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8. PERSPECTIVES ON ENGINEERING CURRICULUM CHANGE

Problem based, project organised learning (PBL) is a learning methodology that has been used to reform engineering education. The implementation of PBL is mainly used to address engineering challenges like globalization, sustainable development, employability, technological innovation, whereas young engineers are equipped with knowledge and competencies needed (Du, de Graaff, & Kolmos, 2009; Graaff & Kolmos, 2007). Furthermore, engineering education organisations and accreditation bodies recognize the need of such competencies in engineering programs (ABET, 2016; ENAEE, 2012; National Academy of Engineering, 2004, 2005; UNESCO, 2010). This book compiles seven examples of curricula change and PBL implementation, including strategies, drivers, challenges and perspectives the authors go through. With this book we hoped to inspire engineering education community, institutions and educators to transform their practices and promote an education of quality for the 21st century.

In this chapter, we summarize and discuss aspects of change of engineering curricula and PBL implementation based on examples described. We particularly emphasise:

- Drivers, approaches, strategies and levels of change,
- Groups of people involved,
- Diversity of PBL models,
- Present challenges

DRIVERS, APPROACHES, STRATEGIES AND LEVELS OF CHANGE

In this section, we discuss the type of drivers for change and relate them to approaches, strategies and levels of change. We understand drivers as factors that constitute the main reasons to change engineering curricula from being traditional, and lecture-based to more active and problem based. Furthermore, these reasons shape and determine some aspects of the change process as well as resources allocated, challenges faced and people involved.

A. Guerra et al. (Eds.), PBL in Engineering Education, 119–133.

Drivers for Change

We categorize the drivers into four groups depending on their origin. The four categories are: educational, professional, political and societal.

Educational drivers have their origin in factors intrinsic to institution such as students, learning, curriculum development, etc. Examples of educational drivers are found in all chapters namely increase of students' intake (Mohd-Yusof, Chapter 2; Bettaieb, Chapter 7), need to increase students' motivation and meaningful learning (Lima et al., Chapter 3). Professional drivers refer to factors originated in practice of the engineering profession and work place. In the PBL models, this type of driver refers to the need for competencies, both technical and transversal, demanded by the industry and workplace. For example, Johnson and Ulseth state:

> […] the traditional engineering programs were not changing the learning activities needed to develop the outcomes being asked for by industry and by the accreditation board. (Johnson & Ulseth, Chapter 4)

Even though the factor is the need for a new qualification profile, which is also related with learning process, its origin comes from industry. In this sense, the profession defines the learning objectives, defined in the curriculum.

Political drivers refer to reasons related to policies namely from governmental, accreditation boards, etc. These also determine what kind of learning objectives should be achieved and type of qualification profile students graduate with. An interesting example is posed by Wang et al. (Chapter 5), who state that PBL "*was found as suitable learning methodology to development the attributes found relevant by the Ministry of Education*". Two other examples are from European universities, University of Minho (Lima et al., Chapter 3) and Mondragon University (Arana-Arexolaleiba & Zubizarreta, Chapter 6) where the Bologna Declaration had a relevant role to foster curriculum change and innovation. In 1999, through the Bologna Declaration, 48 European countries united political efforts to build an educational area where higher education systems are continuously adapted, making them more compatible and strengthening their quality, with main goal to increase staff and students' mobility and to facilitate employability (European Higher Education Area, n.d.).

The last group of drivers refer to societal drivers, which are related to social factors that indirectly impact the engineering profession and educational systems. In this sense, rapid technological development and innovation bring a new generation of students to university (Mohd-Yusof, Chapter 2, Bettaieb, Chapter 7), which pushes for curriculum change. Table 1 summarizes the main drivers.

In sum, the PBL models compiled in the book present several drivers to curriculum change and implementation of PBL. Even though the different cases are driven by common factors, they are also contextual and influenced differently by the approaches, strategies and levels of curriculum change.

Table 1. Group of drivers and examples reported in the PBL models described in the book

Drivers	*Examples*
Educational	Increase of students intake Increase students' motivation Promote meaningful learning
Professional	Need for technical and transversal competences Employability
Political	Bologna Declaration and EHEA guidelines Washington Accord Tunisian Revolution Attributes defined by Ministry of Education
Societal	Changing/ restructuring economies Rapid technological development and innovation brings a new generation of students

In the first chapter, Kolmos refers to three university modes and problem scopes according to the overall curriculum aim (Kolmos, Chapter 1). In mode (1), academic university, the overall aim is to construct theoretical learning and the process of knowledge. This is known as the "traditional university". University mode (2) is characterised as being market driven, focusing on collaboration with companies and development of skills and knowledge for practice. Last, the university mode (3) calls for re-building of the curriculum and a combined approach of mode 1 and 2. In this mode, university is driven by a vision for a better and more equal society.

Based on the drivers, overall aims and collaborations presented, the PBL models compiled in the book navigate between university mode (1) and mode (2). Nevertheless, the process change involves different strategies, calls for re-structuration of curriculum organization and re-definition of learning objectives, roles, and facilities of the learning environment. Figure 1 illustrates the relationship between the university modes and the examples of PBL models.

In the following sections, we address other aspects such as strategies to change and collaborations which emphasise the relation between the curriculum change drivers and university mode 2.

Approaches, Strategies and Levels of Change

Two main approaches to change can be identified: bottom-up and top-down. These approaches depend on who, and where, the incentives to change have their point of departure (Guerra, 2014). Therefore, in the cases described in this book, there are change processes with bottom up approaches which were initiated by academic staff and later involved, or get support from, top management. Example of bottom-up approaches described in this book are: Process Control and Dynamics course

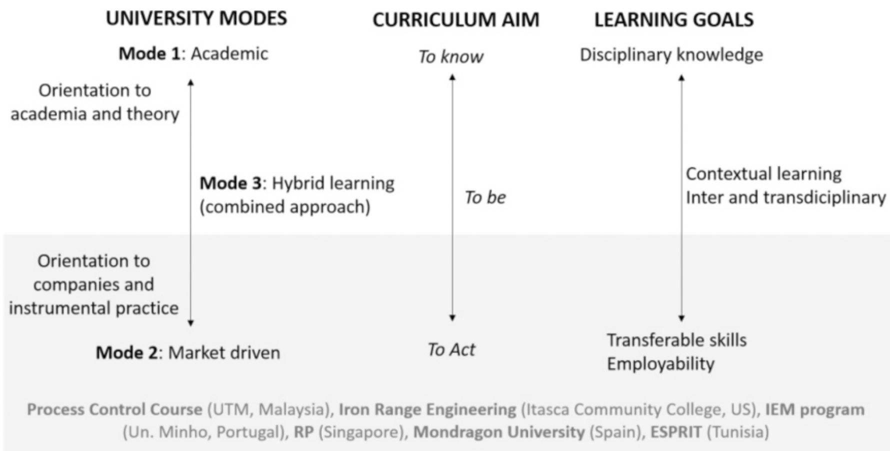

Figure 1. Relation between university modes, curriculum aim and learning goals (based on Kolmos, p. 3) and examples of PBL models (situated in grey area)

at Universiti Teknologi Malaysia (UTM), Malaysia, (Mohd-Yusof, Chapter 2), Integrated Master degree in Industrial Engineering and Management, at School of Engineering in the University of Minho, Portugal (Lima et al., Chapter 3), and Iron Range Engineering Model from Itasca Community College, US (Johnson & Ulseth, Chapter 4), where group of educators come together with aim to develop and implement new curricular models. On the other hand, (Wang et al., Chapter 5), Arana-Arexolaleiba and Zubizarreta, (Chapter 6) and Bettaieb (Chapter 7) described examples of top-down approaches, where the change process departures from top levels (e.g. government policies, management, etc.). For example, Wang et al. (Chapter 5) provides an example of how governments can change the institution's mission as it is stated:

> Polytechnics in Singapore were set up with the mission to train mid-level professionals to support the technological and economic development of Singapore. […] PBL was regarded as a suitable teaching and learning approach to meet the challenges of developing graduates with the desired attributes identified by Ministry of Education.

Bottom-up and top-down approaches have different impacts and they are both important to determine strategies and levels of change. While top-down approaches allow mobilizing and allocating resources, bottom-up approaches provide highly motivated academic staff and students to support the change.

Besides the change approaches, the PBL models described are also examples of different strategies and levels of implementation. Kolmos (Chapter 1) identifies three types of change strategies and levels of PBL implementation. They are: (i) course strategy in an add-on curriculum; (ii) integration strategy; (iii) re-building strategy. The latter strategy refers to macro-level change, including all levels of institution and aiming to a progressive and systemic integration of PBL culminating in a re-building of institution's vision, frameworks and provisions. Close to re-building strategies are Republic Polytechnic (RP), ESPRIT and Mondragon University, whereas PBL is implemented in all engineering programmes. These examples have taken a holistic approach to curriculum change; however, they do not necessarily show a more open approach to problems and critical reflection, which are core aspects of university mode (3) and re-building strategy. Furthermore, these institutions also have political drivers as main point of departure for change. On the other hand, University of Minho and Iron Range Engineering presents meso-level strategies, whereas it is at program level where PBL is implemented, relating the learning of content through courses and seminars and its use in project work. Lastly, an example of PBL implemented at course level is brought by Mohd-Yusof (Chapter 2), at UTM, where the author describes her initial motivations and experiences with PBL in the Process Control course. However, with institutional support and resources (namely for staff training) the courses become problem-based throughout the entire semester, and spread to other courses and disciplines. Figure 2 summarizes the relation between the types of approaches, strategies and levels of change based on Kolmos (Chapter 1) understanding.

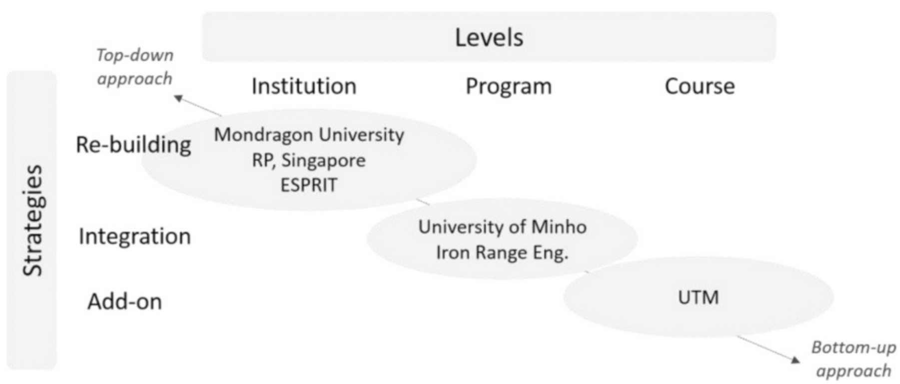

Figure 2. Relation between approach, strategy and level of curricular change and PBL implementation compiled in this book

In sum, different drivers trigger the change, leading to different approaches, strategies and levels of change. The examples described also show that, independently of the type of strategy, the PBL implementation implies deep re-structuration of courses, programs and institutions whereas: (i) new types of collaborations among academic staff, students and other stakeholders take place; and (ii) new models according to learning principles, objectives and vision of what engineering education should be are developed. In the following two sections, we refer to groups of people involved in change and the diversity of PBL models developed.

GROUPS OF PEOPLE INVOLVED

Undoubtedly, change depends on people whereas they take initiative, create opportunities, assume roles and/or support change. Change also involves different groups of people, namely students, teachers, managers, companies, alumni, and/or experts. In this section, we summarize examples of people involved in PBL implementation, the roles they assume and their relations with change approaches. In this book, the PBL models present different approaches, i.e. the point of departure and incentives for change, involving different groups of people. For example, in the bottom up approaches (i.e. UTM, University of Minho & Iron Range Engineering) the point of departure for change involved mainly educators and academic staff, who formed teams and sought support and resources to initiate the change process.

Khairiyah Mohd-Yusof (Chapter 2) states that she started by experimenting cooperative learning methodologies with a group of students in her course and later on got support from the institution management to form a task force to reform the entire course of Process Control, and train other faculty members from other disciplines at UTM. Lima et al. (Chapter 3) and Johnson and Ulseth (Chapter 4) refer to a group of teachers and educators who felt the need to change their programmes. At University of Minho, in the programme IEM, a group of teachers started the journey of implementing active learning in their courses, while the Iron Range Engineering program gathered a group of educators from across the US to develop and implement new curricular models. These two examples highlight not only the importance of forming teams to initiate change but also highlight the need to have support from management and funding as Lima et al. (Chapter 3) stated:

> The project was funded by the Rectory of the University and in March 2005, the group of teachers (authors of this study) and a number of other teachers from different departments and schools of the University of Minho got together to implement a first experience of Project-Based Learning in the second semester of the first year of the IEM program. These experiences were supported, since the beginning and during the following years, by educational researchers that also integrated the coordination team and made the difference, both in regard to the implementation and evaluation process and also the research carried out in the following years.

The above also stresses that teams' formation moves beyond the programme boundaries and might include researchers, experts and educators from other departments and even institutions – interdisciplinary teams. These teams also represent an important role in change process by validating the model through evaluation research-based activities.

While in the bottom up approaches, academic staff team-up to get top-level support and funding, in the top down approaches management nominate academic staff, form task forces and allocate resources to initiate change. Wang et al. (Chapter 5), Arana-Arexolaleiba and Zubizarreta (Chapter 6) and Bettaieb (Chapter 7) bring examples of top-down approaches to change as well as examples of the people involved. Also in these examples academic staff remains a core part of change by starting to experiment with active learning methodologies and design new curriculum models. For example, Arana-Arexolaleiba and Zubizarreta (Chapter 6) mention:

> External experts and internal teaching staff communities of practice led this first experience. This gave the teaching staff the opportunity to develop the skills needed to manage the new activities and new forms of intervention, which were very helpful when we began a thorough redesign of our educational programme.

Besides the core staff involved in initiating and developing new curricula, there are also other groups supporting and collaborating this process. These are mainly alumni and companies. In the cases here presented, these external groups of people participate in the change by providing feedback regarding the competencies needed for engineering, and real problems and contexts for students' learning.

Figure 3 summarizes groups of people involved in change and implementation of PBL as well as some of the roles assumed based on examples compiled in this book.

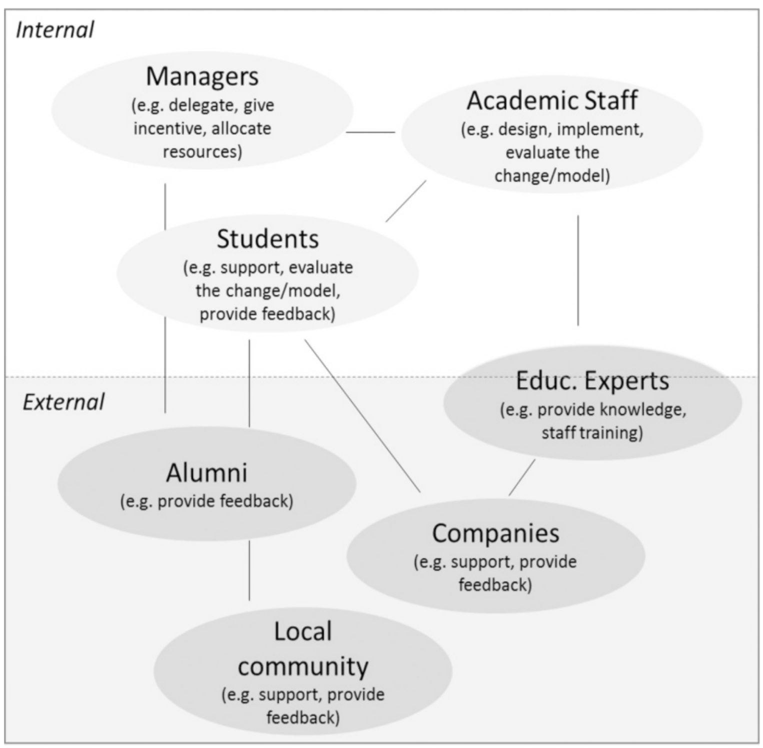

Figure 3. Relationships of people involved in change process and roles assumed (in brackets)

Based on the above, change is a collaborative process by including people from within the institution (i.e. internal collaborative processes) and from outside the institution (i.e. external collaborative processes). The main types of collaboration highlighted in the cases are: (i) interdisciplinary teams formed by teachers, students, educational researchers and experts, and (ii) collaboration with industry and alumni. Even though they have different contributions for the change process, these collaborations present important aspects for the success, legitimacy and validation of PBL models implemented by training staff, forming new communities of practice, providing students real life learning experiences and in the work place context.

DIVERSITY OF PBL MODELS

The models presented in this book are described using the alignment of curriculum elements published by Kolmos et al. (2009) as guidelines. They are:

- Objectives and knowledge;
- Type of problems, projects and lectures;
- Progression, size and duration;
- Students' learning;
- Academic staff and facilitation;
- Space and organisation;
- Assessment and evaluation.

In the present section we will not compare how the curriculum elements are used by the authors to describe their models, but rather highlight the diversity based on the learning principles, objectives and curriculum organisation they present such as:

- Cooperative Problem-Based Learning (CPBL) framework at Universiti Teknologi Malaysia, UTM (Malaysia)
- Interdisciplinary projects at IEM program, University of Minho (Portugal)
- Self-directed learning and professional development competence at Iron Range Engineering (USA)
- Problem/Project-based learning (RP-PBL) at Engineering School, Republic Polytechnic (Singapore)
- Steady increase of project work at Engineering School, Mondragon University (Spain)
- Problem situations and an integrated approach to courses and projects at Engineering School, ESPRIT (Tunisia)

The chapters highlight learning principles and objectives considered as corner stones in the models designed and fulfilment the curriculum overall aim. Furthermore these also stress the contextual aspects and meaning given to models that make them unique. In the following, we briefly address these models considering the learning principles, objectives and curriculum organisation presented.

Cooperative Problem-Based Learning (CPBL) Framework at Process Control Course, UTM (Malaysia)

Khairiyah Mohd-Yusof, in the second chapter, presents a change process at course level, at UTM (Malaysia). Her main objective is to engage and get students to form a learning community through cooperation and create a positive impact on their learning. To fulfil this purpose, Mohd-Yusof and her colleagues search, learn and design a course PBL model whereas a problem triggers the learning process and cooperative learning (CL) scaffolds it – the Cooperative Problem-Based Learning (CPBL) framework. Mohd-Yusof argues that CL allows students to receive support and feedback from their peers and develop team-based skills and do not solely rely on the facilitator.

Initially, the CPBL framework is implemented in all sections of the Process Control course in four cycles of 3–4 weeks each and involves several lecturers. In each PBL cycle, problems are designed to immerse students in different roles and to learn course learning objectives while solving a problem. Lecturers assume the role of facilitators and designers of learning environment by crafting problems. In the PBL implementation, the author highlights three elements: problems (type, role and craft), students (self-directed learners and problem solvers) and lecturers (designers of learning environment and facilitators).

Moreover, several elements of the CPBL framework can be related with contextual design and implementation. For example, CPBL is implemented at the course level and it is organized in cycles inspired in PBL medical models rather than in projects as it is commonly observed in engineering education. Another aspect is the type of problems, roles assumed by the students and the floating facilitation. In each PBL cycle, students develop problem-solving skills and assume roles with increased responsibilities demanded by the workplace (see Figure 2 in Chapter 2). Due to the number of students and facilitators the model uses the concept of a floating facilitator whereas one lecturer guides and supports the team of students in the learning process in the classroom. This process is supported by the CL principles. Besides the cooperative learning, this model also underlies other learning principles such as problem orientation, experiential and exemplary learning. The CPBL model is currently being implemented in other courses and departments in UTM, as well as in other institutions where the lecturers or teachers have been trained in implementing CPBL. Khairiyah Mohd-Yusof presents a good example of PBL implementation at the course level and proves that even though it is a challenge it is possible to make change within a teacher-centred and lectured based curriculum.

Interdisciplinary Projects at IEM Program, University of Minho (Portugal)

Interdisciplinary projects at Industrial Engineering and Management (IEM) at the School of Engineering (University of Minho, Portugal) has been implemented for more than 10 years. As the authors put it, it has been a history of resilience and continuous improvement involving students, teachers, engineering professionals and other collaborators who trust and believe in this change process (Lima et al., Chapter 3). In this model, the project works as the integrator of course knowledge and competences, which are needed to provide solutions to problems formulated in companies' context. In this interdisciplinary perspective, the disciplinary knowledge and its boundaries become blurred as the students need to learn, understand and apply knowledge from different disciplines in order to solve a problem. The course content and learning outcomes that should be incorporated in projects are defined by the course teachers and in the beginning of the semester. Lima et al. (Chapter 3) also point to other aspects, PBL is implemented in different semesters and in different years of program. PBL is implemented in the 1st and 7th semesters with a time gap of 6 semesters, i.e. 3 years. Consequently, the type of students and progression in the program is also different in the two semesters, which is reflected in the type of problems, contexts and courses integrated in the project work. This constitutes a good example of diversity of PBL models that are not only among programs and institutions but also within program where elements are adjusted to address the learning demands within the program.

Self-Directed Learning and Professional Development Competence at Iron Range Engineering (US)

Similar to the IEM model, the Iron Range Engineering model also puts emphasis on interdisciplinary projects where PBL is implemented in two semesters and students have the possibility to run company projects, however how the curriculum is organized around problems and projects is different. In this model, we take the example of the learning objectives and the authors clustered them into three groups: technical outcomes, design outcomes and professional outcomes (see Table 1 in Chapter 4). In this context, the learning experience is seen as a self-development process where the primary objective is to provide learning activities, guidance and feedback so students can become the engineers they envision. The authors address this objective in several ways such as making students' co-designers of change processes; create conditions for self-directed learning and how teams are formed. Here we highlight how the Iron Range Engineering model exemplifies the role of learning outcomes in a PBL environment and how students use them to develop knowledge, skills and competencies. The outcomes are communicated in two ways to students. Firstly, they are integrated in program syllabi and categorized in: (i) technical outcomes, (ii) design outcomes, and (iii) professional outcomes. The categorization of learning outcomes helps students to classify the value of the learning to their future career. Secondly, these outcomes are given to students in a simplified version through a model named *Being an Engineer*. In this way, the authors expect to turn the outcomes more tangible to students and easily incorporated in their daily activities and project work. In sum, the learning outcomes and how they are formulated not only calls for students' participation but also constitute a baseline of knowledge and abilities to excel and exceed. The professional learning is viewed as an individual's own development where the project provides the platform for such. Supporting students learning in this domain is the students' "professional development plan (PDP)" where students employ continuous improvements based on peer, academic staff and experts' feedback of their strategies, successes and failures along the project work. This reflective tool enables students to state goals and actions plans tackling the areas they want to develop further. The Iron Range Engineering model provides a good example of how self-direct learning and professional development are developed through PBL.

Problem/Project-Based Learning (RP-PBL) at School of Engineering, Republic Polytechnic (Singapore)

At Republic Polytechnic (RP), Singapore, PBL is implemented at the institutional level where almost all programs are problem-based or project-based. According to the authors (Wang et al., Chapter 5), RP adopted a unique implementation of PBL where the modules are organized around real-life problems or projects which may last from one day to a few weeks. The authors argue that the strength of this model lies in the solving of small bite-sized problems, during which students regularly reflect on their knowledge construction. Furthermore, PBL distinguishes itself from other active learning methodologies by intertwining fundamental concepts by means of challenges relevant for students and for their future practice, increasing their engagement in the learning process. In this model, the reader finds descriptions on two aspects of the PBL model: (1) the learning phases and (2) the key elements for students' engagement.

The PBL learning involves three phases: phase (1) students unpack and scope the problem and define information needed (i.e. learning objectives), phase (2) students outline inquiry strategies, apply the concepts/ knowledge collaboratively and test possible solutions, and phase (3) students present their solutions and answer questions from their classmates and lecturer to further refine their engagement and understanding of content. Regarding students' engagement in the learning process, the authors considered three key elements: (1) the learning environment and how it is designed (i.e. team based and classroom setting), (2) the problem statement, learning activities and how they are related (i.e. problem scope and design, scaffolding), and (3) reflection on the learning process (regular feedback from peers and supervisors highlighting skills and areas for improvement) (Wang et al., Chapter 5).

In this perspective, PBL phases and elements are well described and provide examples of relevant principles and objectives of PBL: reflection and exemplary learning. By going through PBL cycles of learning and reflecting upon the process, students develop knowledge and skills needed to solve the following problem and meet the learning outcomes needed. In this sense, students become proficient in tackling and solving real life problems.

Steady Increase of Project Work at Engineering School, Mondragon University (Spain)

In the sixth chapter, Arana-Arexolaleiba and Zubizarreta describe a PBL model implemented at the Engineering School, Mondragon University, where all programs are project based and problem oriented. The authors provide a thorough description of the model, its elements and valuable examples of how it is practiced. The main goal in implementing PBL is to equip students with transversal skills, flexibility and adaptability for the labour market. To achieve such a goal, Mondragon University used an integrative strategy whereas each semester is organized in lectures, interdisciplinary PBL and transversal competences workshops (see Figure 2 in Chapter 6). In this context, the PBL progression is done vertically with a steady increase of time allocated to project work (i.e. PBL) during every year of program. For example, time allocated to the project is around 20% each semester, and it increases every year until 100% in the last year, where students carry out their projects in companies. Furthermore, semesters are also organized in a way that the first weeks are allocated to lectures and transversal competence workshops whereas the last weeks are allocated to PBL projects. In this way, students construct the knowledge and skills needed to be used in the interdisciplinary projects later in the semester. Mondragon University presents a good example of PBL curriculum where the program moves from a focus on developing students engineering knowledge with more time allocated to course work towards a more problem-based learning in last years with 100% time allocated to interdisciplinary projects.

Integrated Approach to Courses and Projects at Engineering School, ESPRIT (Tunisia)

ESPRIT, Tunisia, just like the two above examples, implements PBL in all engineering programs. Similarly, it is also described in terms of curriculum organization, learning outcomes, progression, students' and staff, assessment and facilities (Bettaieb, Chapter 7). In this context, and similar to previous examples, the curriculum is problem oriented and organized in lectures and projects. However, aspects like how the learning is organized around problems, how the relation between lectures and projects is, and how students are prepared for PBL learning differs. The author draws our attention to three main aspects: (1) integrated projects (IP), (2) integrated courses (IC) and (3) PBL events like PBL-welcome week and PBL bash. Both IP and IC are problem based however the type of problems and how they are solved highlights the difference of learning context and progression. For example, IP has a duration of a semester and team of students address open, complex and poorly structured problems in connection with business and companies. The IC encloses several learning methodologies, from teacher centred to student centred. One learning methodology used is what the author defines as ProSit (problem situation). Here, students are presented with real life situations where a team of students needs to analyse, understand, apply knowledge and propose an effective solution. In this context, ProSit is typically carried out in three sessions, where two of them held in classroom (Chapter 7). The ESPRIT curriculum also includes two events: (1) PBL-welcome week and (2) PBL Bash. The main goal of these events is to prepare, engage and reward students, and their accomplishments, in the PBL learning environment. As other examples show (see for example, Mohd-Yusof, Chapter 2; Johnson & Ulseth, Chapter 4) it is important to prepare and engage students in change processes and PBL implementation. They are the core actors of the learning process and the purpose is to provide good educational experiences and education of quality.

All PBL examples compiled in this book use the same framework and principles to describe their models and implementation – the alignment of PBL curriculum elements (Kolmos, Graff, & Du, 2009). With the framework we expect to provide detailed descriptions of how PBL is implemented and practiced in different contexts. Nevertheless, in this section we have pointed to aspects from the different models that highlight the diversity of PBL models and the contextual nature of each one of them.

In sum, all the models have an integrative approach whereas discipline knowledge is learned, mobilized and applied in real life situations by teams of students. However, how this integration is made in the curriculum varies considerably from model to model. The reader can find a more detailed description of PBL models and how assessment, students' roles and facilitation, facilities and progression shape these models. Another aspect common to all models is the evaluation of the first PBL implementations and their continuous adjustments. Mohd-Yusof defines this as an evidence-based approach to change which helps to validate and legitimate the change.

PRESENT CHALLENGES

Even though the examples reported present successful examples of engineering curriculum change, these processes are not absent of challenges. In a change process, challenges have an on-going and continuous presence and they vary in nature and context. For example, in bottom-up approaches the lack of financial resources and support is one of the major challenges. At University of Minho (Chapter 3) and Iron Range Engineering Model (Chapter 4) the change process and PBL implementation started once funding was acquired. In this book the reader finds examples of challenges faced before the implementation process and how the different organizations/ agents addressed these challenges. Besides these initial challenges, the authors also report concrete examples of on-going challenges faced during the implementation of PBL. Table 2 summarizes the main challenges faced during the PBL implementation.

Table 2 Summary of main challenges referred to the authors

Challenges
• Resistance and reluctance to PBL (Wang et al., Chapter 5; Bettaieb, Chapter 7) • Curriculum development (Lima et al., Chapter 3; Johnson and Ulseth, Chapter 4) • Infrastructures and group rooms (Lima et al., Chapter 3; Bettaieb, Chapter 7) • Training of staff and students (Lima et al., Chapter 3; Wang et al., Chapter 5; Bettaieb, Chapter 7) • Staff recruitment (Johnson and Ulseth, Chapter 4; Wang et al., Chapter 5) • Collaborations (Lima et al., Chapter 3; Bettaieb, Chapter 7) • Economic (Johnson and Ulseth, Chapter 4; Wang et al., Chapter 5) • Drift back to traditional curriculum (Johnson and Ulseth, Chapter 4)

The challenges summarized in Table 2 are related not only with limitations of PBL curriculum elements and their practice, but also with change management and sustainability. See for example the need for more infrastructures (e.g. group rooms), the curriculum development (e.g. more PBL approaches in the curriculum), staff training, etc.

FINAL REMARKS

As Kolmos points out (Chapter 1), each change "*process will be very different depending on the context of the critical reflection and the creation of meaning*" leading to different approaches (e.g. top-down and bottom-up), strategies and levels (e.g. course and institutional level) of change. In the examples presented, the change processes imply a transformation of vision and values of what learning should be, triggering a transition from traditional learning to PBL. In this sense, PBL is also a learning philosophy and different drivers, facing diverse challenges and involving different actors, trigger its implementation. This book gathers experiences, practices and models, through which we hoped to give a grasp of the complexity, multidimensional, systemic and dynamic nature of change processes. Even though the authors shared a similar vision of what engineering education should be (i.e. quality, innovative, active, participatory, and competence-based), how they reacted to these lead to a diversity of PBL models, emphasising the constructive and contextual nature of the change process and PBL practice. Models are designed, implemented and evaluated continuously aiming their improvement and fulfilment of engineering education vision and aiming to be also a research-based and collaborative perspective to change. The authors brought several references of their previous work and the research carried out within these domains supporting their claims and hypothesis. With this book, we hope we have brought forward examples and inspiration to all of those who aim to change engineering education underlying the principle that anyone can be a change agent and provide an education of quality for the future.

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