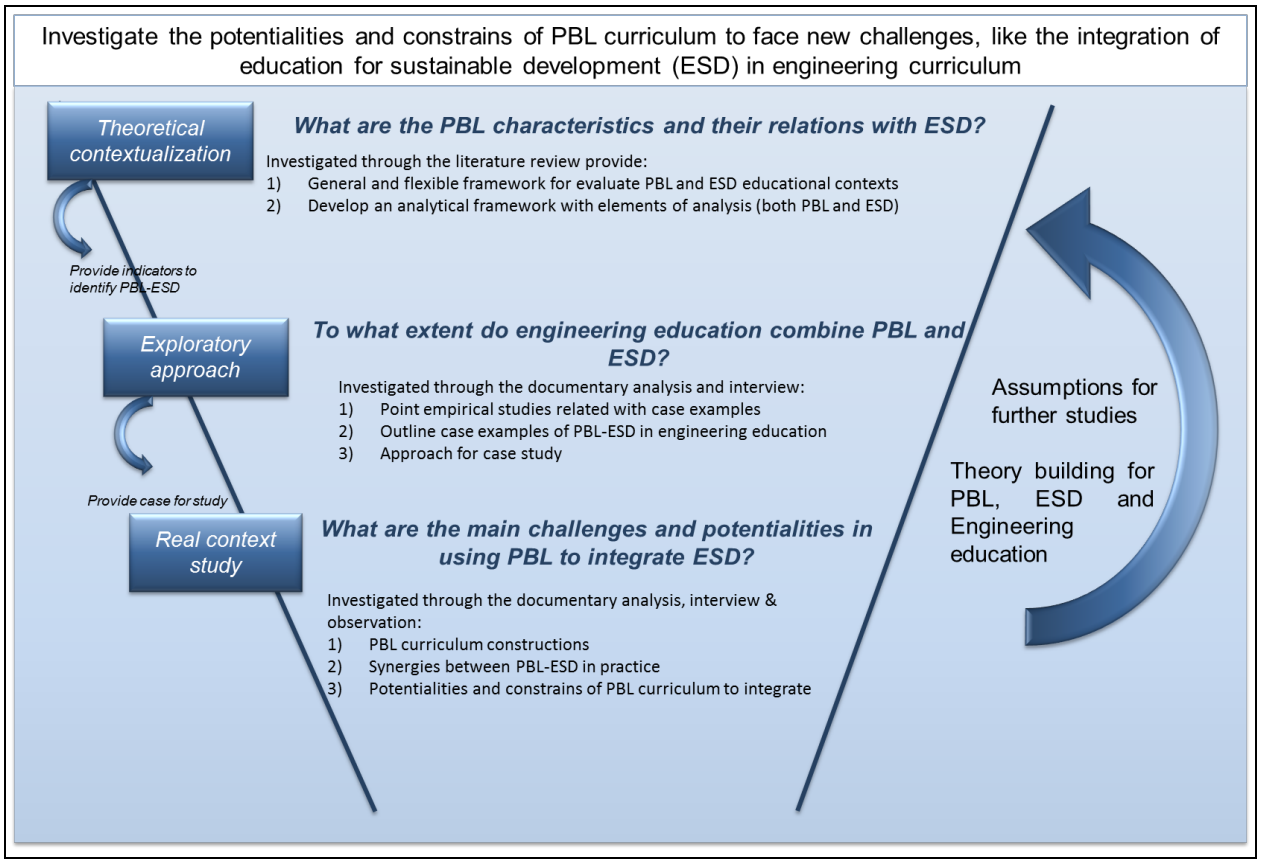

Figure 5. Holistic view of the research design

Another weakness of qualitative case studies pointed in literature is the subjectivity, related with researcher interpretation (Flyvbjerg, 2006; Yin, 2009). Using the literature approach as point of departure is one way to address this weakness by strength the systematic analysis of the cases. Literature review in the first research question allows the development of theoretical, and analytical, framework for systematic collection and analysis of data along the research process. As the process of collecting data and analysis in grounded in general principles and concepts of theory, the same analytical framework can be used cross cases that present the same conditions (e.g. PBL & ESD curriculum), and overall aims (e.g. evaluate PBL curriculum, and its potentialities and constrains for integration of ESD) for comparable studies. Also the findings from different case studies open a door for share of good practices, address challenges and enlarge new understandings of PBL community of practice (Creswell, 2003; Yin, 2009).

These are some of the considerations of the research design presented that addresses it approach, weaknesses and strengths, and more could be made. For example, this research design it may be of relevant interest of researchers in PBL and in ESD, but also to curriculum educational developers.

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