Guidebook for Trainers

Contributors

The ENGINITE Consortium,
led by ThinkUP and AAU

ENGineering and INdustry Innovative Training for Engineers (ENGINITE)

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Consortium

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Executive Summary

The European ENGINITE project (https://www.enginite.eu/) invites the submission of applications of interest by graduate engineers to participate in a postgraduate vocational training programme which will be held during 2018-19. The postgraduate vocational training programme will be based on Problem Based Learning (PBL) pedagogy and will combine advanced applied academic topics with hands-on aspects, in order to endorse the needs of graduate engineers, preparing them for the industry of the 21st century. Grounded on the PBL approach, the ENGINITE postgraduate vocational training programme will contribute to the career and employability skills development of the new engineers – among others: innovation, entrepreneurial skills, efficient quality, health and safety management, problem solving, communication and presentation skills – while it will enhance technical knowledge in critical fields of engineering. Upon the completion of the training programme, participants will be able to enter the labor market, lead multidisciplinary teams, and provide added-value and substantial contribution to their organizations (e.g. engineering companies and industries).

The postgraduate vocational training programme is addressed to graduate engineers with a degree in biochemical, chemical, electrical, electronic, environmental, food, industrial, mechanical, petroleum, safety engineering and/or of a relevant field. Eligible will also be Chemists and Food Technicians graduates.

The target group postgraduate vocational training programme includes:

- Graduate Engineers, who seek for a job and/or who wish to follow a post graduate/vocational training programme;
- Junior Engineers, who are partly-employed and/or working in a different field and wish to follow a post graduate/vocational training programme.

During the program, Industrial Partners in the engineering sector are going to provide internship placements and the following categories are welcome and eligible:

- Companies which seek for professional graduate/ junior engineers for employment;
- Companies which experience lack of innovative ideas and seek for talented engineers who can provide solutions to existing problems and/or promote new ideas/products towards helping the companies to enhance their competitiveness and further grow.

The Purpose of this guidebook

The aim of this guidebook is to provide the ENGINITE trainers with guidance for delivering successfully the ENGINITE courses that they have been assigned. It should be read in conjunction with the ENGINITE *Programme Specifications*.

The guidebook begins with an overview of Problem-Based Learning (PBL), explaining how it differs from traditional learning approaches and what are the main driving forces for educating people using this non-traditional approach.

The second part of the guidebook gives trainers/instructors/facilitators 12 principles for using effectively the PBL methodology. The philosophy of PBL is very different from traditional teaching methods in which the trainer is seen as the holder of wisdom that needs to be transferred to the learner. In PBL, it is the mission of the trainer to help learners identify and solve problems that are important to the learners. This philosophy has far-reaching consequences for how training is delivered in practice. The principles provided in this

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guidebook aim at helping trainers to adopt teaching practices that are aligned with how PBL is being used in the ENGINITE programme.

In the third part of this guide a standard process for running a daily reflective exercise with groups is descripted. This is intended to be a process to be used by all instructors for establishing the importance of reflection as part of learning.

The details of the courses are provided in the appendix, with a summary of how each course's documentation is structured given in part four of this guide.

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Part 1: Introduction to Problem-Based Learning

1.1. The Problem

The 'problem' is the point of departure for Problem-Based Learning (PBL).

- 'The problem' points at something not understood – based on something understood.
- 'The problem' is always owned by somebody – PBL requires it to be owned by the learner/trainee.
- 'The problem' thus denotes a specific relation between the learner and certain reality aspects (the problem field) that the learner sees as problematic – *in an academically or educationally interesting way*.
- Helping the learner to extract 'the problem' from the problem field is one key competence for the PBL supervisor; cf. 'point of departure'.

In PBL, learning cannot get started before/unless learners have identified the problem that shall serve as motor for their learning efforts.

In PBL, projects are organized as group work. 'Projects' mean 'student-initiated and student-designed, empirically based investigation activities aimed at solving the problem'. The project is supported by courses, but the project is what counts as most important. In other words, the project is supported by other courses. High quality PBL presupposes a proper quantitative balance between, and temporal sequencing of project activities and course activities.

1.2. The problem is a driver for the learning process

The diagram below shows the 'Problem Triangle'.

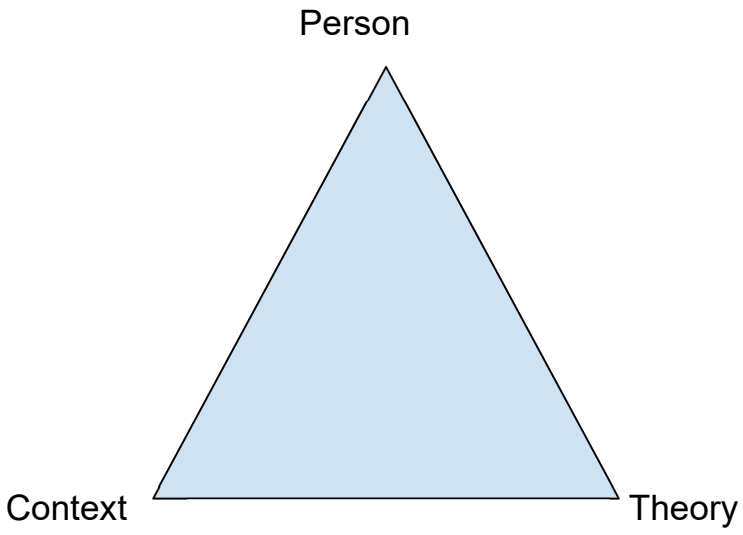

Figure 1: *The triangle of learning domains*

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The triangle simply states that, *on the one hand*, the problematic aspects of 'the problem' may be derived mainly from:

- 'theory', i.e. existing textbook knowledge;
- 'person', i.e. learner;
- 'situational context', including human role-bearers involved in that context …

Yet, PBL requires that more than one of those three problem platforms are involved.

1.3. Problems derived from theory

A PBL problem can have a theoretical angle – based on students' reading and course participation.

Problems are dogmatically required to be 'authentic' meaning that they must be understood, by the learner, as also having relevance "outside of Academia", i.e. for situational contexts (small-scale, large-scale), or for the learners themselves (e.g. "How can I/we make personal sense of theory A or concept B?").
The quantitative balance between, and temporal sequencing of project activities / course activities are of vital importance for the PBL climate of a given educational context.

1.4. Problems derived from situational contexts

The situational context angle may be expressed mainly through a need for intervention or construction e.g.

'How may undesirable state A be overcome and/or replaced by desirable state B?'
or
'How may technical gadget C, serving such and such purposes, come to life?'

… or mainly through a need for understanding or theoretically reflected description
e.g. "Why or how is event D happening the way it is?

1.5. Problems derived from a person, i.e. the learner

Problems may be derived from person(s), i.e. learner(s). PBL is structured as small-scale research activity. But the educational purpose of this research activity is to drive personal learning processes. The personal learning needs that guide PBL project work may have their focus on acquisition of

- general, scientifically corroborated knowledge (textbook++) …
- skills acquisition ("How to … ?" - with no specific regard to context) …
- competence development (skilled problem-solving -*in-complex-situational-context*)

In the collaboration process between student and supervisor (tutor, mentor) specific attention must be paid to personal aspects of the students' learning process

1.6. Supervision, tutoring and mentoring

Student responsibility for learning: *this PBL aspect is what must constantly be negotiated as part of project supervision.*

Donald A. Schön's triadic model for professional training has three training modes:

- Follow me
- Joint Experimentation

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- Hall of Mirrors

High quality supervision requires competence in all three training modes and competence in blending them skillfully in response to evolving supervisory needs. It also needs competence in keeping them nicely separated through process means – they are the gamemasters.

1.6.1. Follow me

- The easiest training mode to explain (according to its name), and *therefore* mentioned first
- Supervisor demands student's obedience wherever such obedience is unquestionably warranted
- To the extent that Follow me is overemphasized, i.e. beyond what is *unquestionably necessary*, the PBL quality of the supervisory relationship gets impaired

1.6.2. Joint Experimentation

In Joint Experimentation leadership / followership is reversed. Supervisor's followership is not uncritical – but critical attitudes are not expressed by means of criticism (fault-finding), but through intellectual challenges, queries for clarification, expressions of bewilderment.

In other words:

  - The student(s) is/are in practice acknowledged as owner(s) of the problem – and the ongoing re-structuring / re-making of the problem
  - The supervisor shows his/her worth by suggesting possible improvements to the students' way of understanding and/or investigating the problem

1.6.3. Hall of mirrors

In Hall of Mirrors the two relational partners, student(s) and supervisor, do a shared scrutiny and/or negotiation of their relationship, i.e. move from the gameplayer to the gamemaster position …

- … either because one or the other or both experience the relationship as, possibly, sub-optimal and in need of improvement, learning-wise
- … or out of learning-motivated curiosity: "What is going on between us? – What professional learning can we extract from our ways of collaborating?"

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Part 2: Principles to reflect on when designing PBL training

2.1. Students experiencing ownership to a problem-within-a-context is a pre-requisite for learning

Problem-Based Learning is learning by doing. Instead of seeing existing, formalized knowledge as a tool for real-life problem solving – as in traditional classroom teaching – real-life problem solving (or inquiry, as Dewey puts it) is used as a pedagogical tool for knowledge acquisition. The problems on which PBL learning shall be based are not problems in and of themselves. They become problems through their way of being embedded in real-life and/or theoretical contexts. The context – or rather: the way that context is understood or experienced by 'somebody' – is what makes them into problems. Step number one in any PBL course must therefore consist in presenting students with possibly problematic contexts and inviting them to search for such problems as will match their learning needs. This search aims at having students experience *ownership* to one or a set of problems.

How can you emphasize students' felt ownership to problem(s)-within-a-context as the starting point for learning?

2.2. Be flexible in defining the learning outcomes

In a classical, teacher-centered learning approach, course instructors (as representatives of their institutions) define the learning outcomes they are aiming for. Based on the ownership concept, the PBL approach requires students, i.e. learners, to delineate their learning outcomes. Negotiations are needed to strike a proper balance between institution-based and student-based requirements

How can you be sufficiently flexible in your teaching to allow students to define their own learning outcomes?

2.3. Aim for exemplarity

The value of student/engineer's learning increases when they can, first, identify knowledge in one specific context, and then generalize this knowledge in ways that make transferable to different context. When this happens, we describe the learning that has taken place as 'exemplary'. When promoted as part of a PBL strategy exemplary learning gives priority to case-based in-depth learning about concrete reality dynamics in favor of broad knowledge acquisition. Once more, some balance must be stricken between institutional breadth ambitions and pedagogically motivated depth ambitions.

Through which pedagogical means can you assist students in making exemplary use of their inquiry-based findings?

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2.4. Learners will arrive at learning outcomes through different routes

When you open the learning process up to a group of learners, it is likely that they will want to explore the problem in different ways. It is important therefore that the knowledge resources, as well as other pedagogical tools they have access to, will allow them the freedom to do this.

What can you do to support your learners exploring the problem in different ways?

2.5. Learning through reflection

Reflection plays a critical part in problem-based learning. It helps learners establish links, back and forth between their concrete, ongoing inquiry-based experiences and general theory. Through reflection-supported inquiry their picture of the world and of real-life events becomes, at one and the same time, more accurate and more diversified. Ideally speaking, theories and textbook models shift from are no longer seen as abstract 'things' with a life of their own but acquire a status as practical tools for enriching one's understanding of world affairs and ways of handling world affairs. Likewise, reflection-supported inquiry helps students understand the impacts of their own actions on their learning and helps them adjust their behavior to make them become better future learners.

How can you put reflective learning at the core of learning activities?

2.6. Let the students be the guide to what they do and don't understand

The PBL-based requirement that learners must own the problem that drives their learning has the implication that only the learners themselves are able to define what new knowledge they need for them to get on with their inquiry. In practical terms this means that students must take active responsibility for describing what they do and don't know as related to the problem. The instructor must find ways of inviting the students to come forth with such descriptions.

Through which practical steps are you going to obtain information from students about their learning and knowledge needs?

2.7. Be a facilitator, not a teacher

A teacher teaches, i.e. conveys teaching content to learners. A facilitator assists learners in teaching themselves through self-guided inquiry processes. The facilitator doesn't know what is needed, or how to start moving until she/he asks the learner. This is an EXTREMELY IMPORTANT sentence! Start from the reality of the student; "What are you struggling with? – Why is this so difficult for you? – What might you possibly need – from me, or otherwise – in order to carry on your learning endeavour?"

How can you be a facilitator, and not a teacher? – Or possibly (dependent on the educational context): how can you strike the proper balance between these two roles?

2.8. Move facilitation style from 'Follow me' to 'Joint Experimentation'

The goal of the ongoing collaboration between student and facilitator is not simply to have the student find the correct (technical) solution to the problem (whoever has originally defined it). Given that the collaboration context is educational, the ultimate goal is to have student become wiser through their inquiry processes. Part of the facilitator's job is to force the student to reflect (for exemplarity's sake) on the how and why, and not only on the what of what they are doing and accomplishing. Formulated in Schön language, this requires the facilitator to move from a 'Follow-Me' style to a 'Joint Experimentation' style.

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How can you move your facilitation style from 'Follow Me' to 'Joint Experimentation'?

2.9. Learning through social processes

Problem-Based Learning puts Above, much has been said about the collaboration between student and facilitator as one important social resource within PBL. Mutual peer learning, possibly structured as team-based learning, provides additional invaluable support for individual PBL learners. The facilitator must therefore see him-/herself as helper not only at individual, but also at team and supra-team, i.e. organizational levels.

How will you design social processes and support culture building among your students with a view to optimizing individual learning?

2.10. Create the physical learning environment for Problem-Based Learning.

Your students/engineers will most probably have developed their learning habits in a series of traditional teacher-centered educational set-ups. Even if they give voice positive attitudes towards a PBL approach, their habituated learning approach may well override even their most well-intentioned PBL efforts. The traditional teacher-centered approach is closely linked with traditional classroom arrangement (students in rows facing teacher's desk). Disrupting the traditional classroom arrangement may help disrupting teacher-centeredness.

How can you set up the learning environment to support PBL?

2.11. Assessment

Traditional teacher- or institution-centered assessment does not fit with a PBL model. Students/engineers who are invited to own their own learning process and, by implication, are asked to delineate their learning outcomes, should also have practical stakes in defining the criteria by which their learning gets assessed.

Within the constraints of your teaching institution's rules, what can you do to enable students to own the process of assessment?

2.12. Learner skills and attitudes for problem-based learning

The success of your PBL endeavors is crucially dependent on the kind of collaboration climate you succeed in bringing about between you and your students. Teacher-centered teaching may follow its course even with disinclined students. PBL-based facilitation comes to a stop if students don't ask for it and don't in practice appreciate it. For a vast majority, if not all of your students, however, PBL will represent unfamiliar territory, and may at the outset not have a great, immediate appeal. Part of your initial moves as PBL instructor must therefore consist in helping students become interested in being your active PBL collaboration partners.

What pre-training might be needed before your students are properly prepared and motivated to play along with you as PBL partners – and how will you find out about those needs?

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Part 3: Standardized approach to group reflection sessions

Reflective learning is fundamental to PBL. The following process is provided as a standard procedure for instructors to use to emphasize the importance of reflective working and to enable trainees to develop their reflective skills across all the courses.

The following reflective procedure is to be carried out in every face-to-face session. This reflective process is more important than any specific piece of knowledge-based content and so should not be left out to make room for other content.

1. Ask students to spend 10 minutes on their own answering the following questions:

   [First session]
   What do you want to learn today?
   What support resources will you use?
   How will you know when you have learnt it?

   [Subsequent sessions]
   What did you learn yesterday?
   What do you want to learn today?
   How will you know when you have learnt it?

2. Ask trainees to pair up and spend five minutes telling each other the answers to these questions

3. The instructor says, 'I want to understand where we are on our learning journey – based on your conversations, what can you tell me.

4. Instructor summarizes what she/he understands about the lie of the land, and what progress is being made towards the groups aims.

To support these last two points, the instructor can ask a trainee to be a scribe.

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Part 4: Overview of course materials

The details of each of the courses are provided in the appendix. The documentation for each course is structured as follows:

- **Part A - General course information -** Contains information on: keywords, authors, duration, language of materials, type and number of sessions, number of participating engineers and group setting.

- **Part B - Course overview and Key Learning Outcomes** - An overview of the course, a complete list of learning outcomes and a description of software needed to deliver the course.

- **Part C - The learning scenario** - Describes the problem context within which the trainees will be working, with background reading to help the trainer familiarize themselves with this area. Includes photos that can be used as media in training sessions.

- **Part D - Pre-module preparation** - Provides lists of materials that could be used as background reading and additional case study material.

- **Part E - Module overall presentation** - Makes reference to the PowerPoint presentation used to deliver the course and provides a suggested list of discussion questions.

- **Part F - Post-module (post training)** - Provides a list of reflective questions that instructors can use to help trainees assess their level of understanding. It also provides details of any outputs that the trainees will need to produce.

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