

How to coach engineering project-based learning?

M. Burman

Educational Research Assistant
KU Leuven
Leuven, Belgium

E-mail: marjolijn.burman@eng.kuleuven.be

I. Van Hemelrijck

Staff Member Education
KU Leuven, LESEC
Leuven, Belgium

E-mail: inge.vanhemelrijck@eng.kuleuven.be

E. Londers

Staff Member Education
KU Leuven, LESEC
Leuven, Belgium

E-mail: elsje.londers@eng.kuleuven.be

Y. Berbers

Vice dean of the Faculty of Engineering Science
KU Leuven
Leuven, Belgium

E-mail: yolande.berbers@eng.kuleuven.be

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INTRODUCTION

The Faculty of Engineering Science at the KU Leuven has over ten years of experience in providing project-based learning (PBL). In the course 'Problem Solving and Design' (P&D), students encounter from the first semester on real-life engineering problems. In order to complete these assignments, the students have to work in small groups and integrate the basic principles of their regular scientific and technical courses. This way, they learn both to understand the relevance and applicability of those principles and to master the abstract theories presented in lectures. Furthermore, they should develop technical and social competences, such as communication skills, a systematic approach to problem solving and engineering design, teamwork and project management [1]. During these projects, the students are coached by PhD students with an additional teaching assignment, further referred to as teaching assistants (TAs) [2].

However, the TAs coaching P&D teams encounter several specific challenges and problems. They indicate the following three issues as their main problems: (1) teams that do not seem to make progress after the assignment is defined, (2) teams that do not search independently for solutions, yet that expect these answers to be handed over by the TA, and (3) teams that take too little initiative by themselves [3]. Thus, TAs generally encounter difficulties when motivating students to cooperate actively [4]. Since a correct interpretation of the coaching role is crucial for a successful PBL and a qualitative education for the students, the coaches of PBL need to be professionally trained and supported [5]. Therefore, the faculty decided to create a didactic training module specifically for TAs who coach P&D sessions.

The work of Dekeyser and Baert (1999) was clarifying to get a general understanding of PBL and its different components [6]. However, the research of Van der Hoeven and Peeters (2013) offered a specific framework that defines nine different roles a coach can take on during PBL. A first reason to adopt these coaching roles was that they were situated in the same context, namely higher education in science and engineering. Secondly, the framework highlighted a broad range of roles that could be taken on by TAs. A third reason is that the authors developed a web application about their study, which can be useful for TAs who want more information [5]. In consequence, the faculty chose to create a new TA training, based on the aforementioned coaching roles a TA can take on during P&D. This training module fits into an already existing educational training programme of the faculty, called SWEET² or 'Starters Week of Engineering and Education: Training for TAs'.

The focus of this paper is the role of the coach during PBL. It will first explain SWEET² to provide a general description of the TA training. Next, we will focus on the module 'coaching P&D sessions'. This module was organized in order to support and guide TAs that coach PBL and took place for the first time in February 2015. The objectives, guiding principle and materials of the module will be presented. Finally, both the evaluation of the first session and prospective plans will be described.

1 SWEET²

PhD students at the Faculty of Engineering Science can take part in a TA training programme since 2005. In 2013, the PRIMA project (Professionalization in Engineering Science: the Millennium Assistant) was launched to evaluate the existing programme and adapt it to the needs and expectations of the present-day TAs [7]. As a result of PRIMA, the previous training programme was thoroughly changed and SWEET² or 'Starters Week of Engineering and Education: Training for TAs' was established as a new educational training programme.

As shown in *Figure 1*, the general objectives of SWEET² are threefold. The TAs should acquire both the educational concept of the KU Leuven and the educational vision of the Faculty of Engineering Science. The third objective aims at letting the participants experience how certain educational strategies can be put into practice. This refers to the 'teach as you preach' principle, so that each module departs from a specific teaching format and corresponds to the teaching practice of the TAs, such as supervising exercise sessions or guiding a master thesis [7].

SWEET² contains five different training modules, among which coaching P&D. Every module consists of two sessions, each of them lasting two hours. This way, TAs receive support and guidance before they start their teaching assignment, and feedback on their teaching experience during the second part.

Furthermore, thanks to PRIMA, two actions are being taken to enable more interaction between the TAs and to facilitate peer learning during the TA training.

Commenté [BM1]: 'basiscomponenten van een onderwijspraktijk'

Firstly, the number of participants was reduced and maximum 15 assistants could enrol in the module 'coaching P&D'. Secondly, the faculty introduced flipped teaching by asking the TAs to prepare an assignment before each session (see Fig. 1) [7].

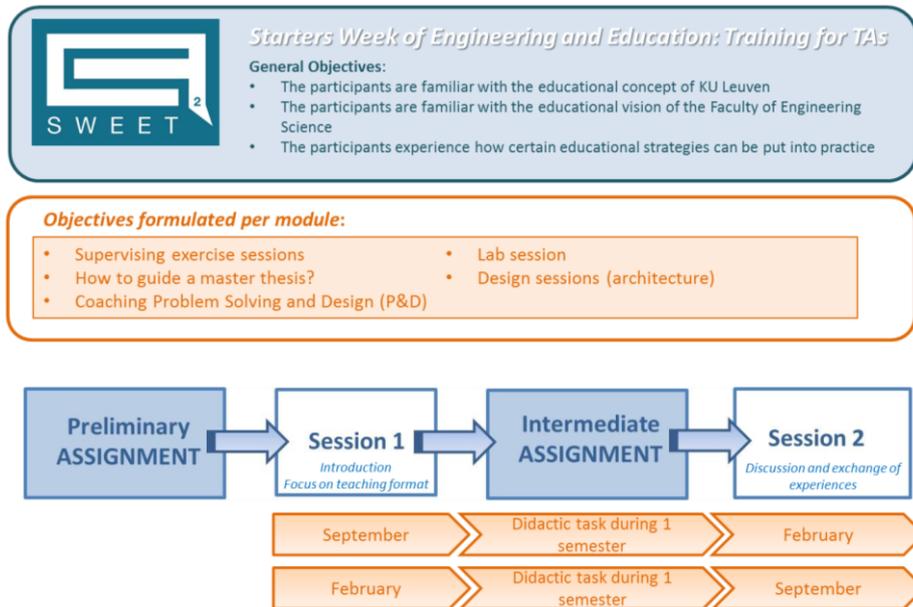


Fig. 1. Blueprint for the new educational training program

The TA training is organized twice every academic year, at the start of each semester. TAs can choose if they start a module in September or in February, but they must complete all four parts of one module to receive a certificate of participation. Since 2011 obtaining this certificate is a compulsory part of the PhD training at the Faculty of Engineering Science [2].

2 COACHING PBL

2.1 Objectives

As represented in Figure 1, a general objective of SWEET² is to make the TAs familiar with the educational vision of the Faculty of Engineering Science. These faculty guidelines are formulated specifically for each module in order to make the expectations of the faculty clear. Table 1 presents the guidelines for coaching P&D.

Table 1. Faculty guidelines for coaching P&D

<ol style="list-style-type: none"> 1. The TA knows his/her <i>teaching assignment</i> and the <i>responsibility</i> that goes with it: he/she knows how much support students are entitled to and under which form. 2. The TA is well aware of the <i>objectives</i>, as well as the <i>evaluation criteria</i> of the learning activities that are linked to his/her teaching assignment. 3. The TA pays attention to the <i>student characteristics</i>: he/she can identify different types of students and respond to their needs. 4. The TA encourages students to <i>actively process</i> the subject matter: he/she is well aware of which coaching roles he/she can take on. 5. The TA makes sure that every student receives sufficient <i>feedback</i> on a regular basis in order to support the learning process. 6. The TA is in close contact with the course coordinator and the rest of the <i>didactic team</i>. 7. The TA strives to gain insight into his/her own <i>teaching style</i> through <i>self-reflection</i>.

The training sessions are provided by educational staff members of the Faculty of Engineering Science. These instructors defined **specific objectives** for the module coaching P&D (see *Table 2*).

Table 2. Specific objectives for coaching P&D

1.	The participants are familiar with the <i>nine coaching roles</i> , as formulated within the project OWP 2010/22.
2.	The participants receive <i>tips</i> to adequately support a group.
3.	The participants know their <i>teaching assignment</i> and the <i>responsibility</i> that goes with it.
4.	The participants know the importance of <i>communication within the didactic team</i> . Furthermore, they are informed how they can contact the course coordinator and other assistants to discuss the P&D sessions.
5.	The participants know where to obtain <i>background information</i> in the context of their teaching assignment.
6.	The participants acquire more insight in their role as a TA through <i>reflection</i> on their own teaching practice.
7.	The participants know the significance of <i>feedback</i> and can apply it in the context of the teaching format.
8.	The participants can identify the different <i>types of students</i> in a group and (receive advice to) adequately adapt themselves to their different needs.

2.2 Teach as you preach

Since the guiding principle of SWEET² is ‘teach as you preach’, the TAs will only receive information that is applicable for their teaching assignment. Specifically for the module about coaching P&D, the TAs will learn about the nine roles a coach can take on during PBL, as presented in *Table 3* [5].

Table 3. Nine coaching roles

Advisor	Provides the students with indirect answers and advice.
Authority	Provides the students with ready-to-use answers and instructions.
Educator	Steers the learning process by urging the students to reflect on their personal development and their learning methods.
Feedback provider	Provides feedback on a regular basis to the individual students and the group.
Group specialist	Makes sure the group and all its members are functioning properly.
Inspector	Checks if the students are working and making progress.
Model	Acts as an example for the students: the students gain insight in the reasoning and thinking of the coach.
Motivator	Motivates the students during the course of the project.
Problem solver	Can be reached when problems emerge and helps to solve them.

As a consequence of the ‘teach as you preach’ principle, the TAs will work in groups. This way, the training better reflects the contact moments between the TA and the students during P&D, where students work in teams for PBL.

In *Figure 2*, the structure of the module ‘coaching P&D’ is displayed. Since the core theme of the module contains the nine coaching roles TAs can take on during P&D sessions, the preliminary and intermediate assignment refer to these roles. In both assignments, the TAs find a short description of the nine roles. In the preliminary assignment, the TAs are asked to write down which roles they would (not) take on and why. For the intermediate assignment, they should reflect on which coaching roles they actually take on and why. Thus, while the preliminary assignment mainly serves as an introduction to the session, the intermediate assignment is meant to let the TAs reflect on how they act as a coach during P&D sessions. By making these assignments in advance, the TAs can really use the sessions to discuss the theory, share experiences and learn from their peers.

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	Component	Content	Teaching format	Coaching roles (teach as you preach)	Materials (during session)	Booklet	Objective	Faculty guideline	
0	Preliminary assignment	9 coaching roles	Preliminary reflection	Educator	Table with 9 coaching roles	9 coaching roles	1	4, 7	
1	Exercise 9 coaching roles	9 coaching roles	Cases, feedback exercise	Buzz groups	Model, advisor	Cases, preliminary assignment	9 coaching roles, tips	1, 2	1, 4
2	Explain faculty guidelines	Role of TA	Brainstorm		Authority	PPT : responsibilities TA during P&D	Faculty guidelines	3	1, 2
3	Exercise building an observation post	Solving a problem in group	Discussion		Problem solver, group specialist	Cards with information	Group dynamics	2	4
4	Communication within the didactic team	How to discuss with the course coordinator?	Testimonial, discussion		Advisor, motivator, inspector	PPT : coaching large didactic teams	Points of attention	2, 4	2, 6
5	Completion	9 coaching roles	Explicate coaching roles		Advisor, model	Overview 9 coaching roles	9 coaching roles, tips	1, 5	4
6	Intermediate assignment	Insight in own education	(self) assessment	Educator	Table with 9 coaching roles	9 coaching roles, tips	1, 6	4, 7	
7	Reflection on self-assessment	Insight in own education	Peer feedback	Buzz groups	Educator	Intermediate assignment	Peer feedback, self-assessment	1, 2, 6	7
8	Exercise presentations	Oral feedback	Assess presentation, discussion		Feedback provider	Film, feedback sheet: oral communication	Feedback (what, why, who, how), tips	2, 7	5
9	Exercise role-playing	Written feedback, student archetypes	Role-playing	Feedback provider	Paper, cards with roles and archetypes, feedback sheet: written communication	Feedback (what, why, who, how), tips, student types	7, 8	3, 5	
10	Completion	Questions and to do	Plenary	Advisor, problem solver	Blanco list	Tips	2, 6	7	
11	Additional material	Background, interesting links, literature, ...	Online information	Advisor	Website	Background information, lexicon	5	7	

Fig. 2. Overview of the module 'coaching P&D sessions'

After defining the objectives and faculty guidelines, the instructors selected information and exercises they wanted to work on during the sessions. According to the 'teach as you preach' principle, the teachers themselves take on the coaching roles during the sessions. Hence, they act as a **model** for the TAs, in order to provide an example.

Furthermore, the instructors want to stress the coaching role of an **advisor** by providing the TAs indirect answers and advice. The role of **authority**, on the contrary, offers ready-to-use answers and instructions. Since the teachers want to activate the TAs' own expertise and encourage them to search for a right solution themselves, they will not often act as an authority. For instance, to present the faculty guidelines, the TAs are requested to have a brainstorm and write down the responsibilities of a TA during P&D sessions. This way, the TAs do not just passively learn about the guidelines. Thus during the module, TAs receive advice of their peers or of the teachers, as stated in the second specific objective.

Finding an appropriate way to act as a **group specialist** and **problem solver** was the biggest challenge during the elaboration of the module. The instructors wanted to let the TAs solve a problem so they can experience themselves the dynamics that appear in a group. They selected an exercise where the participants should share information with each other to find the solution. After this exercise, the teachers refer to several topics of group dynamics, such as (in)formal leaders, the distinction between task oriented and relation oriented actions, etc. Furthermore, the instructors wished to inform the TAs about different student types in a group. They struggled with finding a transparent presentation. Since the nine coaching roles were already presented in a list, they decided not to offer another list with (dys)functional roles group members can take on [6]. Finally, they chose for the Rose of Leary, which clearly represent the interaction between people and the impact of a certain behaviour on a group.

An important issue the faculty wanted to discuss with the TAs is **providing feedback** to the students. During the educational project RAPPING (OWP 2011/13), the Faculty of Engineering Science developed feedback sheets and guidelines for technical reporting. Since the instructors noticed that the TAs do not often use these sheets, the TA training will be a good opportunity to pay attention to feedback. This topic would be discussed during the second session of the module.

Another important coaching role the instructors take on is the role of the **educator**. Since they recognise the importance of self-reflection for the TAs to gain more insight into their own teaching style, both objective 6 and faculty guideline 7 prescribe this topic. The role of an educator will mainly be taken on during the second session, after the TAs have obtained some teaching experiences where they can reflect on.

Finally, the instructors take on the role of **motivator** and **inspector** during the exercise about communication within the didactic team. However, both coaching roles are also taken on during other exercises. Thanks to the PRIMA project, the faculty became aware that the communication between TAs and the didactic team was not always ideal. Hence, attention is paid to this topic during the first session, before TAs actually start with their teaching assignment. As a motivator, the teachers stress the importance of discussing the P&D sessions with the course coordinator. As an inspector, the instructors monitor whether the proposed planning and related goals will be achieved. This role of inspector was translated in the second faculty guideline, and can also be discussed within a didactic team.

2.3 Materials

For the instructors, a script was made to describe the course of the module 'coaching P&D sessions' in detail. This serves as a guidebook and contains all the information needed to organize the module. It lists the goals of the module, as well as the faculty guidelines regarding coaching P&D. Furthermore, the teaching formats are explained, including the duration of each exercise. When necessary, the solution of an exercise is provided or guiding questions are developed for the teachers. All the materials for the exercises are collected in a container. Besides, a PowerPoint was made which only contains the core of the session. Because of the 'teach as you preach' principle, the instructors wanted to let the TAs work in group and interact with each other, instead of offering them a lecture.

For the participants, a booklet was designed. The challenge was to find a good balance between theory and background information on the one hand, and practical tips and tricks on the other hand. For instance, after an explanation of each coaching role, tips were formulated to provide the TAs hands-on advice. In sum, the booklet provides first the educational concept of the KU Leuven and the faculty guidelines (see the first two general objectives in *Fig. 1*). Then, an explanation about P&D is given, since international TAs also coach this course, without having taken part in it by themselves. Moreover, the booklet offers case studies, background information about group dynamics and feedback, attention points about communication with the didactic team, a lexicon and feedback sheets. During the session, the instructors refer often to the booklet, so the participants know they can find more information there. In addition, TAs can use a website that is developed specifically for SWEET². It contains all necessary documents, such as the preliminary and intermediate assignment, and additional information.

3 EVALUATION FROM THE PARTICIPANTS

In February 2015 the Faculty of Engineering Science provided the first session of the module 'coaching P&D sessions'. It was organised twice and attended by sixteen TAs. Afterwards, the instructors asked the participants to write down three positive aspects and three points that need improvement. In general, the reactions of the TAs were positive. 81% gave three positive remarks. Besides, 68,75% of the TAs wrote less than two negative aspects (see *Table 4*).

Table 4. Number of remarks

	3 remarks	2 remarks	1 remark	0 remarks
Positive	81,25 %	18,75 %	0 %	0 %
Negative	12,5 %	18,75 %	56,25 %	12,5 %

The TAs gave positive comments about the 'teach as you preach' principle, such as "[the session] simulates the real situation during P&D to better understand the P&D" (respondent A) or "the teachers take on different coaching roles to illustrate their use" (respondent B). Besides, 62,5% of the participants defined the exercise about group dynamics as interesting and helpful to understand the topic. In addition, the coaching of the instructors was positively evaluated, e.g. during the facilitation of the group discussion. The TAs appreciated that the teachers encouraged discussions and provided feedback. Moreover, they considered the tips from the instructors concrete and helpful to fulfil their teaching assignment.

Regarding the timing and organisation, the opinions were mainly positive. Furthermore, the TAs appreciated the possibility to interact with peers. Working in

group, sharing experiences and discussing problems that occur during P&D were indicated as positive aspects of the session. However, the TAs asked more time to discuss both the exercises and their own experiences.

The TAs formulated two remarks about the preliminary assignment, like "I don't think the preliminary assignment was very relevant (seemed vague without explanation about different roles)" (respondent C). One TA noted that the exercise about the communication within the didactic team could be discussed differently according to him. Another suggestion came from respondent D, who pointed out: "I would like a little bit more explanations".

After presenting the evaluation of the TAs concerning the first session 'coaching P&D sessions', we appoint some changes that will be made in the future.

4 PROSPECTIVE PLANS

First of all, the instructors were pleased with the positive evaluation about the 'teach as you preach' principle, since this is concerned as guiding principle of SWEET² and stated as third general objective of the educational training for TAs (see *Fig. 1*).

Secondly, the feedback of the TAs indicated that the rationale of the sessions is not always clear for the participants, although the instructors tried to make it explicit. A first case is the preliminary assignment. As explained earlier this assignment is given as part of flipped teaching. In order to activate the TAs during the session and immediately let them discuss the theory, TAs should prepare themselves before each session. However respondent C mentioned that the assignment seemed vague without an explanation about the coaching roles. Thus, the instructors shall add the instruction that TAs should first read the explanation about the coaching roles. This information was already presented on the website, but was not explicitly written on the assignment itself.

Besides, some TAs asked for more information. However, the instructors developed a booklet and a website with additional information, since they are aware that the theory will only be explained in general during the session itself. This remark of the TAs indicates that the instructors should explain more clearly to the participants that the sessions mainly serve to interact with peers instead of providing theory. Another example is the comment that the TAs wanted more time to discuss with peers about their personal teaching experience. Since the second session of the module mainly serves to interact and reflect, the content of that session will be more stressed next time.

Finally, the teachers decided to change the exercise about 'communication within the didactic team'. Next session, a movie with interviews of course coordinators will be shown. This way, the lecturers themselves can explain their point of view about communicating with TAs for the course P&D. Although just one TA stated that he would adapt this exercise, the instructors themselves found that the specific objective 4 was not reached.

In conclusion, the first session of the new module 'coaching P&D sessions' was mainly positively evaluated by the TAs who coach PBL teams. According to the 'teach as you preach' principle, the instructors themselves take on nine coaching roles in order to clarify the diversity of the teaching assignment of a TA. During the second session, the TAs will reflect on their teaching practice and learn about feedback.

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