

AC 2008-1031: HOW TO HELP SENIOR CHEMICAL ENGINEERING STUDENTS ENHANCE AND DEVELOP THEIR LEADERSHIP COMPETENCE

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How to Help Senior Chemical Engineering Students Enhance and Develop Their Leadership Competence

Abstract

Chemical engineering students at the University Rovira i Virgili (Tarragona, Spain) have the opportunity to enhance and develop their leadership competence by taking on a team leadership role in a first-year integrated design project. All fourth-year students enrolled for the Project Management in Practice (PMP) course go through a comprehensive team leader selection process. This selection process involves doing three psychometric tests (Belbin, Myers-Briggs, and Leadership Styles) and a competency-based interview with all the PMP's instructors. Finally, a group of about a dozen students are chosen to lead teams formed of first-year students and to manage the design project in which all first-year courses actively participate (hence the adjective of integrated). First-year team member selection is done by team leaders who develop their own selection criteria and take into account first-year students' Belbin roles. The PMP course, like the first-year integrated design project, lasts two consecutive 15-week periods with 4 class hours per week. One hour is reserved for the individual coaching process between a PMP instructor and his/her assigned team leaders. Two more hours are devoted to teaching leadership, project management, and facilitation concepts, techniques, and tools. The remaining class hour is devoted to the weekly formal meeting of leaders with the first-year project team. Hence, there is also a vertical integration between the PMP course and the first-year integrated design project. The assessment of the team leaders' leadership competence is carried out at the individual and team levels. At the individual level, the following processes are in place: (a) a 360-degree feedback process, (b) project management reports (a team charter and a final report per period), oral presentations (one presentation per period), (c) learning journals, (d) behavioral event interviews, and (e) focus groups with team members. Team effectiveness is measured by: (a) a team climate survey, (b) the evaluation of project products (a design report and a poster or an oral presentation followed by a defense), and (c) focus groups with first-year instructors.

Introduction

In 1996, the fourth-year Project Management in Practice (PMP) course was created as an elective in the Chemical Engineering program at the University Rovira i Virgili (Tarragona, Spain). The creation of this course responded to two needs although, actually, one of them was much more compelling than the other. Four instructors teaching three first-year chemical engineering courses - Transport Phenomena, Fluid Mechanics, and Transport Phenomena Laboratory - wanted their students to carry out an integrated design project based on a lactose recovery plant.¹ The integrated design project approach devised by these instructors was based on a combination of project-based and cooperative learning methodologies.² First-year students were organized into 23 teams formed of 5-6 members. The challenge for these instructors was how to provide strong leadership to these project teams, as team leadership is one of the key elements to guarantee project teams' success. The allocation of several professors to tutor each team was not practical, given the constraints of limited faculty staff and budget. Then, it was thought that senior students might take on that role. Given that there was a compulsory Project Management course assigned to the fourth year of the program, a new course that enabled fourth-year students to simulate the practice of a project manager was thought to be a great idea. In this way, the idea of project

teams formed by first-year students and led by a more experienced student, not a course peer, could be put into practice. This asymmetric team setup has eventually proved to be an excellent laboratory to develop personal competences such as leadership.³

Leadership development has ultimately come to our attention as a natural evolutionary step in our efforts to improve the effectiveness of PMP students. The education part of the PMP course was initially focused on project management and facilitation skills.⁴ However, while this education is necessary, it is not enough to cope with the challenges encountered by fourth-year students with the first-year integrated design project. In addition to the usual changes experienced by all students beginning their university studies,⁵ our first-year Ch.E. students find themselves suddenly immersed in a very demanding active learning environment that requires them to change their learning and working habits, sometimes to a dramatic extent.⁶ In general, fourth-year students have to deal with first-year students who: (a) show little motivation to study (the minimum grade required to enter our Ch.E. program is low); (b) are willing to do a lot of things at the same time (they do not know how to prioritize or are not prepared to make personal sacrifices); (c) are not used to studying and working at a constant pace and following a plan, (d) are relatively unaccustomed to learning by themselves, either particular contents from the first-year courses or specific skills such as necessary software programs, (e) are unused to depending on others for obtaining a mark; etc. Certainly, it can be said that fourth-year students' main task is to facilitate first-year students' change to new learning and work habits by influencing, motivating and inspiring them, that is, by demonstrating leadership competence.⁷

The purpose of this paper is to describe the system of enabling and assessment processes implemented in the PMP course to facilitate the development and measurement of the leadership competence by fourth-year Ch.E. students. Although the participants in this study are Ch. E. students, what is described can be readily transferred to any other engineering program or any program in general that is based on extensive use of project-based and cooperative learning methodologies.

II. Research question and research method

The number of fourth-year students who take on the team leader role in first-year project teams is very small, about a dozen, which renders experimental designs that require comparisons between groups statistically unviable.⁸ Therefore, a case study⁹ approach has been adopted to carry out an exhaustive and intensive study of each team leader to answer the following research question: *How do senior engineering students cope with the leadership development challenge that entails performing the team leader role of first-year design project teams?* The case study approach implies the use of a wide range of diverse methods of data collection –participant observation, learning journals, focus groups, etc. - and analysis. Accordingly, appropriate enabling and assessment processes have been implemented in the PMP course and are explained in the following section.

III. The Project Management in Practice course

The goal of the PMP course is to enable students to experience the demands of a team leader role and to provide them with the appropriate education and coaching support for their personal development.¹⁰ The main figures of the PMP course for the 2007/08 academic year are shown in Table I. It can be seen that only eleven of the students enrolled for the PMP course can actually act as team leaders of first-year project teams and four more students perform that role for project teams formed by peers (eighteen in total).

Table I. The main figures of the PMP course for the 2007/08 academic year.

Indicator	Amount
Number of instructors	4
Number of class hours per week	4
Number of students enrolled	33
Number of first-year project team leaders	11
Number of project teams formed only of PMP students	4

Table II collects the main enabling and assessment processes implemented throughout the PMP course. These processes are sorted out depending on whether they affect only the team leader (individual) or the whole project team (team). All these processes are explained turning the next section of this paper.

Table II. The enabling and assessment processes implemented in the PMP course.

Level	Enabling processes	Assessment processes
<i>Individual</i> (Team Leader)	<ul style="list-style-type: none"> ▪ Team Leader selection. ▪ Education. ▪ Learning journals. ▪ Individual coaching. 	<ul style="list-style-type: none"> ▪ Formal meeting observation. ▪ 360-degree feedback. ▪ Behavioral-event interviews*. ▪ Focus groups with team members. ▪ Project management reports. ▪ Oral presentations.
<i>Team</i> (First-year project team)	<ul style="list-style-type: none"> ▪ First-year integrated design project. 	<ul style="list-style-type: none"> ▪ Team climate survey. ▪ Project products. ▪ Focus groups with first-year instructors.

* This process is applied temporarily within the framework of a Ph.D. project. For the moment, it is not a regular process of the PMP course.

III.1 Enabling Processes

First-Year Integrated Design Project

First-year chemical engineering students carry out an integrated design project working in teams. It is an integrated project because all of the first-year courses participate in it. First-year instructors set aside part of their class hours so that teams can work autonomously on their projects, on average five hours a week during two consecutive fifteen-week periods. It is a design project since first-year students have to solve design problems concerning a given manufacturing process. This process has to produce a particular final product, for example nitric acid, or to transform a specific raw material, for example grapes, into different final products. In the latter case each project team must produce a different final product.

First-year students have to define the scope of the project, which is made up of a set of design objectives, taking into consideration the instructional objectives provided by first-year instructors. First-year instructors expect first-year students to learn by themselves part of the content of their courses' syllabuses and apply that knowledge to solve the design objectives. Needless to say, first-year students alone are not able to cope alone with the cognitive and social challenges posed by this project-based cooperative learning experience.

To ensure the success of first-year project teams, some of the fourth-year students enrolled for the PMP course take on the leadership role in the first-year project teams. The PMP course, like the first-year integrated design project, lasts two consecutive fifteen-week periods with four class hours per week. One hour is reserved for the individual coaching process between a PMP instructor and his/her assigned team leaders. Two more hours are devoted to teach leadership, project management, and facilitation concepts, techniques, and tools. The remaining class hour is devoted to the weekly formal meeting of leaders with the first-year project team. Hence, there is also a vertical integration between the PMP course and the first-year integrated project. In addition to the scheduled formal meeting, team leaders meet at least once more with their teams weekly.

Team Leader Selection

The number of leadership positions available is dependent on the number of students enrolled for first year courses. On average, a dozen first-year project teams may be formed. Therefore, approximately only one third of the usual number of students who take the PMP course can actually become first-year project team leaders. The selection of these team leaders is a key process of the PMP course. This process has been designed to select those students who have the highest potential to lead and manage a project team and who are willing to do so. It is structured into three main steps: (1) pre-selection: academic qualification and motivation to be a team leader, (2) screening: personality profile, (3) selection: demonstration of leadership competence. In the first step, all students enrolled for the PMP course have to fill out a short form to check their academic eligibility for the position and their motivation to be a team leader. In the second step, all PMP's students are asked to complete three psychometric tests: Belbin's Team Role Inventory,^{11,12} Myers-Briggs Inventory,^{13,14} and Leadership Style Inventory.¹⁵ The analysis of the results obtained from steps one and two using a set of research-based criteria yields a list of

candidates. Finally, the PMP instructors conduct behavioral-based interviews of all candidates to validate test findings and assess their level of leadership competence to ensure that the best candidates are chosen for the position.

The remaining PMP students form teams to carry out other projects than the first-year integrated project. However, one of these projects, the “Monitoring Team” (MT), is strongly linked to first-year project team leaders. The MT team is formed of eight to twelve PMP students. The goal of this team is twofold. First of all, the MT team assists first-year project team leaders to become more effective in performing their role by providing them with quantitative and qualitative feedback data and by creating tailored training resources. Secondly, it supports PMP instructors by collecting data from first-year students and first-year instructors that facilitates the assessment of the leadership competence level of team leaders. The specific interventions of the MT team are described throughout this paper.

Education

The PMP syllabus has been planned to teach the knowledge, skills, and behaviors required by team leaders to perform properly the leader, team administrator, and facilitator roles that may be needed at any given time while doing the project.¹⁶ Exhibit 1 shows the topics covered during the course, which are taught in the two hours per week that are devoted to education.

Exhibit 1. Contents of the Project Management in Practice course.

Roles	Topic
<i>Leader</i>	<ul style="list-style-type: none"> ▪ High impact leadership behaviors: Leadership Competency Dictionary ▪ Listening skills ▪ Giving and receiving constructive feedback ▪ How to provide effective recognition ▪ Selecting a team: Team capabilities ▪ Setting team direction ▪ Team development
<i>Team Administrator</i>	<ul style="list-style-type: none"> ▪ Planning the project: Team Charter ▪ Monitoring the project ▪ Closing-out the project: Final Report ▪ Performance management
<i>Facilitator</i>	<ul style="list-style-type: none"> ▪ Core practices and key behaviors of facilitators ▪ Fostering participation ▪ Effective decision making ▪ Meeting management ▪ Managing conflict ▪ Process tools

Topics are generally covered when students experience the need. On one hand, class scheduling has to be consistent with project and team dynamics. Thus, for example, the “Selecting a team: Team Capabilities” topic must be taught before “Planning the project.” On the other hand, other topics such as “Giving and receiving constructive feedback” or “Managing conflict,” can be

programmed with more flexibility. In these instances, the assessment processes and the learning journals help spot the opportunity to introduce any given topic. For instance, it is foreseeable that when the MT team members start observing project team meetings and providing feedback to team leaders, some of these may contradict the feedback received and argue against the MT team members. Then, students are ready to be instructed on the “Giving and receiving constructive feedback” topic.

A Leadership Competency Dictionary has been created to support both this education process and the majority of assessment processes described in subsection III.2. In the first place, this dictionary provides students with a framework of high-impact leadership behaviors. The implicit hypothesis is that the more team leaders show effectively these behaviors, the higher their performance will be as team leaders.¹⁷ Videos and clips from movies are extensively used in class to illustrate leadership and facilitator behaviors. Learning journals are commonly the measure used by PMP’s instructors to assess the impact of these learning resources. In the second place, this dictionary is the basis to code all of the written reports, the oral presentations, and to carry out the 360-degree feedback, all of them explained in the assessment process section.

The Leadership Competency Dictionary is in line with other leadership models.^{18,19} It is constituted by eight competencies:²⁰ Commitment to learning, interpersonal communication, drive for excellence, integrity, results orientation, client orientation, responsiveness to change, and teamwork and cooperation. These competencies have been identified by analyzing the Fundamental Concepts of Excellence²¹ of the EFQM Excellence Model.²² Each of these competencies has been defined by the intent of the person applying it and developed according to three proficiency levels. Each level is described in its turn by a definition and five behavioral descriptors. The Exhibit 2 shows part of the integrity competency as an example. The sum of the behavioral descriptors corresponding to the first level of development of the eight competencies gives rise to a forty-statement questionnaire, used for the 360-degree feedback process, which characterizes the first level of leadership: *leadership without position power*. First and second-year students practice this level in their respective design projects. Likewise, the second level of leadership, *team leadership*, is made up by the behavioral descriptors that form the second level of development of the eight competencies. Third and fourth-year students experiment this second level. Finally, the third level of leadership, *transformational leadership*, is reserved for post-graduate students.

Exhibit 2. Part of the integrity competency from the Leadership Competency Dictionary.

INTEGRITY		
The ability to harmonize honestly words and feelings with thoughts and actions, with the only purpose of doing the good for others, without any evil intent or willingness to cheat, to take advantage of, to manipulate or control them; reviewing constantly his/her own determination and struggling for congruence.		
LEVEL 1 UPRIGHT	LEVEL 2 COMPASSIONATE CONFRONTATION	LEVEL 3 SOCIAL RESPONSIBILITY
Keeps his/her promises and meets expectations. Personal integrity generates trust.	Recognizes and confronts faults of integrity in others but within an authentic context of tact, concern, and warmth toward the others.	Makes a genuine effort to balance and meet the expectations of all organization's stakeholders.
<ul style="list-style-type: none"> ■ Keeps promises made to others. ■ Expresses what he/she actually thinks and feels even when the message may not be welcome by other people. ■ ... 	<ul style="list-style-type: none"> ■ Is able and willing to confront others as needed. ■ Admits openly mistakes and faults. ■ ... 	<ul style="list-style-type: none"> ■ Is a role model of the organization's values for the others. ■ Does not compromise when convinced that something is correct and necessary though unpopular. ■ ...

Learning Journals

Every team leader keeps a learning journal,²³ which is shared only with the PMP's instructor acting as his/her coach. Learning journals are kept electronically in the space reserved for the PMP course in the university virtual campus, being easily accessible to PMP instructors. Students are required to make at least one entry each week. These journals play a pivotal role in team leaders' leadership developmental process since they provide them with:

1. An opportunity to record and reflect on critical work events, either positive or negative. Exhibit 3 contains a few examples of these events as reported by team leaders. This reflection about the action is essential to learn from experience.
2. A means by which PMP's instructors can offer useful feedback and support to team leaders and determine their future development needs
3. An opportunity to practice critical and evaluative thinking with respect to actions and experiences.
4. A means of integrating theoretical learning with workplace leadership practice.
5. A means of "social hygiene" to allow the team leader to vent in a constructive fashion.

Exhibit 3. Examples of critical incidents reported by team leaders.

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- A team member wants to quit the project team.
 - Lack of project buy-in by team members.
 - Comments made by project clients that undermine team leaders' self-esteem.
 - Success when giving constructive feedback to team members according to what was explained at PMP classes.
 - A team member reproaching the team leader for not knowing the chemical process as well as team members.
 - A team leader not doing what he felt was correct to do because he was afraid this would be detrimental to his popularity.
 - A new team member that appears to be overbearing towards his team leader.
 - Project clients give the Team Charter a low score.
 - A team leader is shaken when his team members do not show any sign of excitement when they deliver the final report.
 - A team leader is shocked when her team members do not care if they do not achieve all the project objectives.
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Although team leaders can make entries to the journal on any and every appropriate occasion, they are encouraged to describe critical work events in particular. Team leaders are trained to explain these critical events by using the following structure, which is used in job competency assessment processes.²⁰

1. What was the situation? What events led up to it?
2. Who was involved?
3. What did you think, feel, or want to do in the situation?
4. What did you actually do or say?
5. What was the outcome?

This way, both students and PMP's instructors can better identify habitual patterns of behavior and evaluate them. For this reason, learning journals could also be placed among the individual assessment processes collected in Table II.

At the end of both fifteen-week periods, team leaders are asked to review and evaluate the content of their journals. They are given the following questions to guide them in their reflection:

1. How do I behave and respond in a given workplace situation?
2. Can I identify habitual patterns of behavior/response?
3. Are these helpful or unhelpful behaviors/responses?
4. What leadership strengths are apparent in the behavior patterns?
5. What leadership limitations are apparent in the patterns?

Team leaders write the conclusions of this activity in the final reports for the first and second periods.

Individual Coaching

Each PMP instructor coaches a small group of team leaders, between four and six depending on his/her teaching workload. Coaching is restricted to the behavioral and underlying driver levels, defined by the Center for Creative Leadership²⁴ and characterized in Table III. The challenge for PMP instructors is to interpret team leaders' behaviors from the perspective of what they reveal about their underlying drivers (preferences, beliefs, etc.) as well as what they mean for performance and leadership capabilities. Exhibit 4 provides an example of coaching at these two levels.

Table III. Levels of coaching and data sources.

Coaching Levels	Sources
Behaviors: Observable actions, verbal and nonverbal.	Learning journals and evaluation of formal project team meetings.
Underlying drivers: Personal style, preferences, orientation, culture, aspirations, motivations, mental models, assumptions, values, beliefs, core needs, life experiences (known and understood).	Belbin's roles, Myers-Briggs Types, Leadership Styles Inventory, and Schwartz's Value Survey.

Exhibit 4. Example of coaching at the behavioral and underlying driver levels.

A team leader did a very poor project team launch. His Team Charter got the lowest grade. He wrote on his learning journal that he probably deserved that grade, no objection, but the fact was that he strongly believed that all this planning and team building stuff was useless. He explained that his experience with the second and third-year integrated design projects was that the only things that were really needed to get a good grade in the project were to have motivated peers and good relationships among them. Certainly, although this is true for any team endeavor, it is not enough to achieve optimum team performance. Effective leadership and operating methods must also be in place. However, the context of the second and third-year integrated projects, which is very different from the first-year one, reinforced that belief in that student. An analysis of his personal preferences - shaper (Belbin's role), pacesetter (leadership style), and ESTJ (Myers-Briggs' Type) – revealed that this student was very action oriented and planning was not probably one of his favorite activities.

The PMP instructor meets formally and individually with each team leader for at least twenty minutes each fortnight on Monday's scheduled class. Before this meeting, both the student and the PMP instructor can analyze and interpret individually the student's learning journal and the formal meeting observation feedback provided by the MT team. Then, during the meeting the student and the PMP instructor can discuss critical events and patterns of behavior and relate them to the skills, knowledge, and effective behaviors that are introduced in the education component of the course. In addition to these formal meetings, the team leader can ask his/her assigned instructor to meet whenever the need arises.

Creating a safe and challenging environment in which team leaders can take risks and learn is the responsibility of PMP instructors. However, currently all of them also wear an evaluative hat as they have to eventually grade students. This fact, which is common for any leader, who acts as a coach in any organization,²⁴ might make team leaders reluctant to take appropriate risks and to get out of their comfort zones. Although the grading system for the course has been designed to mitigate this risk, see subsection III.3, additional feedback from students is needed to evaluate whether the dual role of PMP instructors is representing an obstacle.

III.2 Assessment processes

Table IV displays the assessment processes and when they are executed throughout the PMP course. Except for the formal meeting observation process that takes place weekly, the other processes happen only once or twice all over the PMP course. Therefore, the majority of the assessment processes deployed in the PMP course aim to gauge outcomes, be it the team climate or the leadership competencies actually shown by students.

Table IV. The assessment processes and their implementation throughout the PMP course.

Dimension	Assessment Processes	When are they executed?	By whom?
<i>Individual</i> (Team Leader)	Formal meeting observation.	Weekly. Starting weeks 9 or 10 of the first period.	Monitoring Team (MT)
	360-degree feedback	Twice. Weeks 1 and 14 of the second period.	Project Management in Practice (PMP) instructors
	Behavioral-event interviews	Once. Weeks 10 and 11 of the second period.	Ph.D. student
	Focus groups with team members	Once. Weeks 10 and 11 of the second period.	MT
	Project management reports	Twice. Team Charters: week 6 of the first period and week 3 of the second period. Final Reports: after the completion of each period.	PMP instructors
	Oral presentations	Twice. Once each period is finished.	PMP instructors
<i>Team</i>	Team climate survey	Twice. Week 13 of each period.	MT
	Project deliverables	Twice. Design Report: week 14 of each period. Poster or oral presentation and defense: week 15 of each period.	First-year instructors
	Focus groups with first-year instructors	Once. Week 15 of the second period.	MT

Formal meeting observation

Members of the MT team observe formal project team meetings weekly and evaluate team leaders' performance. An observation form made up of facilitator's skills and behaviors and meeting and project management items is created by the MT team to facilitate this task.²⁵ For this reason, formal meeting observation cannot start until weeks 9 or 10 of the first period (see Table IV). Completed observation forms are sent electronically to PMP instructors and team leaders by Friday so they can analyze and interpret this feedback before their coaching meeting held on Mondays.

The fact that team leaders' peers can observe and evaluate these meetings has two advantages: (a) they can provide feedback weekly, helping to spot timely areas of needed improvement, and (b) the tension that any observation process may bring about is eased if this is done by a peer rather than by a PMP instructor.

360-degree feedback process

After the intense experience of a whole fifteen-week period, both team leaders and team members are prepared to participate in a 360-degree feedback process.²⁶ This process enables team leaders to self-assess the degree to which they demonstrate the set of forty leadership behavioral descriptors that characterize the Team Leadership level of the Leadership Competency Dictionary (see subsection III.1, *education*). At the same time, team members can rate their team leaders against the same set of behavioral descriptors. This assessment process has been completely automated by means of a web-based application. Students can access the application through internet by means of a user name and a password. To ensure that the questionnaire is adequately filled in, all team leaders and team members are convened in a computer lab where PMP instructors can: (a) explain to students the rationale of the process, (b) train them to use the application, and (c) address any concern that may arise. In this gathering, students are reassured about the anonymity and confidentiality of the entire process.

Team leaders receive a Leadership Feedback Report as the product of the 360-degree feedback process. The analysis of this report along with the conclusions collected in the Final Report for the first fifteen-week period (see further on *project management reports*) enable team leaders to create a Personal Development Plan. Team leaders are encouraged to capitalize on the opportunities offered by the first-year integrated project during the second fifteen-week period but also on other experiences that go beyond the limits of the PMP course. Thus, they can take into account future internships, other courses, sport and leisure activities, etc. At the end of the second fifteen-week period, the 360-degree feedback process is executed again. Fourth-year students receive another Leadership Feedback Report which may be used for their self-directed continuing leadership development.²⁷

Behavioral-event interviews

Team leaders undergo a behavioral event interview²⁰ (BEI) which is conducted by a PMP instructor before the end of the second period. A BEI involves asking students to reconstruct between four and six significant events that they experienced while working with their team and in which they felt particularly effective or ineffective. PMP instructors push to elicit the specific thoughts, behaviors, and actions that students showed in those situations. PMP instructors review the team leaders' learning journals before conducting the BEI to identify potential critical incidents. This way, they can catalyze the interview in case the student gets blocked when trying to think of critical incidents. A typical BEI lasts about one hour and is tape-recorded and transcribed. PMP instructors code the transcripts for all of the leadership competencies of the Leadership Competency Dictionary.

It has to be highlighted that this process overlaps in some way with the learning journal process (see subsection III.1, *learning journals*). BEIs are currently conducted as a part of the Ph.D. project done by one of the authors. It depends on the conclusions of this project whether this process will be kept or removed from the system. For the moment, team leaders are given the transcript of their interview along with their coding and the conclusions drawn once the course is completed.

Focus groups with team members

The MT team is responsible for preparing, planning, and running focus groups with first-year students, one focus group for each project team. The purpose of organizing these focus groups is to get insights into: (a) the work processes and related changes that have taken place within the teams and that can be associated to the PMP course, and (b) the behaviors demonstrated by team leaders and the perspectives and sentiments of first-year students towards them. All focus groups are tape-recorded and transcribed. PMP instructors analyze the transcripts to identify: (a) working team practices and their correlation to team climate and team performance, (b) which leadership competencies have actually been shown by team leaders and their impact on first-year students. All this analyses serve to draw conclusions to improve the education component of the PMP course, the individual coaching process, and the Leadership Competency Dictionary.

It is expected that first-year students will be more unguarded in focus groups that are conducted by students than by PMP instructors, despite the fact that these do not grade first-year students at all.

Project management reports

Team Charters

The first project management report that is required from team leaders is the Team Charter.²⁸ The importance of this document for managing the first-year design project cannot be understated. The Team Charter embodies the foundations of the team in its forming stage and the planning of the project (see Exhibit 5). It is co-created by the team leader and his/her team

members. The power of this document comes from the discussion and agreements that are recorded on it.

Exhibit 5. Content of the Team Charter.

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1. The project team
 - 1.1 Roster
 - 1.2 Talent inventory
 - 1.3 Roles description
 - 1.4 Team norms
 - 1.5 Lessons learned and recommendations for improvement
 2. Project scope
 - 2.1 Project clients
 - 2.1.1 Clients' needs
 - 2.1.2 Clients' requirements
 - 2.2 Project products
 - 2.3 Project objectives
 - 2.4 Work Breakdown Structure
 3. Project schedule (Gantt chart)
 4. Meeting management
 5. Stakeholders communication strategy
 6. Attachments
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Team Charters, Final Reports, and oral presentations are all of them coded against some of the competencies of the Leadership Competency Dictionary (see Table V).

Table V. Competencies that are coded for the Team Charter, Final Report, and oral presentations delivered by team leaders.

Element	Competencies Coded	Levels
Team Charter	Commitment to learning	1, 2, and 3
	Drive for excellence	1, 2, and 3
	Results orientation	2 and 3
	Client orientation	1
	Responsiveness to change	2 and 3
	Teamwork and cooperation	2
Final Report	Commitment to learning	1, 2, and 3
	Drive for excellence	1 and 2
	Integrity	1
	Client orientation	1 and 2
	Responsiveness to change	2 and 3
	Teamwork and cooperation	2
Oral Presentation	Interpersonal communication	1, 2, and 3
	Integrity	1
	Commitment to learning	1
	Drive for excellence	1

Final Reports

At the end of each period, team leaders are required to write a Final Report.²⁹ To this end, team leaders hold a team meeting to perform a review and evaluation of the period just finished. This review and evaluation is structured in line with the content of the Final Report, which is shown in Exhibit 6. Team leaders hand over the Final Report and deliver an oral presentation to their respective coaches (see Table IV). After the oral presentation, team leaders have the opportunity to receive additional feedback from their coaches on the content of the Final Report.

Exhibit 6. Content of the Final Report.

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1. Project Management
 - 1.1 Project scope
 - 1.2 Schedule
 - 1.3 Staff time
 - 1.4 Additional issues: new members and/or drop outs, conflicts, etc.
 - 1.5 Lessons learned and recommendations for improvement
 2. Evaluation
 - 2.1 First-year instructors' satisfaction
 - 2.2 Team performance
 - 2.3 Individual member performance
 - 2.4 Team leader performance
 - 2.5 Lessons learned and recommendations for improvement
 3. Strengths and recommendations for improvement for the PMP course and the first-year integrated project
 4. Attachments
-

The first section of the Final Report, project management, deals with the characteristic review issues when managing a project. Thus, project teams must give answer to questions such as: What was really created versus what was planned? Were there deviations from the project scheduling? Why did the deviations occur? Could they have been avoided? etc.

The second section involves a thorough evaluation of the project team at different levels. Firstly, team members, with the help of their team leader, analyze the individual grades and feedback received from first-year instructors. On one hand, all project products - design report, poster or oral presentation, and defense - have been evaluated by first-year instructors and these have already shared their views during the defense. In addition, team leaders have also met with first-year instructors to give and discuss with them their grading of first-year students and to solicit their feedback about the functioning of the different project teams. Secondly, the team analyzes the results of the team climate survey to evaluate team performance. Thirdly, although team leaders carry out individual performance evaluation meetings with their team members, they also share the main results of these individual evaluations with the whole team and first-year instructors. In addition to a grade, team leaders provide team members with a summary of strengths and areas of improvement. The latter will form part of the lessons learned and recommendations for improvement subsection. Fourthly, team leaders must also review and reflect on their own performance. Team leaders are asked to review their learning journals, the

feedback received from their coaches throughout the period, and to solicit feedback from their team members (for example through a needs & offers feedback exercise).

Finally, the third section compiles the strengths and recommendations for improvement for the PMP course and the first-year integrated project.

Oral presentations

Once each period is finished, team leaders are required to prepare and deliver a ten-minute oral presentation based on their Final Report. Final Reports are handed over one week before the presentation so that PMP instructors have enough time to grade and code the report. The presentation is followed by a five-minute question-and-answer period. The entire presentation and question-and-answer period are videotaped for later analysis and coding by PMP instructors.

Team climate survey

Team leaders' practices and competencies influence team climate – team climate is what it feels like to work together in a team - more than any other factor.⁸ Therefore, team climate is open to improvement as a result of a leadership development process. The analysis of team climate measurements (see Table IV) may help to recognize and understand positive changes in team leaders' leadership competence.

A twenty-two statement questionnaire has been developed to measure the perception of project team members including team leaders. Four of these statements are directly related to the team leader. The reliability of the questionnaire was assessed in terms of the internal consistency using the Cronbach's alpha coefficient. An alpha coefficient of 0.91 was obtained, far exceeding the minimum of 0.70 to be considered reliable.

The team climate survey process is managed completely by the MT team to ensure anonymity to respondents. Team leaders and their coaches receive the results of the team climate survey. Team leaders use these results to engage team members in a discussion to identify ways to improve and PMP instructors may use them in the individual coaching process.

Project deliverables

All teams must deliver a Design Report and present and defend their results to all first-year instructors (see Table IV). The presentation and defense of project results are carried out through either a three-hour long public poster session or a fifteen-minute oral presentation followed by a fifteen-minute question-and-answer period. The defense of project results consists of first-year students being interviewed individually by first-year instructors who assess the degree to which each student has achieved the instructional objectives "lent" to the integrated design project. Team leaders are not allowed to participate directly in the presentation and defense session.

Focus groups with first-year instructors

The MT team is also responsible for carrying out a focus group with first-year instructors at the end of the second fifteen-week period. Unlike focus groups with first-year students, PMP instructors give support to MT members in running this focus group. The purpose of organizing this focus group is to elicit first-year instructors' thoughts and feelings about the functioning of first-year project teams. A focus group is very convenient in this case because first-year instructors can comment on one another's contributions.

III.3 Grading of the PMP course

As Table VI shows, the grading system of the PMP course is based on the various reports and oral presentations that students have to deliver throughout the course and also a final exam.

Table VI. Grading system for the PMP course.

Element	Weight (%)
Team Charter 1 st period	8
Team Charter 2 nd period	12
Final Report 1 st period	6
Final Report 2 nd period	9
Oral presentation plus defense 1 st period	12
Oral presentation plus defense 2 nd period	18
Personal Development Plan	10
Exam	25

It is critical to emphasize that all deliverables are graded according to the specificity, clarity, and comprehensiveness of the analyses made and their logic, not on to what extent students have demonstrated specific leadership competencies or not. For example, a student may conclude in her Final Report for the first period that she needs to improve her interpersonal communication competency. What is graded by the PMP instructor is the process followed by this student to reach such conclusion. The PMP instructor may agree that that is effectively an area of development for that student; however, this fact does not have a negative effect on the grade. Each PMP instructor grades the written deliverables produced by the team leaders that they coach. Therefore, they are in the best position to check the coherence of what is written by team leaders with the data collected from the learning journal or the formal meeting observation processes, for example.

IV. Concluding remarks and next steps

A comprehensive system of enabling and assessment processes has been put in place to foster and measure the development of the leadership competence by senior Ch. E. engineering students. A first-year integrated design project creates the appropriate challenging experiences that call on team leaders to move out of their comfort zones. The PMP course provides team leaders with both the support and the assessment that are necessary in order that they can steer their own leadership development. A complete evaluation of the effectiveness of each of the enabling and assessment processes will be carried out in April 2008.

In order to make the system sustainable, it is necessary to have a MT team formed of 8-12 students which is closely monitored by one of the PMP instructors. This team is in charge of carrying out four of the nine assessment processes: formal meeting observation, focus groups with team members, team climate survey, and focus groups with first-year instructors. On one hand, PMP instructors alone cannot execute all the processes. Moreover, students feel more comfortable if they are observed or interviewed by peers than by instructors.

A Leadership Competency Dictionary based on the EFQM Excellence Model has been created. This dictionary provides team leaders with a framework of high-impact leadership behaviors with a clear progression from lower to higher levels of proficiency. Team leaders can reflect on these behaviors, understand their impact, and decide whether to practice them. PMP instructors use the dictionary to code various deliverables generated through the assessment processes together with the learning journals. In addition, team leaders experiment a 360-degree feedback process that has been completely automated by means of a web-based application. The regular application of this 360-degree feedback process with different cohorts of students will enable to refine the dictionary by means of the application of statistical analyses. On the whole, team leaders get used to concepts and methodologies widely employed in organizations and, what is more important, they can improve in those competencies that are most relevant to these organizations.

A Ph.D. project is currently underway to measure the impact of the PMP course on team leaders of first-year design projects. Each team leader is then the subject of a case study, being all the data collected through the enabling and assessment processes analyzed and correlated in order to shed light on the effect of the whole experience on each team leader's leadership development. It is expected to have this project completed by mid 2009.

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