Appendices

Appendix A.

Coaching Related Competencies

DEVELOPMENT OF COACHING COMPETENCIES IN STUDENTS THROUGH A PROJECT-BASED COOPERATIVE LEARNING APPROACH

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Abstract *– First-year chemical engineering students carry out a horizontally integrated design project working in teams. The teams are each led by two fourth-year students, one taking on the role of team leader and the other of knowledge manager so that the project is also vertically integrated. Team leaders facilitate project and team management while knowledge managers facilitate the learning process of first-year students in such a way that both are essentially coaches. Fourth-year students experience alternatively both roles during the two semesters (15 weeks) of the academic year. These new roles require a new set of technical and social skills: Team management, facilitative leadership, and project management skills, which are formally introduced in the fourth-year Project Management course and put into practice in the Project Management in Practice course. The real challenge of the whole approach is ensuring that fourth-year students resist the temptation of reproducing the supervisory role of professors in the classical classroom environment, despite the pressure of achieving project objectives, the inexperience of first-year students who are not used to this approach, and the cultural inertia of the professors involved.*

Index terms – Coaching skills, cooperative learning, project-based learning.

INTRODUCTION

Historically, engineering education has mainly focused on delivering scientific and technical information to students. However, in modern corporate environments, scientific and technical knowledge can only be applied effectively if it is combined with adequate social skills and management methodologies such as team and facilitative leadership skills and project management [1].

Social skills cannot be easily addressed after graduation by additional training [2]. They are best developed across a curriculum from the introductory to the professional levels in a stepwise fashion, with appropriate repetition and positive reinforcement. In this respect, industry has repeatedly and clearly demanded that the scope of undergraduate engineering education should be accordingly broadened [3]. The message is clear, start working the above skills as soon as possible.

Project-based learning [4] coupled with cooperative learning [5] enable engineering students to combine the building of knowledge with its application to real-life problems while simultaneously developing the social skills needed in any challenging relational environment. In addition, one of the key elements for the success of any team endeavor is leadership. The challenge at hand is how to provide strong leadership to project teams formed by first-year students. The allocation of several professors to tutor each team is not practical given the constraints of limited faculty and budget. One alternative is to create and develop empowered student teams, ultimately capable of self-management; project teams formed by first-year students and led by senior undergraduate students who have fully experienced project-based and cooperative learning in their own education, and are equipped with team and facilitative leadership skills and project management know-how.

This paper describes how fourth-year chemical engineering students at the School of Chemical Engineering (ETSEQ) of the University Rovira i Virgili (Tarragona, Spain), develop and practice facilitative leadership skills and apply project management methods and tools through a learning approach that combines both project-based and cooperative learning.

THE PROJECT-BASED COOPERATIVE LEARNING APPROACH (PBCLA)

The PBCLA has been designed to facilitate the empowerment of teams formed by four or five first-year students and two fourth-year students to carry out a design project. The first pilot experience of the PBCLA at the ETSEQ was conducted during the Spring semester of the 1996-97 academic year. Then, 3 first-year and 2 fourth-year courses, 5 instructors and 23 teams of 5-6 students were involved. Currently, when the stationary state has been reached, all first-year courses, that is 12, 2 fourth-year courses, 24 instructors and 23 teams of 4-5 students are involved. Over 200 senior students have gone through the PBCLA experience during this period. The reason why to devise and implement the PBCLA, the description of the approach and its assessment during the first years of implementation are described in detail elsewhere [6]-[7].

In the last two years, the assessment of the PBCLA has been extended to include measurements of the development of skills by students. This is part of a doctorate project being carried out by one of the authors with the support of Dow Chemical Co. It is also worth to mention that in 2001, the ETSEQ was honored by the Catalan Government with the

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Jaume Vicens Vives accolade for the improvement in teaching achieved through the PBCLA.

Figure 1 illustrates the organizational environment in which the PBCLA is implemented and takes place. The design project starts the first week of classes and lasts for the two semesters of the academic year. Thus, first-year students begin team activities when they do not possess either the necessary technical abilities and knowledge or the appropriate team-based relational skills to carry out the project.

The scope of the design project has to be defined by each project team. On the one hand, the instructors (first and fourth year professors) that participate in the PBCLA select a chemical product or a process that will be the subject of study of the design project. For instance, sulfuric acid is the current 2001/02 subject while the thermal treatment of industrial wastes was selected for the 1998/99 academic year. On the other hand, each first-year instructor selects a set of instructional objectives from his/her course syllabus, which will not be covered in the regular class hours but rather achieved through the design project. The general instructional objective fixed by the school for the first-year students is that they begin the development of lifelong-learning skills within the team-based working environment of a professional chemical engineer.

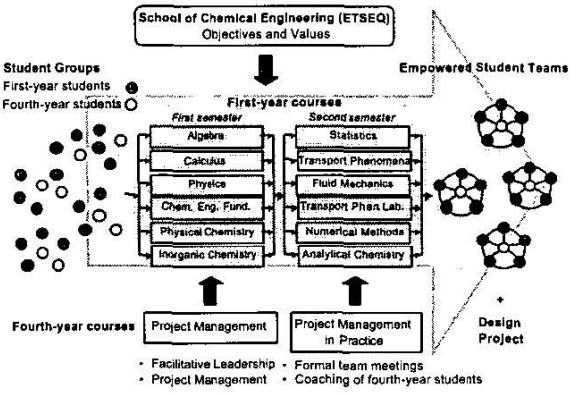

FIGURE 1
THE PROJECT-BASED COOPERATIVE LEARNING APPROACH AS DEPLOYED AT THE FIRST AND FOURTH ACADEMIC YEARS OF THE CHEMICAL ENGINEERING CURRICULUM AT THE ETSEQ.

Project teams are encouraged and guided to attain full empowerment to make decisions in all of the tasks that constitute the learning process [4]. This level of empowerment to project teams can only be granted by first-year instructors in view of the solid leadership that fourth-year students can provide. These students have accredited the knowledge needed to carry out the project activities and have already gone through the same experience a few years ago. In addition, they have been specifically trained in facilitative leadership skills and those needed to enhance team performance [8]. However, they are now asked not to do the project activities again, that is, play the game, but rather to coach a group of first-year students through the different tasks involved in the learning process to achieve the project objectives. This new role requires that fourth-year students be equipped with facilitative leadership skills and project management know-how. This is the purpose of the Project Management (PM) course allocated in the fourth-year of the curriculum (see Figure 1).

Regarding time resources for the PBCLA, each first-year instructor dedicates between 20-50% of his/her class hours to the project so that the teams can attain their goals within the school schedule. This percentage is also the weight of the project in the first-year students' final grade in each course.

The Project Management in Practice (PMP) course provides the time needed for (i) formal team meetings (3 hours per week) wherein all team members, first and fourth-year students, are present, and (ii) plenary sessions (1 hour per week) between fourth-year students and the instructors of PMP and PM. The remaining time provided by the first-year instructors, which is not dedicated to formal team meetings, is used by first-year students to carry out project activities. Instructors are present in their class hours during these activities but they are no longer responsible for any of the tasks of the learning process. They act, like fourth-year students, as coaches of the project teams.

FOURTH-YEAR STUDENTS AS COACHES

Fourth-year students take on the roles of team leaders and knowledge managers in the project teams. Team leaders help first-year students develop team skills and practice project management methods and tools. Knowledge managers do the same with problem-solving and life-long learning skills. However, neither the team leader nor the knowledge manager works with first-year students on the learning activities that the project involves.

The specific responsibilities of teams leaders are:

- Develop and apply a method to establish the composition of project teams.
- Help the team to set its overall goal and specific objectives and develop an appropriate project plan.
- Manage the change that the PBCLA represents for first-year students.
- Help team members to clarify their roles, responsibilities, quality standards for their jobs, team norms and operational procedures.
- Manage the project and the formal team meetings.
- Facilitate the development of the team through the phases of formation, solidification and optimum team performance.
- Help the team to manage conflict.
- Develop communication and decision-making skills in team members.

- Facilitate the integration of new students into the team.
- Evaluate regularly and provide a final grade on the development of team skills and the quality of the job done by first-year students.

The responsibilities of the knowledge managers are:

- Establish a liaison with first-year instructors to clearly identify their needs and requirements on the project and to assure that the project scope is aligned with them.
- Identify first-year students' knowledge gaps.
- Devise learning activities to help first-year students to achieve by themselves the instructional objectives selected by the instructors.
- Assure that first-year students achieve the instructional objectives.
- Assist the team to connect with project stakeholders (other project teams, instructors, professionals from industry, School's authorities, etc.) to obtain the materials and knowledge necessary to solve the project, to cooperate, to arrange for training, to obtain resources, etc.
- Evaluate regularly and provide a final grade on the knowledge acquisition by first-year students.

Additionally, both roles share the following responsibilities:

- Help the team in the application of the evaluation procedure developed by first and fourth-year students and approved by the instructors participating in the project.
- Work with the professors of the PM and PMP courses to assure that the development process of the team is aligned to the School's objectives and values.

It should be noted that the roles of team leader and knowledge manager were both assumed by only one fourth-year student during the first years of application of the PBCLA [7]. The separation of roles resulted when an assessment of the approach revealed that the workload of fourth-year students was excessive. Currently, each fourth-year student alternatively assumes these roles during each semester.

The mission of the PM course is to provide the knowledge, methods, and tools on facilitative leadership and project management to fourth-year students so that they can perform effectively their coaching roles. Table I summarizes the syllabus of the PM course, which is imparted two hours per week during the whole academic year.

TABLE I
SYLLABUS OF THE PROJECT MANAGEMENT COURSE

- The project-based and cooperative learning approaches.
- The coach role.
- Change management.
- Project management.
- The Team Charter.
- Meeting management.
- Fostering participation.
- Effective decision-making.
- How to provide and receive effective feedback.
- Conflict management.
- Facilitation tools.

FOURTH-YEAR STUDENTS IN ACTION

The learning wheel shown in Figure 2 summarizes graphically the actions involved in the PBCLA. First-year students go through the four phases of the wheel - planning, executing, reviewing and acting - as many times as it is necessary to achieve the instructional objectives and project goals stated by first-year instructors and team leaders. Fourth-year students facilitate this cyclical journey while practicing the facilitative leadership skills and project management methods and tools learned during the training activities in team-skills provided by external resources [8], under the partnership with the Dow Chemical Co., and by the PM and PMP courses. Teams go to phase 5 when the project has to be closed out at the end of each semester. The role of fourth-year students is described next for every phase of the learning wheel in Figure 2.

FIGURE 2
THE LEARNING WHEEL AS EMBEDDED IN THE PBCLA.

1. PLANNING

During the planning phase, the team leader and the knowledge manager form and focus the team. This is achieved by following a prescribed set of steps leading to the production of a team charter [9], similar to the one included in Table II. First and fourth-year students work jointly to elaborate each of the sections of the team charter. The contribution of fourth-year students focuses more on the identification of Specific, Measurable, Attainable, Relevant and Time-limited (SMART) objectives (section 6 of the team charter), and on the corresponding learning activities to fulfill those objectives (section 7). Fourth-year students

adopt a directive leadership style (at least during the first semester) in these two items of the charter while a problem solving style is applied in the rest of the charter items.

The formulation of SMART objectives aligned to the project's overall goal requires a combined effort of analysis and synthesis. Figure 3 is part of a tree diagram (section 8 of the team charter) that could represent the scope of the design project for any team. The first level of deployment of the tree is generally formed by between 5-7 objectives. These objectives are selected because they pose real design problems for the sulfuric acid process (analysis) and their resolution requires the achievement of instructional objectives from different courses in a series of integrated activities (synthesis). In the example provided, instructional objectives from calculus, algebra and physics are applied to design a tank to store the raw material sulfur.

TABLE II
CONTENT OF THE TEAM CHARTER

1.	Roster
2.	Rules of the team
3.	Meeting logistics
4.	Team member knowledge and skills profile
5.	Team's overall goal, customers, stakeholders, and products
6.	SMART objectives
7.	Action plan
8.	Tree diagram
9.	Gantt diagram
10.	Stakeholder communication strategies
11.	Team contract

Fourth-year students are fully aware from their own experience that the planning phase has to be capitalized on to manage the big change that the PBCLA represents for most of the first-year students; they have been thrust into a project team which will be led by two fourth-year students acting only as coaches and all this within a student-centered environment where instructors will also serve as coaches, offering guidance and encouragement to teams. This sudden increase in responsibility generally creates stress in both fourth-year and first-year students. Fourth-year students are reminded that the PBCLA involves the following issues:

- Greater independence from instructors and consequently greater student accountability for their learning process.
- Greater initiative from students.
- Taking on unfamiliar tasks and roles and, consequently, higher risks.

Completion of section 5 of the team charter in Table II requires that the teams discuss thoroughly the rationale of the PBCLA. Debating about the needs of instructors, who are the clients of the project, and the needs of industry as a key stakeholder help first-year students to reflect on the very human "what's in it for me" and buy-in to the PBCLA. In general, the development of the whole team charter provides the structure that a new team needs to start working and helps to create a comfortable climate that reduces the anxiety feelings that inevitably arise in students.

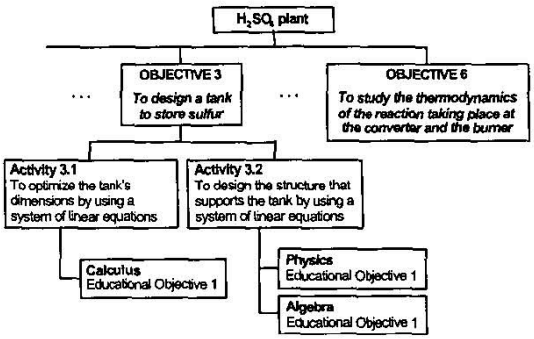

FIGURE 3
TREE DIAGRAM SHOWING PART OF THE SCOPE OF A PROJECT.

The last basic task of the planning phase is that fourth-year students develop the evaluation process that will be applied to themselves and to first-year students in the PBCLA. Regarding fourth-year students, the grade obtained by applying the evaluation process is directly that of the PMP course and is used to determine the grade of the PM course. The evaluation process is the only decision that needs to be approved by all of the instructors participating in the project. Basically, the evaluation process has to be a 360 degree one, including self and peer evaluation.

2. EXECUTING

During the execution phase of the project, the knowledge manager, with the support of the team leader, designs in more or less detail the learning activities identified in section 7 of the team charter. These activities help fourth-year students to set-up clear directions and to clarify what is expected from first-year students. Knowledge managers and team leaders should do the activities before handing them out to first-year students. Thus, they can modulate the amount of work required in each activity by providing more or fewer data depending on the time available.

The knowledge manager and the team leader assign activities to first-year students by taking into account their knowledge and skill profiles (section 4 of the team charter) and the project progress (Gantt diagram). Generally each knowledge manager and team leader pair applies different approaches for assigning the activities. Some assign each activity to a pair of first-year students, one of them regarded as more "capable" than the other. Others assign each activity to a responsible member that must deliver the solved activity when it is due. In this case, the whole team has to define strategies to assure personal accountability of each team member for the work done by a single student. In any event, first-year students must carry out any activity outside the time allocated to formal team meetings, either at home or during the time shared by the different project courses.

3. REVIEWING AND 4. ACTING

The reviewing and acting phases of the learning wheel in Figure 2 take place at the formal team meetings. These are carefully planned and managed by the team leader. The main purpose of these meetings is to assess learning by first-year students and to ensure that all of them achieve all of the instructional objectives in time. This is a key responsibility of the knowledge manager. The presence of passengers in the project teams is not the problem since they are easily spotted. The challenge rather lies in the fact that when first-year students self-organize to carry out the learning activities they may specialize solely in the particular skill or set of skills (making calculations, building graphs, etc.) that they excel at or like them most, which generally coincide.

The approach followed by most knowledge managers to ensure that all first-year students master the instructional objectives is to ask some of them to facilitate learning to the rest of team members while knowledge managers help in the process by asking questions in greater depth. This questioning process enables knowledge managers to easily assess the degree of learning of each team member. Feedback from team leaders and knowledge managers highlights the fact that at the beginning of the project most first-year students panic when asked to present orally any material or to teach others even though they may actually master the topic. The development of both abilities is also a benefit of the PBCLA.

Team leaders and knowledge managers assess whether the objectives of any activity have been accomplished during the reviewing phase. An activity is considered as accomplished when the written resolution is correct, it has been drawn up according to the final report guidelines and all of the first-year students have achieved the instructional objectives involved. Once the activity is completed, the whole team reflects on how they have interacted to carry it out. This reflection is facilitated by both the team leader and the knowledge manager by using questionnaires that address different aspects related to the learning process, such as the design of the learning activity, the role of fourth-year students, the degree of participation of team members, etc.

The team proceeds again to the planning phase after the reviewing and acting phases are completed irrespectively of the evaluation of the activity; the team leader has to check the Gantt diagram to detect and analyze any time deviations from the plan, compute the actual number of hours invested in the learning activity, etc. Depending on the progress made on the project and the evaluation of the activity, the team leader has to decide whether or not to introduce changes into the plan, launch the next project activity/ies or continue working on the current activity if it has not yet been completed. In this case, the team will be spinning around the learning wheel until the activity is finalized. Depending on the complexity of the activity, the team can go around the wheel between 420 times. When all the activities of the project have been accomplished, the team moves to the closing-out of the project.

5. CLOSING OUT

A closing-out phase is systematically managed by one team of fourth-year students at the end of each semester. The purpose of this phase goes beyond merely delivering a final report to first-year instructors. Its purpose is multifold:

1. Communicate the results achieved in the project.
2. Evaluate the performance of team members.
3. Reflect on how the team has accomplished the results: lessons learned and areas of improvement.
4. Provide positive reinforcement to students.

All project teams must deliver a final report and present and defend their results in a public poster session. During the five-hour long poster sessions, first-year students are interviewed individually by first-year instructors to assess the degree to which each student has achieved the instructional objectives. Thus, first-year instructors can grade individual team members and contrast their grades with those granted by team managers. The grade given by first-year instructors accounts for 30% of the project's grade while the remaining 70% is the responsibility of fourth-year students. In the event that the first-year-student grades given by instructors differ by more than 2 points from those given by fourth-year students, a joint meeting is called upon to solve the discrepancy. This poster session compels fourth-year students to put in place mechanisms to assure that the instructional objectives are really achieved by all first-year students and to be honest in their evaluations.

Poster sessions are an excellent opportunity to provide positive reinforcement to students and keep momentum. The experience shows that most first-year students can manage successfully the questioning by instructors and, in some cases, much to the surprise of fourth-year students. When first-year students have to explain (verbalize) what they have done and, more importantly, how it was done, they gain a deeper understanding of the material and lots of positive reinforcement is generated. In addition to this, the final poster session that is held at the end of the second semester is split into two consecutive mornings. The second one is open to everybody from university, industry, and society in general (parents, spouses, friends, etc.). These stakeholders also discuss with students the results of their projects and how they have organized themselves to obtain those results. Finally, fourth-year students deliver symbolic, tangible objects with the ETSEQ logo printed on them to everybody attending the poster session to extend the lifespan of the experience by creating memories.

All project teams have also to report the results accomplished in the project and how these have been achieved during each semester. This closing-out written document reports the performance of team members in the project, evaluates all feedback received from instructors and

stakeholders (including the grades obtained), captures all lessons learned and makes recommendations to the instructors of the PMP course for improvements of the PBCLA. After the action involved in the other four phases of the learning wheel, it is essential to force this reflection in teams. This is particularly important at the end of the first semester since teams can identify and develop ideas of improvement and apply them during the second semester.

In addition to the closing-out report, the team leader and knowledge manager deliver an oral presentation of the report to the instructors of the PMP course. The session, which is open to other fourth-year students and faculty, is an opportunity for the instructors to discuss the self and peer evaluation of fourth-year students, give feedback on technical and process related aspects of the project, assess their oral and communication skills, and provide recognition and positive reinforcement to them. This recognition is essential to call for the extra effort required from fourth-year students for making the PBCLA a success.

CHANGE MANAGEMENT IS KEY

One of the most critical items in the implementation of the PBCLA is the role of first-year instructors. As explained earlier, the instructors of the PM and PMP courses coach fourth-year students and these, in turn, do the same with first-year students. However, the latter rely strongly on their instructors at the beginning of the academic year. First-year students are very sensitive to the words, body language and actions of their instructors. It is thus important that they refrain from conveying any premature evaluation or perception on the PBCLA or its implementation since it may weaken the trustworthiness of first-year students in fourth-year students, making the task of the latter even more challenging.

At the heart of the PBCLA is the concept of the empowerment of students. Students should assume responsibility for their own learning, create their own job profiles and gain the appropriate self-discipline and self-criticism to complete a complex task. In this environment, instructors can no longer assume a command-and-control role. Like fourth-year students, professors should take on a coach role. Figure 4 summarizes the fundamental role changes that instructors must assume in the PBCLA.

The understanding and assumption by instructors of their role change, together with the concomitant training, are essential for the success of the PBCLA. The ETSEQ has organized external non-compulsory training in team skills, cooperative learning and other effective teaching methods since 1996. In addition, the ETSEQ has intensified its partnership with the Dow Chemical Company to obtain expertise in coaching and change management skills, particularly in faculty management education. These are essential to involve faculty in effective teaching and to deploy the PBCLA across the engineering curriculum [6].

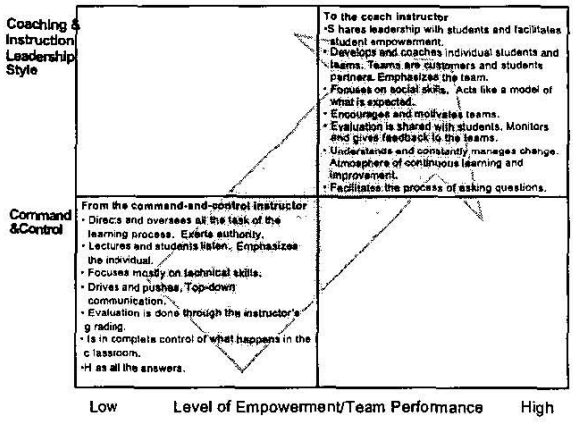

FIGURE 4
CHANGES IN THE ROLE OF INSTRUCTORS IN THE PBCLA

ACKNOWLEDGMENT

To the University Rovira i Virgili for its continuous support to innovate in undergraduate education. To Dow Chemical Co., in particular to Mr. Lluís Vernis, for their sharing of coaching and change management expertise. Finally, to the Cahners TRACOM Group for their permission to use the Enhancing Team Performance materials.

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Appendix B.

Original Survey Forms

B1. Original Survey Forms

In the following the original survey forms are presented. The surveys carry a header for the DNI number, which is the individual identification of the students, so it is assured that the relevant surveyed population participated, but also that confidentiality is assured as the author of this thesis work had no access in any form to that DNI number. The table B1 shows the sequence of the surveys and the respective target population.

Survey No.	Description
1	Baseline assessment for team members
2	Team members after receiving the intervention
3	Team members three months after the intervention
4	Team members six & nine months after the intervention
5a	Team Leader & Knowledge Manager baseline assessment
5b	Team Leader & Knowledge Manager 3 months after the intervention
5c	Team Leader 6 & 9 months after the intervention
5d	Knowledge Manager 6 & 9 months after the intervention

Table B1. Survey sequence

B.1.1. Survey 1: Baseline Assessment for Team Members

1. How much experience do you have with “working in a team”?
   (definition of working in a team: “A team that, within a given set of boundaries, is authorized, capable and willing to manage its own activities with interdependence to produce an agreed upon set of target outcomes”).

none	almost none	a little bit	some	a lot

If some or a lot, from where:_____

_____

_____

2. A) Provided, you had experience with working in teams, in which areas did you find the greatest difficulties

Please rank the 3 most important ! (1=most important)

Purpose & Objectives of Team (the reason why the team exists)	
Capabilities of Team (the ability to build on the differences in skills, knowledge, experiences & individual differences)	
Dealing with Change (the ability to handle changes and respond to them)	
Team Rules & Norms (the adherence of the individual to the defined group behaviors)	
Communication (the ability to communicate and interact effectively amongst each other)	
Handling Conflict / Conflict Resolution (the ability to solve conflicts constructively)	
Recognition & Reward (the way in which achievements are recognized and celebrated)	
Team Operating Procedures (the extent to which a team is using methods and tools to improve its performance)	
Integrating New Team Members (the ability to handle changes in team membership	
Evaluation of Team Performance (the extent to which the team is assessing its own overall performance)	
Evaluation of Team Members Performance (the extent to which each member is assessing its own performance and that of others)	

2 B) In case you have not worked in teams, where would you anticipate the greatest difficulties?

Please rank the 3 most important! (1=most important)

Purpose & Objectives of Team (the reason why the team exists)	
Capabilities of Team (the ability to build on the differences in skills, knowledge, experiences & individual differences)	
Dealing with Change (the ability to handle changes and respond to them)	
Team Rules & Norms (the adherence of the individual to the defined group behaviors)	
Communication (the ability to communicate and interact effectively amongst each other)	
Handling Conflict / Conflict Resolution (the ability to solve conflicts constructively)	
Recognition & Reward (the way in which achievements are recognized and celebrated)	
Team Operating Procedures (the extent to which a team is using methods and tools to improve its performance)	

Integrating New Team Members (the ability to handle changes in team membership	
Evaluation of Team Performance (the extent to which the team is assessing its own overall performance)	
Evaluation of Team Members Performance (the extent to which each member is assessing its own performance and that of others)	

3. Assuming that you want to improve your skills for working in a team, which training/learning method would you prefer?

Please mark your preferred method

Lecturing	
Interactive Workshop	
Case Studies	
Special Task Assignment with Coach Support	
Experiential Learning within your Team	
Self-study through reading, etc.	

4. Demographics

When you entered this university, was Chemical Engineering your first option / choice?

Yes	No

Male	Female

17- 20	21-25	26-30	over 31

5. Please list a maximum of three hobbies (activities) that you practice:

_____

_____

_____

6. Please list three non-professional activities that you don't like or hate:

_____

_____

_____

DNI: _____

7. Please indicate the background of your education.

_____
_____
_____

8. Please indicate any previous working experience.

_____
_____
_____

B.1.2. Survey 2: Team Members after Receiving the Intervention

1. Do you perceive this teamwork intervention helpful?

not at all	a little bit	somewhat	rather	very much

2. Which module did you find most valuable?

Rank the 3 most important! (1=most important)

Common Purpose	
Team Capabilities	
Change	
Team Norms	
Communication / Conflict	
Recognition / Reward	
Team Operating Procedures	
New Member Integration	
Evaluation	

Please explain why: _____
_____
_____

3. How would you rate the effectiveness of the delivery?

bad	low	acceptable	High	very high

4. Comments / Suggestions about the delivery_____
_____
_____

DNI: _____

5. List at most five activities of any kind that you carried out prior to university without a conscious or explicit plan for expected tangible results (no clear purpose):

6. List at most five activities of any kind that you carried out prior to university with a conscious or explicit plan for expected tangible results (clear purpose):

7. List at most three activities of any kind that you participated in their conception, design, planning and implementation prior to university:

8. In the activities listed in items 6 and 7 above did you (alone or with others) evaluate the results attained?

not at all	a little bit	somewhat	rather	very much

9. Do you usually assume responsibility for your own good or bad results prior to university?

fully assume	mostly assume	partly assume	some blame to others	blame others

10. Did you like to interact with others or alone prior to university?

always with others	mostly with others	sometimes with others	more on my own	always alone

11. Are you presently economically independent from your parents?

not at all	a little bit	partly	very much	completely

12. Demographics (gender and age)

Male	Female	17-20	21-25	26-30	Over 31

B.1.3. Survey 3: Team Members Three Months after the Intervention

1. Which module out of the enhancing team performance training has helped you most in your work so far?

Rank the 3 most important! (1=most important)

Common Purpose	
Team Capabilities	
Change	
Team Norms	
Communication / Conflict	
Recognition / Reward	
Team Operating Procedures	
New Member Integration	
Evaluation	

Please explain your ranking: _____

2. Could you give two specific examples on how the most important ranked item from above has helped you so far in the project?

3. In which area do you feel a need to get additional help?

Please explain why.

Please indicate potential solutions.

4. What issues do you think are still not covered?

_____
_____
_____
_____

5. List two activities that you carried out alone (not related to team activities) at the ETSEQ during the past 3 months with a conscious or explicit plan for expected tangible results (clear purpose):

6. In the two activities that you listed above in item 5, have you qualitatively or quantitatively evaluated the results attained?

not at all	a little bit	somewhat	rather	very much

7. List a maximum of five activities that you carried out at the ETSEQ as a team member during the past 3 months with a conscious or explicit plan for expected tangible results (clear purpose):

8. In the activities that you listed above in item 7, has your team qualitatively or quantitatively evaluated the results attained?

Not at all	a little bit	somewhat	rather	very much

9. After 3 months at the ETSEQ, do you consider that your attitude with respect to assuming responsibility for the results obtained by yourself has changed with respect to prior to university?

not at all	a little bit	somewhat	rather	very much

10. Do you now establish and follow a plan to overcome any of the difficulties concerning learning or team work organization that you (or your team) have identified?

not at all	a little bit	somewhat	rather	very much

11. How many hours per week do you meet with the team leader regarding your project (first and fourth – year students' project)?

1 h	2 h	3 h	4 h	5 h or more

If your answer is 5 hours or more, then please specify.

_____

_____

_____

12. How many hours per week do you meet with the knowledge leader? regarding your project (first and fourth – year students' project)?

1 h	2 h	3 h	4 h	5 h or more

13. How many hours per week do you meet with only your peers regarding your project (first and fourth – year students' project)?

1 h	2 h	3 h	4 h	5 h or more

14. What percentage of the total time allocated to team meetings is dedicate to discuss with your peers on the average ?

0 %	25 %	50%	75 %	100 %

15. What percentage of the total time allocated to team meetings is dedicated to discuss scientific or technical matters on the average?

0 %	25 %	50%	75 %	100 %

16. What percentage of the total time allocated to team meetings is dedicated to discuss organizational matters on the average?

0 %	25 %	50%	75 %	100 %

17. How would you characterize your attitude during team meetings, as mostly listening or mostly talking?

mostly listen				mostly talking

18. How much have you contributed so far to establish the purpose (objectives) of your team?

not at all	a little bit	somewhat	rather	very much

19. How much do you contribute to the planning of the project by your team?

not at all	a little bit	somewhat	rather	very much

20. How often does your team evaluate its own activities to identify the causes for success or failure (strive for improvement)?

never		once a month		weekly

21. Please list the most relevant activities carried out in team meetings with the team leader and the time (%) dedicated to each of them?

	%
	%
	%
	%
	%
	%
	%
	%

Comments: _____

22. Please list the most relevant activities carried out in team meetings with the knowledge manager and the time (%) assigned to each one?

	%
	%
	%
	%
	%
	%
	%
	%

Comments: _____

23. How responsible are you for the work assigned to you by the team (concerning first and fourth year students' project) ?

not at all	a little bit	somewhat	rather	very much

24. How many times have you failed to attend team meetings during the past 3 months (concerning first and fourth year students' project) ?

never	once	twice	3 to 5 times	6 or more

25. How many times have you failed with team project deadlines in the work assigned to you during the past 3 months (concerning first and fourth year students' project)?

never	once	twice	3 to 5 times	6 or more

26. How many times have your peers helped you understand a technical issue or scientific question through face-to-face discussions so far (concerning first and fourth year students' project)?

never	once	twice	3 to 5 times	6 or more

27. How many times have you helped your peers understand a technical issue or scientific question through face-to-face discussions so far (concerning first and fourth year students' project)?

never	once	twice	3 to 5 times	6 or more

28. Have you learned something from your peers through the reasoning, methods and skills that they applied to deal with the project (concerning first and fourth year students' project)?

no	a little bit	somewhat	rather	very much

29. How much have you learned from the discussions and interaction with the knowledge manager of your team (concerning first and fourth year students' project)?

Nothing		somewhat		a lot

30. How many times have you consulted the team members and knowledge leader of other teams during the past 3 months (concerning first and fourth year students' project)?

Never	once	twice	3 to 5 times	6 or more

31. How many times have you shifted roles with your peers during the past 3 months (concerning first and fourth year students' project)?

Never	once	twice	3 to 5 times	6 or more

32. How many times have you qualitatively or quantitatively evaluated your own work (self-evaluation) during the past 3 months (concerning first and fourth year students' project)?

Never	once	twice	3 to 5 times	6 or more

33. How many times have you qualitatively or quantitatively evaluated the work of the other team members during the past 3 months (concerning first and fourth year students' project)?

Never	once	twice	3 to 5 times	6 or more

34. How many times have you qualitatively or quantitatively evaluated the team leader during the past 3 months (concerning first and fourth year students' project)?

Never	once	twice	3 to 5 times	6 or more

35. How many times have you qualitatively or quantitatively evaluated the knowledge manager during the past 3 months (concerning first and fourth year students' project)?

Never	once	twice	3 to 5 times	6 or more

36. How many times has the team evaluated the deviations of the work done (attained objectives) with respect to the planned one (concerning first and fourth year students' project)?

Never	once	twice	3 to 5 times	6 or more

37. How many times have you been requested to learn the work done by a peer and checked on it (concerning first and fourth year students' project)?

Never	once	twice	3 to 5 times	6 or more

38. Do you perceive the team work in the project as an "all float or all sink"-situation (concerning first and fourth year students' project)?

"all sink"				"all float"

39. Comments / Suggestions _____

40. Demographics (gender and age)

Male	Female	17-20	21-25	26-30	Over 31

B.1.4. Survey 4: Team Members 6 and 9 Months after the Intervention

1. Which module out of the enhancing team performance training has helped you most in your work so far?

Rank the 3 most important! (1=most important)

Common Purpose	
Team Capabilities	
Change	
Team Norms	
Communication / Conflict	
Recognition / Reward	
Team Operating Procedures	
New Member Integration	
Evaluation	

Please explain why: _____

2. Could you give two specific examples on how the most important ranked item from above has helped you so far in the project?

3. In which area do you feel a need to get additional help?

Please explain why.

Please indicate potential solutions.

4. What issues do you think are still not covered?

5. List two activities that you carried out alone (not related to team activities) at the ETSEQ during the past 3 months with a conscious or explicit plan for expected tangible results (clear purpose):

6. In the two activities that you listed above in item 5 have you qualitatively or quantitatively evaluated the results attained?

not at all	a little bit	somewhat	rather	very much

7. List a maximum of 5 activities that you carried out at the ETSEQ as a team member during the past 3 months with a conscious or explicit plan for expected tangible results (clear purpose):

8. In the activities that you listed above in item 7, has your team qualitatively or quantitatively evaluated the results obtained?

not at all	a little bit	somewhat	rather	very much

9. After 3 or 9 months at the ETSEQ do you consider that your attitude with respect to assuming responsibility for the results obtained by yourself has changed with respect to prior to University?

not at all	a little bit	somewhat	rather	very much

10. Do you now establish and follow a plan to overcome any of the difficulties concerning learning or team work organization that you (or your team) have identified?

not at all	a little bit	somewhat	rather	very much

11. How many hours per week do you now meet with the team leader?

1 h	2 h	3 h	4 h	5 h or more

12. How many hours per week do you now meet with the knowledge manager?

1 h	2 h	3 h	4 h	5 h or more

13. How many hours per week do you now meet with only your peers?

1 h	2 h	3 h	4 h	5 h or more

14. What percentage of the total time allocated to team meetings is dedicate to discuss with your peers on the average?

0 %	25 %	50 %	75 %	100 %

15. What percentage of the total time allocated to team meetings is dedicated to discuss scientific or technical matters on the average?

0 %	25 %	50 %	75 %	100 %

16. What percentage of the total time allocated to team meetings is dedicated to discuss organizational matters on the average?

0 %	25 %	50 %	75 %	100 %

17. How would you characterize your attitude during team meetings, as mostly listening or mostly talking?

mostly listening				mostly talking

18. How much have you contributed so far to establish the purpose (objectives) of your team?

not at all	a little bit	somewhat	rather	very much

19. How much is now your contribution to the planning and realization of the project by your team?

not at all	a little bit	somewhat	rather	very much

20. How often does your team now evaluate its own activities to identify the causes for success or failure (strive for improvement)?

never		once a month		weekly

21. Please list the most relevant activities carried out in team meetings with the team leader during the past three months and the time (%) dedicated to each of them?

	%
	%
	%
	%
	%
	%
	%
	%

Comments: _____

22. Please list the most relevant activities carried out in team meetings with the knowledge manager during the past three months and the time (%) assigned to each of them?

	%
	%
	%
	%

Comments: _____

_____

_____

23. How responsible are you now for the work assigned to you by the team so far (concerning the first and fourth year students' project)?

not at all	a little bit	somewhat	rather	very much

24. How many times have you failed to attend team meetings during the past 3 months (concerning the first and fourth year students' project)?

never	once	twice	3 to 5 times	6 or more

25. How many times have you failed with team project deadlines in the work assigned to you during the past 3 months (concerning the first and fourth year students' project)?

never	once	twice	3 to 5 times	6 or more

26. How many times have your peers helped you understand a technical issue or scientific question through face-to-face discussions during the past 3 months (concerning the first and fourth year students' project)?

never	once	twice	3 to 5 times	6 or more

27. How many times have you helped your peers understand a technical issue or scientific question through face-to-face discussions during the past 3 months (concerning the first and fourth year students' project)?

never	once	twice	3 to 5 times	6 or more

28. How much have you learned from your peers through the reasoning, methods and skills that they applied to deal with the project so far (concerning the first and fourth year students' project)?

nothing	a little bit	somewhat	quite a lot	a lot

29. How much have you learned from the discussions and interaction with the knowledge manager of your team so far (concerning the first and fourth year students' project)?

nothing	a little bit	somewhat	quite a lot	a lot

30. How many times have you consulted the team members and knowledge manager of other teams during the past 3 months (concerning the first and fourth year students' project)?

never	once	twice	3 to 5 times	6 or more

31. How many times have you shifted roles with your peers during the past 3 months (concerning the first and fourth year students' project)?

Never	once	twice	3 to 5 times	6 or more

32. How many times have you qualitatively or quantitatively evaluated your own work (self-evaluation) during the past 3 months (concerning the first and fourth year students' project)?

never	once	twice	3 to 5 times	6 or more

33. How many times have you qualitatively or quantitatively evaluated the work of the other team members during the past 3 months (concerning the first and fourth year students' project)?

never	once	twice	3 to 5 times	6 or more

34. How many times have you qualitatively or quantitatively evaluated the team leader during the past 3 months (concerning the first and fourth year students' project)?

never	once	twice	3 to 5 times	6 or more

35. How many times have you qualitatively or quantitatively evaluated the knowledge manager during the past 3 months (concerning the first and fourth year students' project)?

never	once	twice	3 to 5 times	6 or more

36. How many times has the team evaluated the deviations of the work done (attained objectives) with the respect to the planned one during the past 3 months (concerning the first and fourth year students' project)?

never	once	twice	3 to 5 times	6 or more

37. How many times have you been asked to learn the work done by a peer and checked about it during the past 3 months (concerning the first and fourth year students' project)?

never	once	twice	3 to 5 times	6 or more

38. Do you perceive the team work in the project as an "all sink or all float"-situation?

"all sink"'				"all float"

39. Comments / Suggestions_____

_____

_____

_____

_____

_____

40. Demographics (gender and age)

Male	Female	17-20	21-25	26-30	Over 31

41. Demographics (choice of school) : When you entered this University, was Chemical Engineering your first choice?

Yes	No

If no, what was your first choice? _____

DNI: _____

B.1.5. Survey 5a : Team Leader and Knowledge Manager Baseline Assessment

1. How much experience do you have with "working in a team"?
   (definition of working in a team: „A team that, within a given set of boundaries, is authorized, capable and willing to manage its own activities with interdependence to produce an agreed upon set of target outcomes").

none	almost none	a little bit	some	a lot

If some or a lot, from where:_____

_____

_____

_____

_____

2. In which areas did you experience or do you anticipate the greatest difficulties when working in teams?

Please rank the 3 most important! (1=most important)

Purpose & Objectives of Team (the reason why the team exists)	
Capabilities of Team (the ability to build on the differences in skills, knowledge, experiences & individual differences)	
Dealing with Change (the ability to handle changes and respond to them)	
Team Rules & Norms (the adherence of the individual to the defined group behaviors)	
Communication (the ability to communicate and interact effectively amongst each other)	
Handling Conflict / Conflict Resolution (the ability to solve conflicts constructively)	
Recognition & Reward (the way in which achievements are recognized and celebrated)	
Team Operating Procedures (the extent to which a team is using methods and tools to improve its performance)	
Integrating New Team Members (the ability to handle changes in team membership	
Evaluation of Team Performance (the extent to which the team is assessing its own overall performance)	
Evaluation of Team Members Performance (the extent to which each member is assessing its own performance and that of others)	

3. Assuming that you want to improve your skills for working in and leading a team, which training/learning method would you prefer?

Please mark your preferred method

Lecturing	
Interactive Workshop	
Case Studies	
Special Task Assignment with Coach Support	
Experiential Learning within your Team	
Self-study through reading, etc.	

4. How do you classify yourself with respect to the following characteristics?

analytic :

not at all		somewhat		Extremely

creative :

not at all		somewhat		Extremely

controlling :

not at all		somewhat		Extremely

visionary :

not at all		Somewhat		extremely

leading by examples :

not at all		Somewhat		extremely

opportunistic :

not at all		Somewhat		extremely

hierarchy driven :

not at all		Somewhat		extremely

informal :

not at all		Somewhat		extremely

independent :

not at all		Somewhat		extremely

risk taking :

not at all		Somewhat		extremely

5. How would you like your role to be?

commanding :

not at all		Somewhat		extremely

uniform :

not at all		Somewhat		extremely

inspirational :

not at all		Somewhat		extremely

methodical :

not at all		Somewhat		extremely

people oriented :

not at all		Somewhat		extremely

performance driven :

not at all		Somewhat		extremely

rewards driven :

not at all		Somewhat		extremely

6. Please list three hobbies:

_____
_____
_____

7. Please list the three things of any kind that you dislike the most:

_____
_____
_____

DNI: _____

8. Demographics

Team Leader ☐ Knowledge manager ☐

Male	Female

17- 20	21-25	26-30	over 31

B.1.6. Survey 5b: Team Leader and Knowledge Manager 3 Months after the Intervention

1. Which module out of the enhancing team performance training has helped you most in your work so far?

Rank the 3 most important! (1=most important)

Common Purpose	
Team Capabilities	
Change	
Team Norms	
Communication / Conflict	
Recognition / Reward	
Team Operating Procedures	
New Member Integration	
Evaluation	

Please explain why.

_____

_____

_____

2. Can you give a specific example on how the most important ranked item from above has helped you?

_____

_____

_____

3. In your role as team leader or knowledge manager where did you experience the greatest difficulties when working with your team?

Please rank the 3 most important ! (1=most important)

Purpose & Objectives of Team	
Capabilities of Team	
Dealing with Change	
Team Rules & Norms	
Communication	
Handling Conflict / Conflict Resolution	

Recognition & Reward	
Team Operating Procedures	
Integrating New Team Members	
Evaluation of Team Performance	

Please explain why.

_____
_____
_____
_____

4. In which area do you feel a need to get additional help? What issues do you think are still not covered?

Please explain.

_____
_____
_____

Please indicate potential solutions.

_____
_____
_____

5. How would you describe your role with the team ?

commanding :

not at all		somewhat		extremely

uniform :

not at all		somewhat		extremely

inspirational :

not at all		somewhat		extremely

methodical :

not at all		somewhat		extremely

people oriented :

not at all		somewhat		extremely

performance driven :

not at all		somewhat		extremely

rewards driven :

not at all		somewhat		extremely

6. How would you characterize your attitude during team meetings, as mostly listening or mostly talking?

mostly listen				mostly talking

7. How much have you contributed so far to establish objectives in your team?

not at all	a little bit	somewhat	rather	very much

8. How much have you contributed so far to the planning of your team?

not at all	a little bit	somewhat	rather	very much

9. How often does your team evaluate its own activities to identify the causes for success or failure (strive for improvement)?

never		once a month		weekly

10. Please list the most relevant activities carried out in team meetings by you during the past three months and the time (%) dedicated to each of them?

	%
	%
	%
	%
	%
	%
	%
	%

Comments: _____

DNI: _____

11. Demographics

Team leader ☐ Knowledge manager ☐

Male	Female

17- 20	21-25	26-30	over 31

B.1.7. Survey 5c: Team Leader 6 and 9 Months after the Intervention

Which module out of the enhancing team performance training has helped you most in your work so far?

Rank the 3 most important! (1=most important)

Common Purpose	
Team Capabilities	
Change	
Team Norms	
Communication / Conflict	
Recognition / Reward	
Team Operating Procedures	
New Member Integration	
Evaluation	

And please explain why.

Can you give a specific example on how the most important ranked item from above has helped you?

In your role as team leader, in which area did you experience the greatest difficulties when working with your team?

Please rank the 3 most important! (1=most important)

Purpose & Objectives of Team	
Capabilities of Team	
Dealing with Change	
Team Rules & Norms	
Communication	
Handling Conflict / Conflict Resolution	
Recognition & Reward	
Team Operating Procedures	
Integrating New Team Members	
Evaluation of Team Performance	

And please explain why.

Could you have solved your project work without the Enhancing Team Performance Intervention?

not at all	a little bit	somewhat	rather	very much

How much has this intervention helped you in your role as team leader to solve your project task?

Not at all	a little bit	somewhat	rather	very much

How much has this intervention increased your productivity / effectiveness in your role as team leader?

0 %	25 %	50 %	75 %	100 %

In which area do you feel a need to get additional help? What issues do you think are still not covered?

Please explain.

Please indicate potential solutions.

_____

_____

_____

Assuming that you want to improve your skills for working in and leading a team, which training/learning method would you prefer?

Please mark your preferred method

Lecturing	
Interactive Workshop	
Case Studies	
Special Task Assignment with Coach Support	
Experiential Learning within your Team	
Self-study through reading, etc.	

9. How would you describe your role with the team?

commanding :

not at all		somewhat		extremely

uniform :

not at all		somewhat		extremely

inspirational :

not at all		somewhat		extremely

methodical :

not at all		somewhat		extremely

people oriented :

not at all		somewhat		extremely

performance driven :

not at all		somewhat		extremely

rewards driven :

not at all		somewhat		extremely

DNI: _____

10. How would you characterize your attitude during team meetings now, as mostly listening or mostly talking?

mostly listen				mostly talking

11. How much have you contributed so far to establish objectives in your team?

not at all	a little bit	somewhat	rather	very much

12. How much have you contributed to the planning of your team now?

not at all	a little bit	somewhat	rather	very much

13. How often does your team evaluate its own activities now to identify the causes for success or failure (strive for improvement)?

never		once a month		weekly

14. Please list the most relevant activities carried out in team meetings by you during the past three months and the time (%) dedicated to each of them?

	%
	%
	%
	%
	%
	%
	%
	%

Comments: _____

15. Please list the names of your clients:

16. Please list the names of your sponsors:

17. Do you know the requirements of your clients?

not at all	a little bit	somewhat	rather	very much

18. How many times have you used the Memory Jogger: The Team pocket guide?

never	sometimes	often	very often	Always

19. How many times have you used the Memory Jogger: The Project management pocket guide?

never	sometimes	often	very often	Always

20. Did a Change in your leadership style occur since the beginning of the project ? (A change from “Leader directed” to “Shared Leadership”)

Yes: (Please explain)

No: (Please explain)

21. When did the Change in your leadership style from “Leader directed” to “Shared Leadership” occur since the beginning of the project?

not yet	1 month	2 months	3 months	4 months	6 months	8 months

22. Can you recall “Surprises”, when working with your team?

Positive: _____

_____

_____

Negative: _____

_____

_____

23. Demographics

Male	Female

17- 20	21-25	26-30	over 31

B.1.8. Survey 5d: Knowledge Manager, 6 and 9 Months after the Intervention

1. Which module out of the enhancing team performance training has helped you most in your work so far?

Rank the 3 most important! (1=most important)

Common Purpose	
Team Capabilities	
Change	
Team Norms	
Communication / Conflict	
Recognition / Reward	
Team Operating Procedures	
New Member Integration	
Evaluation	

And please explain why.

_____

_____

_____

_____

_____

_____

_____

_____

2. Can you give a specific example on how the most important ranked item from above has helped you?

3. In your role as knowledge manager, in which area did you experience the greatest difficulties when working with your team?

Please rank the 3 most important! (1=most important)

Purpose & Objectives of Team	
Capabilities of Team	
Dealing with Change	
Team Rules & Norms	
Communication	
Handling Conflict / Conflict Resolution	
Recognition & Reward	
Team Operating Procedures	
Integrating New Team Members	
Evaluation of Team Performance	

And please explain why.

4. Could you have solved your project work without the Enhancing Team Performance Intervention?

not at all	a little bit	somewhat	rather	very much

5. How much has this intervention helped you in your role as knowledge manager to solve your tasks?

not at all	a little bit	somewhat	rather	very much

6. How much has this intervention increased your productivty / effectiveness in your role as knowledge manager?

0 %	25 %	50 %	75 %	100 %

7. In which area do you feel a need to get additional help? What issues do you think are still not covered?

Please explain.

_____

_____

_____

Please indicate potential solutions.

_____

_____

_____

8. Assuming that you want to improve your skills for working in a team, which training/learning method would you prefer?

Please mark your preferred method

Lecturing	
Interactive Workshop	
Case Studies	
Special Task Assignment with Coach Support	
Experiential Learning within your Team	
Self-study through reading, etc.	

9. What would you describe your role with the team?

commanding :

not at all		somewhat		extremely

uniform :

not at all		somewhat		extremely

inspirational :

not at all		somewhat		extremely

methodical :

not at all		somewhat		extremely

people oriented :

not at all		somewhat		extremely

performance driven :

not at all		somewhat		extremely

rewards driven :

not at all		somewhat		extremely

10. How would you characterize your attitude during team meetings now, as mostly listening or mostly talking?

mostly listen		somewhat		mostly talking

11. How much have you contributed so far to establish objectives in your team?

not at all	a little bit	somewhat	rather	very much

12. How much have you contributed to the planning of your team?

not at all	a little bit	somewhat	rather	very much

13. How often does your team evaluate its own activities now to identify the causes for success or failure (strive for improvement)?

Never		once a month		weekly

14. In case there are deviations between your evaluation of a team member's performance and his/her self-evaluation, what do you do? (provided you do evaluations)

15. Does your team discuss openly the results of all evaluations of team members, including tests, exams, laboratory reports, etc.?

Never	seldom	sometimes	often	always

DNI: _____

16. Please list the most relevant activities carried out in team meetings by you during the past three months and the time (%) dedicated to each of them?

	%
	%
	%
	%
	%
	%
	%
	%

Comments: _____

17. Please list the names of your clients:

18. Please list the names of your sponsors:

19. Do you know the requirements of your clients?

not at all	a little bit	somewhat	rather	very much

20. How many times have you used the Memory Jogger: The Team pocket guide?

Never	sometimes	often	very often	always

DNI: _____

21. How many times have you used the Memory Jogger: The Project management pocket guide?

Never	sometimes	often	very often	always

22. Did a Change in your leadership style occur since the beginning of the project? (A change from “Leader directed” to “Shared Leadership”)

Yes: (Please explain)

No: (Please explain)

23. When did the Change in your team style from “Leader directed” to “Shared Leadership” occur since the beginning of the project?

not yet	1 month	2 months	3 months	4 months	6 months	8 months

24. Can you recall “Surprises”, when working with your team?

Positive:

Negative:

25. When revisiting the first year subjects, have you realized that there were things you did not learn? Could you list some of them?

26. By defining a plan for the first year students to learn, did you yourself learn things from the first year subjects? Could you list some of them?

DNI: _____

27. Could you briefly list (describe) the methods that you use to manage the knowledge and the learning within your team?

28. Are you now able to identify where first year students have more difficulties in learning?

No	a little bit	somewhat	rather well	very much

29. Could you comment on these difficulties and make suggestions?

30. Demographics

Male	Female

17- 20	21-25	26-30	over 31

Appendix C.

Improved Survey Forms

C.1 Introduction to Improved Survey Forms

Here a short recommendation list for future work is presented. The subsequent improvement opportunities can be summarized in 4 bullet categories:

1. Number of questions
2. Consistency of questions
3. Type of questions
4. Evaluation form of questions

Numerous feedback from the students and the evaluation personnel has amounted to questions being too many. Particularly the 40 question survey forms of 6 and 9 months into the research are considered overwhelming. For that reason, it is recommended to reduce the number of questions in future surveys. In the improved survey forms, a number of approximately 30 questions maximum is proposed.

Furthermore the survey process can be enhanced by introducing more consistent and streamlined questions: such as questions aiming at the same objective should not be phrased differently (e.g. question number 3 in the 3 month survey and question number 4 in the 9 month survey). It is also helpful to have equivalent questions targeting the same objective to have consistent numbering of questions. The above principle applies to question 4 in the 3 month survey and question 5 in the 9 month survey. Another example is question number 9 in the 3 month survey and question number 11 in the 9 month survey. Enhanced transparency and consistency will help improving survey feedback, and simplify evaluation work.

Concerning the type of questions, multiple choice is always the preferred way of asking the participants. The number of responses as well as the students' feedback clearly indicates that open ended questions should be avoided, if at all included. Very few participants use the feedback mechanism of open ended questions and the comments section. Therefore, the improved survey form has no open ended questions, other than the possibility to provide comments at the end of the survey.

When it comes to the fashion of evaluating the questions, there are primarily two options to provide pictorial representation of the survey results. First option is the display using a pie chart; the other option is using a bar chart. When confronted with these two options, the bar chart version presents a better way of conveying results, particularly when comparing the two academic years against one another, as selected in chapter 3.

C.1.1. Improved Survey Forms. Team Members 3 Months after the Intervention

1. Which module out of the enhancing team performance training has helped you most in your work so far?
    a. Common purpose
    b. Team capabilities
    c. Change

d. Team norms
e. Communication/conflict
f. Recognition/Reward
g. Operating procedures
h. New member integration
i. Evaluation

2. In which area do you feel a need to get additional help?
    a. Common purpose
    b. Team capabilities
    c. Change
    d. Team norms
    e. Communication/conflict
    f. Recognition/Reward
    g. Operating procedures
    h. New member integration
    i. Evaluation

3. Please list one activity which you carried out at the ETSEQ as a team member during the past 3 months with a conscious or explicit plan for expected tangible results (clear purpose)?

    _____

4. In the activity listed above in item 3, how often has your team qualitatively or quantitatively evaluated the results?
    a. not at all
    b. very little
    c. occasionally
    d. frequently
    e. always

5. How much has your attitude with respect to assuming responsibility for the results obtained by you or your team changed so far?
    a. not at all
    b. very little
    c. a lot
    d. completely

6. Do you now establish and follow a plan to overcome any of the difficulties concerning learning or teamwork organization that you (or your team) have identified?
    a. never
    b. sometimes
    c. always

7. How many hours per week do you meet with the team leader regarding your project?
    a. 1 hour
    b. 2 hours
    c. 3 hours

d. 4 hours
e. 5 or more hours

8. How many hours per week do you meet with your knowledge leader?
    a. 1 hour
    b. 2 hours
    c. 3 hours
    d. 4 hours
    e. 5 or more hours

9. How many hours per week do you meet with only your peers?
    a. 1 hour
    b. 2 hours
    c. 3 hours
    d. 4 hours
    e. 5 or more hours

10. What percentage of the total time allocated to team meetings is dedicated to discussions among your peers?
    a. 100%
    b. 75%
    c. 50%
    d. 25%
    e. less than 25%

11. What percentage of the total time allocated to team meetings is dedicated to discuss scientific or technical matters?
    a. 100%
    b. 75%
    c. 50%
    d. 25%
    e. less than 25%

12. What percentage of the total time allocated to team meetings is dedicated to discuss organizational matters?
    a. 100%
    b. 75%
    c. 50%
    d. 25%
    e. less than 25%

13. How would you characterize your attitude during team meetings, as mostly listening or mostly talking?
    a. mostly talking
    b. mostly listening
    c. equally talking and listening
    d. somewhat talking
    e. somewhat listening

14. How much have you contributed so far to establish the purpose (objectives) of your team?

a. none
b. very little
c. some
d. a lot

15. How much do you contribute to the planning of the project by your team?
    a. not at all
    b. very little
    c. some
    d. a lot

16. How often does your team evaluate its own activities to identify the causes for success or failure (strive for improvement)?
    a. never
    b. weekly
    c. biweekly
    d. monthly

17. Which of the activities carried out by the team leader do you feel is most relevant to team meetings?
    a. evaluating work
    b. clarifying project expectations
    c. resolving conflicts
    d. setting the agenda
    e. coaching team members
    f. contributing to the content of the project work

18. Which of the activities carried out by the knowledge manager do you feel is most relevant to team meetings?
    a. evaluating work
    b. clarifying project expectations
    c. resolving conflicts
    d. setting the agenda
    e. coaching team members
    f. contributing to the content of the project work assigning work

19. How accountable are you for the work assigned to you by the team?
    a. very little
    b. some
    c. a lot
    d. completely

20. How many times have you failed to attend team meetings during the past 3 months?
    a. once
    b. twice
    c. 3 to 5 times
    d. more than 6 times
    e. never

21. How many times have you failed with team project deadlines in the work assigned to you during the past 3 months?
    a. once
    b. twice
    c. 3 to 5 times
    d. more than 6 times
    e. never

22. How many times have your peers helped you understand a technical issue or scientific question through face-to-face discussions?
    a. once
    b. twice
    c. 3 to 5 times
    d. more than 6
    e. never

23. How many times have you helped your peers understand a technical issue or scientific question through face-to-face discussions?
    a. once
    b. twice
    c. 3 to 5 times
    d. more than 6
    e. never

24. How much have you learned from your peers through the reasoning, methods, and skills?
    a. nothing
    b. minimal
    c. some
    d. a lot

25. How much have you learned from the discussions and interactions with the knowledge manager?
    a. nothing
    b. minimal
    c. some
    d. a lot

26. How many times have you consulted the team members and the knowledge leader of other teams during the past 3 months?
    a. once
    b. twice
    c. 3 to 5 times
    d. more than 6
    e. never

27. How many times have you shifted roles with your peers during the past 3 months?
    a. once
    b. twice
    c. 3 to 5 times

d. more than 6
e. never

28. How many times have you qualitatively or quantitatively evaluated your own work (self-evaluation)?
    a. once
    b. twice
    c. 3 to 5 times
    d. more than 6
    e. never

29. How many times have you qualitatively or quantitatively evaluated the work of other team members?
    a. once
    b. twice
    c. 3 to 5 times
    d. more than 6
    e. never

30. How many times have you qualitatively or quantitatively evaluated the team leader?
    a. once
    b. twice
    c. 3 to 5 times
    d. more than 6
    e. never

31. How many times have you qualitatively or quantitatively evaluated the knowledge manager?
    a. once
    b. twice
    c. 3 to 5 times
    d. more than 6
    e. never

32. How many times has the team evaluated the deviations of the work completed with respect to the work that was planned?
    a. once
    b. twice
    c. 3 to 5 times
    d. more than 6
    e. never

33. How many times have you been requested to learn work done by a peer and checked on it?
    a. once
    b. twice
    c. 3 to 5 times
    d. more than 6
    e. never

34. Do you perceive the teamwork in the project – as an “all float or all sink” situation?
    a. all float
    b. all sink
    c. neutral

35. Comments/Suggestions:

Demographics (gender & age)

Male	Female	17-20	21-25	26-30	31 or Over

C.1.2. Improved Survey Forms. Team Members 9 Months after the Intervention

1. Which module out of the enhancing team performance training has helped you most in your work so far?
    a. Common purpose
    b. Team capabilities
    c. Change
    d. Team norms
    e. Communication/conflict
    f. Recognition/reward
    g. Operating procedures
    h. New member integration
    i. Evaluation

2. In which area do you feel a need to get additional help?
    a. Common purpose
    b. Team capabilities
    c. Change
    d. Team norms
    e. Communication/conflict
    f. Recognition/reward
    g. Operating procedures
    h. New member integration
    i. Evaluation

3. Please list one activity which you carried out at the ETSEQ as a team member during the past 3 months with a conscious or explicit plan for expected tangible results (clear purpose)?

    _____

4. In the activity listed above in item 3, how often has your team qualitatively or quantitatively evaluated the results?
    a. not at all
    b. very little
    c. occasionally
    d. frequently
    e. always

5. How much has your attitude with respect to assuming responsibility for the results obtained by you or your team changed so far?
    a. not at all
    b. very little
    c. a lot
    d. completely

6. Do you now establish and follow a plan to overcome any of the difficulties concerning learning or teamwork organization that you (or your team) have identified?
    a. never
    b. sometimes
    c. always

7. How many hours per week do you meet with the team leader regarding your project?
    a. 1 hour
    b. 2 hours
    c. 3 hours
    d. 4 hours
    e. 5 or more hours

8. How many hours per week do you meet with your knowledge leader?
    a. 1 hour
    b. 2 hours
    c. 3 hours
    d. 4 hours
    e. 5 or more hours

9. How many hours per week do you meet with only your peers?
    a. 1 hour
    b. 2 hours
    c. 3 hours
    d. 4 hours
    e. 5 or more hours

10. What percentage of the total time allocated to team meetings is dedicated to discussions among your peers?
    a. 100%
    b. 75%
    c. 50%
    d. 25%
    e. less than 25%

11. What percentage of the total time allocated to team meetings is dedicated to discuss scientific or technical matters?
    a. 100%
    b. 75%
    c. 50%
    d. 25%

e. less than 25%

12. What percentage of the total time allocated to team meetings is dedicated to discuss organizational matters?
    a. 100%
    b. 75%
    c. 50%
    d. 25%
    e. less than 25%

13. How would you characterize your attitude during team meetings, as mostly listening or mostly talking?
    a. mostly talking
    b. mostly listening
    c. equally talking and listening
    d. somewhat talking
    e. somewhat listening

14. How much have you contributed so far to establish the purpose (objectives) of your team?
    a. none
    b. very little
    c. some
    d. a lot

15. How much do you contribute to the planning of the project by your team?
    a. not at all
    b. very little
    c. some
    d. a lot

16. How often does your team evaluate its own activities to identify the causes for success or failure (strive for improvement)?
    a. never
    b. weekly
    c. biweekly
    d. monthly

17. Which of the activities carried out by the team leader do you feel is most relevant to team meetings?
    a. evaluating work
    b. clarifying project expectations
    c. resolving conflicts
    d. setting the agenda
    e. coaching team members
    f. contributing to the content of the project work

18. Which of the activities carried out by the knowledge manager do you feel is most relevant to team meetings?
    a. evaluating work

b. clarifying project expectations
c. resolving conflicts
d. setting the agenda
e. coaching team members
f. contributing to the content of the project work

19. How accountable are you for the work assigned to you by the team?
    a. very little
    b. some
    c. a lot
    d. completely

20. How many times have you failed to attend team meetings during the past 3 months?
    a. once
    b. twice
    c. 3 to 5 times
    d. more than 6 times
    e. never

21. How many times have you failed with team project deadlines in the work assigned to you during the past 3 months?
    a. once
    b. twice
    c. 3 to 5 times
    d. more than 6 times
    e. never

22. How many times have your peers helped you understand a technical issue or scientific question through face-to-face discussions?
    a. once
    b. twice
    c. 3 to 5 times
    d. more than 6
    e. never

23. How many times have you helped your peers understand a technical issue or scientific question through face-to-face discussions?
    a. once
    b. twice
    c. 3 to 5 times
    d. more than 6
    e. never

24. How much have you learned from your peers through the reasoning, methods, and skills?
    a. nothing
    b. minimal
    c. some
    d. a lot

25. How much have you learned from the discussions and interactions with the knowledge manager?
    a. nothing
    b. minimal
    c. some
    d. a lot

26. How many times have you consulted the team members and the knowledge leader of other teams during the past 3 months?
    a. once
    b. twice
    c. 3 to 5 times
    d. more than 6
    e. never

27. How many times have you shifted roles with your peers during the past 3 months?
    a. once
    b. twice
    c. 3 to 5 times
    d. more than 6
    e. never

28. How many times have you qualitatively or quantitatively evaluated your own work (self-evaluation)?
    a. once
    b. twice
    c. 3 to 5 times
    d. more than 6
    e. never

29. How many times have you qualitatively or quantitatively evaluated the work of other team members?
    a. once
    b. twice
    c. 3 to 5 times
    d. more than 6
    e. never

30. How many times have you qualitatively or quantitatively evaluated the team leader?
    a. once
    b. twice
    c. 3 to 5 times
    d. more than 6
    e. never

31. How many times have you qualitatively or quantitatively evaluated the knowledge manager?
    a. once
    b. twice

c. 3 to 5 times
d. more than 6
e. never

32. How many times has the team evaluated the deviations of the work completed with respect to the work that was planned?
    a. once
    b. twice
    c. 3 to 5 times
    d. more than 6
    e. never

33. How many times have you been requested to learn work done by a peer and checked on it?
    a. once
    b. twice
    c. 3 to 5 times
    d. more than 6
    e. never

34. Do you perceive the teamwork in the project – as an “all float or all sink” situation?
    a. all float
    b. all sink
    c. neutral

35. How beneficial has the Enhancing Team Performance Intervention been in helping you solve your work project so far?
    a. very beneficial
    b. beneficial
    c. neutral
    d. not beneficial

36. How much has this intervention increased your productivity/effectiveness so far?
    a. not at all
    b. moderately
    c. significantly
    d. extremely

37. What is the weight of the participation of the team members in the decision making process compared to that of the two leaders?
    a. 100%
    b. 75%
    c. 50%
    d. 25%
    e. less than 25%

38. Comments/Suggestions:

39. Demographics (gender & age)

Male	Female	17-20	21-25	26-30	31 or Over

Appendix D.

International Journal of Engineering Education: Reviewer's Comments

INTERNATIONAL JOURNAL OF ENGINEERING EDUCATION

REFEREE'S REVIEW FORM

Reviewer's reference : IJEE Review Witt-4-05C Date: 4-18-05

1.1 TOPIC AREA: Curriculum development, social, business and teamwork skills

1.2 TITLE OF REVIEWED PAPER: A Competency-Based Educational Model in Chemical Engineering Schools

1.3 AUTHOR(S): Hans-Jorg Witt, Joan R. Alabart, Frances Giralt, Joan Herrero, Lluis Vernis, Magda Medir

	score	Out of
2.1 CONTENT (e.g.: Clarity of objective; basis of theory; conclusions drawn; understanding of subject, contribution to engineering education.) **Comments**: The authors have done a nice job in presenting their innovative curriculum development. They have a thorough presentation of the objectives and appear to have a good understanding of the subject matter. The paper is universal in its contribution to engineering education and their work can apply to other engineering disciplines besides chemical engineering.	18	20
2.2 DEGREE OF NOVELTY OR ORIGINALITY (e.g.: presence of new ideas; innovative contribution; bulk of the material has not been published elsewhere.) **Comments**: The authors have integrated the business skills into chemical engineering in a unique way. There have been other papers published on various facets of the subject, but the authors work is a unique integration of those and has industry input and applicability.	9	10
2.3 STRUCTURE OF PAPER (e.g.: general layout; use and number of figures/diagrams, etc.) **Comments**: The paper is well organized. Figures and tables are proper to the discussion, although in some cases too detailed. The main concern is the overall paper length and extensive detail in tables that support the figures.	6	10
2.4 QUALITY OF TEXT (e.g.: Clarity of expression; consistency; readability; number of quotations and references) **Comments**: The paper is quite clear and easy to follow. The authors have a significant reference listing although some references in the area of teamwork, communication skills and project-based learning could be included, see below: Newell, J. A., A. J. Marchese, R. P. Ramachandran, B. Sukumaran, and R. Harvey, "Multi-Disciplinary Design and Communication: a Pedagogical Vision," *International Journal of Engineering Education* 15 (5), 376 (1999). Farrell, S., R. P. Hesketh, J. A. Newell, and M. J. Savelski, C. S. Slater, "A Model	7	10

for Synergistic Interaction between Industry and Universities with a Focus on Undergraduate Education," in *Engineering Education and Research - 2003: A Chronicle of Worldwide Innovations*, (2005).

2.5 REVIEWER'S GENERAL OPINION AND COMMENTS (e.g.: correctness of the text; applicability of the items included; quality of the paper; scope covered.)

Comments: The paper is of high quality and has extensive detail in the background and concepts of the curriculum development.
The authors make a controversial statement in section 1.b. on page 4, "technical and natural selection played a major role in the evolution of the genus homo over the past 2,500,000 years." I would put any anthropology and evolution theory in the appropriate journals and not in this one.
The term "social competencies" might be better stated as "business or management skills." Another term used is "soft skills." The authors may want to consider consolidating some parts of the paper that could be referenced to a web site at their school.

	43	50
TOTAL	83	100

2.6 RECOMMENDATIONS

Accept	
Accept with modifications	X
Reject	

REVIEWER'S FAMILIARITY WITH THE AREA DISCUSSED IN THE PAPER:

FAMILIAR: REASONABLY FAMILIAR: X COMMENT:

Appendix E.

Details of Some Interventions and Additional Short Courses/Seminars

E.1 Communication and Human Interaction

In chapter 1 the importance of communicating effectively has been highlighted. It is fair to say that there are a lot of learning resources available on the market which are offering solutions to this skill deficit. However, there is only a limited number of resources which are robust enough to pertain in different cultures and parts of the world. In addition, a lot of them are either too theoretical and conceptual and lack a skill building piece or are ill designed the other way round. Based on this dilemma it is proposed to use a specifically designed intervention to account for the appropriate skill building in this area. The proposal calls for a one day workshop with two components. The first component would talk about the principles and dynamics of communication [1]. This conceptual part would be followed by a practical life skill building. The best way to do so, is by using the principle of experiential learning [2], which is commercially available by the Galli Business Theatre [3]. This company offers a unique approach by using classical theatre principles applied to today's business environment. Preliminary contacts with this company have already been established and they graciously offered to sponsor such a prototype. With the valid assumption that this prototype will be successful, a similar agreement to the one with the "Enhancing Team Performance©" supplier could be envisioned in order to support the large scale building of Communication and Human Interaction competency. Attached is a first pass of an outline of the workshop's agenda.

Workshop Agenda

08:30 hrs	**Welcome and Learning Objectives**
08:45 hrs	Introduction of Participants
09:30 hrs	Principles of Communication Part I
10:30 hrs	**Break**
10:45 hrs	Communication Theatre
11:30 hrs	Principles of Communication Part II
12:15 hrs	**Lunch**
13:15 hrs	Feedback Theatre
14:00 hrs	Debrief & Reflection
14:30 hrs	**Break**
14:45 hrs	Principles of Communication Part III
15:30 hrs	Communication Group Exercise
16:00 hrs	Human Dynamics
17:00 hrs	Evaluation and Discussion
18:00 hrs	**End of Workshop**

E.2. Cultural Background and Diversity

The examples quoted in chapter 1 (Market for Pre-Prepared Lettuce and BMW 3-Series) clearly stress the importance of cultural diversity [4]. The ability to interact with all types of cultures in a global village environment is a strategic asset. The need for this competency has caused a nearly mushrooming effect of learning resources to cope with demand. The author of this research investigated the supplier market for this competency and is now proposing to set off with a course called Managing across Cultures© by Trompenaars Hampden-Turner [5]. One of

the founders of this company, Fons Trompenaars is well renowned and has built his research on the époque making work of Hofstede [6]. The extensive and profound research is reflected in the quality of the course. Managing across Cultures© is extensively used by the Dow Chemical Company and has yielded a significantly better understanding of cultural differences. Because of the excellent working relationship between the Dow Chemical Company and Fons Trompenaars, the author of this work was able to get the commitment from the latter supplier to provide the Managing across Cultures© course with a licensing agreement similar to the one of the "Enhancing Team Performance©" course. The references point to the full course material. For the sake of illustration a short description of the course is following. First the participants have to fill out a survey. The results are then correlated to a comprehensive data base and plotted against their cultural behaviors in relation to individualist/collectivist society and other major cultural patterns. In the class the participants learn and understand how other cultures relate to these behaviors and to what extent a conflict may be provoked by different societal norms and values. The comprehension of the sources of potential conflicts leads to more empathy, understanding, forgiveness and ability to reconcile differences. The total time commitment for a participant is approximately 3 days, whereby 2 days are spent in the classroom and the remaining day is split up between pre work and follow up work.

E.3. Facilitative Leadership

In today's environment, organizations are trying to reduce hierarchal layers and move towards flat and lean structures [7]. This calls for a very different leadership style. Irrespective of whether one comes from a business or a non profit organization, the leadership style of tomorrow is increasingly based on coaching, facilitation, mentoring, etc., rather than on leading by power of authority [8]. The following graph sums up the needs of tomorrow's leadership.

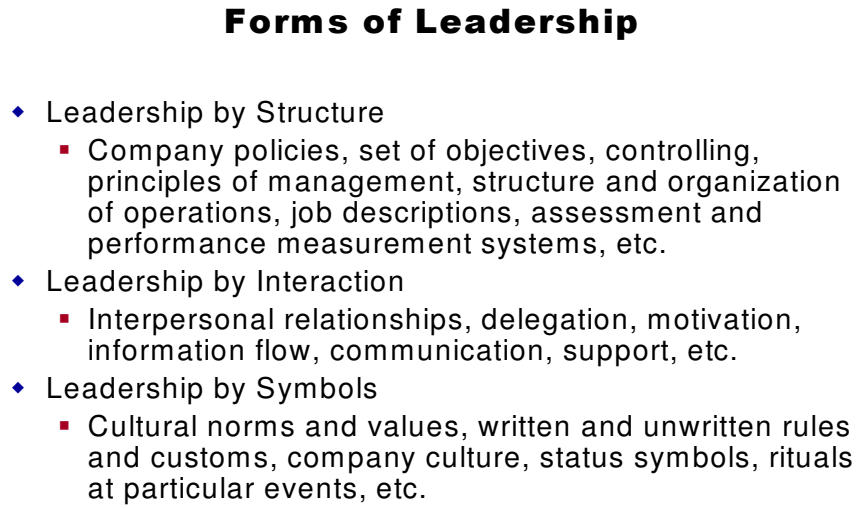

Figure E.3. Forms of Leadership

This role scenario requires the current and future leaders to adapt their leadership style and display a significant amount of versatility, irrespective of their power and authority. This is particularly difficult in case the leader does not possess a lot of hierarchal power, as is the case for the team managers of the integrated project. As they have very little balance of consequences to direct towards undesired behavior of a team member, they need facilitative leadership and conflict resolution skills. For the latter, the skill set needed goes beyond the teaching which occurs in the Communication and Conflict module of Enhancing Team Performance©. As a solution for closing this skill gap, the course Human Interaction© by Witt & Partner [9] is proposed. This is a 3 day course which focuses primarily on skill building comprised of training on general theory of facilitation supplemented by tools and techniques [10, 11]. The participants have to design a case study and are video taped while presenting their case. The course instructor of this course injects disruptive behavior to push the participants out of their comfort zone with the aim of exploring different behavior patterns. During the feedback session of the video replay, the participants have an opportunity of analyzing their reaction and judging which of the behavior traits are effective/ineffective when facilitating the case. Participants learn the prime task of facilitation, which is balancing the triangle of content, group and individual.

The target audience for this course would be primarily team managers and professors.

E.4. Organizational Development and Performance

Along with the changes in business and society, the perception of organizations changes as well. Traditionally organizations have been perceived from a deterministic perspective based on Taylorism [12]. However, there is a growing appreciation of organizations as much more complex socio-technical systems [13,14]. Based on system thinking [15], organizations can be characterized as an equivalent to a living organism or as communication nodes, producing a desired result [16, 17]. That in turn calls for the global engineer of tomorrow to be equipped with basic understanding of organizational design, of aligning the employees within that organization and of synchronizing the whole system for an optimal level of performance. Currently not a lot of learning resources exist to cover this need in a comprehensive fashion. For that reason only preliminary thoughts and concepts exist on how to build this skill. The first part of a proposal is looking into a self-learning case study, whereby over the course of a semester, a small task force of students would have to solve a case study which is centered on the three components (Organizational Design, Strategy Alignment, Organizational Development and Performance). Considerable research and work in this area is needed to pull such a case study together along with necessary education and skill building.

E.5 References for Appendix E

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CHAPTER 1

Introduction, Background and Objectives

1.1 Introduction

When looking at Chemical Engineering education system in general, it is important to realize that it is tailored more or less exclusively for an industrial workplace. The present study of Chemical Engineering education system derives its reason for existence solely in the overall objective to achieve higher standard of living by enhancing technology performance. Priority number one is to investigate current and future work environment in order to design appropriate education to ensure that the graduates leaving Chemical Engineering schools have the best possible skill-set when entering a workplace. Therefore it is appropriate to begin by providing a brief history of industrial development in the past century.

Industrial work place is a concept which is about one hundred years old [1-3]. It can be rooted in three industrial revolutions:

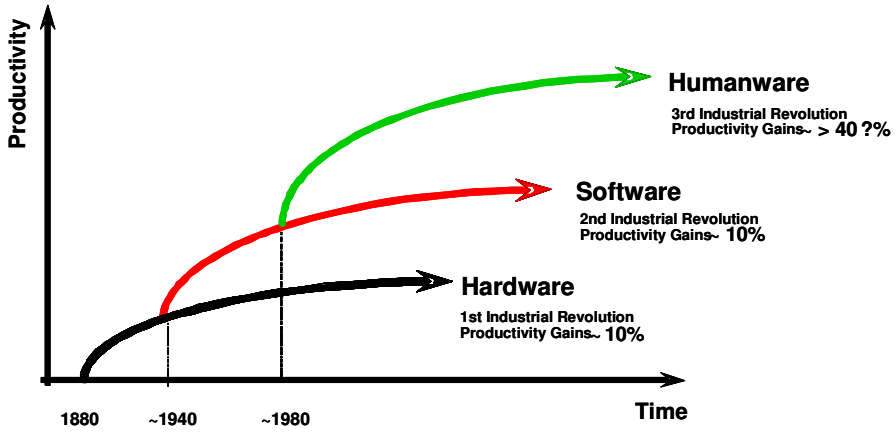

Figure 1.1. A Century of Industrial Development

During the first industrial revolution, the emphasis clearly fell on “hardware”. The tasks of chemical engineers evolved in the direction of improving operations and particularly the machinery to enhance productivity and output. One has to keep in mind that then the workforce available was clearly uneducated and relied on engineers and management to run the factories and decision making has been carried out by higher hierarchal institutions. The second era of this journey is characterized by “software” introduction. The first computers for industrial application appeared on the horizon, like the Zuse 1 (interestingly enough that huge machine had a programming capacity which is nowadays contained in the equivalent of a greeting music card [4]). Naturally that technological breakthrough created a tremendous shift in workplace and prompted a revisit of the entire curriculum of Chemical Engineering, subsequently introducing subjects like programming, automation, process control, etc.

The third industrial revolution, the era of “humanware” or the “communication age” is also called “the logarithmic world” [5]. The reason for calling it so lies in the simple fact that tremendous changes are hitting today’s society at speed close to exponential. The following facts support this hypothesis [5,6]:

- Television took 38 years to reach 50 million people, the Internet took only 4
- From April 1995 – April 1996, the capitalization of Internet companies rose from $0 to $10 billion
- In the United States per year, the rate of jobs being eliminated (about 20%) is equal to the amount of new jobs created
- The life span of new products launched has been reduced from about 2 years to now 6-12 months in the last 5 years

Given today’s globalization and tremendous interdependency of societal developments (e.g. the customer’s demand for safety, ecology, etc.) and political and economical power, it has become close to impossible to predict trends and to forecast potential developments in the marketplace.

One example of this trend is illustrated in figure 1.2 [5].

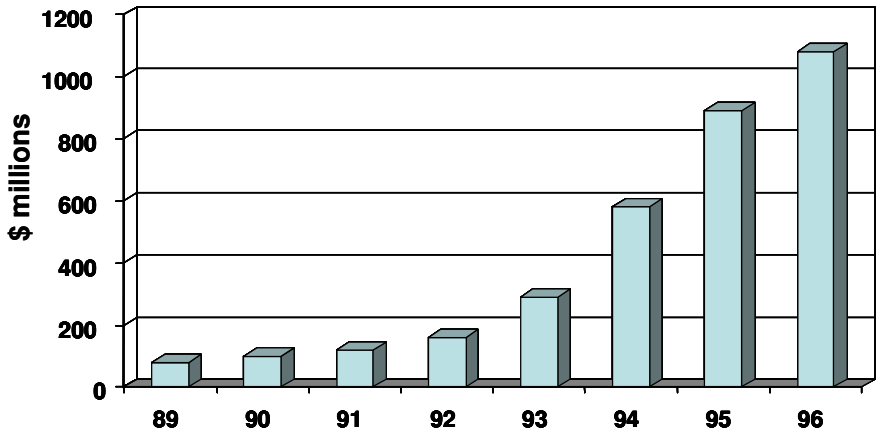

Figure 1.2. Size of Market for Pre-prepared Lettuce

Over the past two decades, tremendous changes in the work environment took place, which in turn have caused significant changes in role clarity between males and females. Dual careers for females have merely become a standard in industrialized western hemisphere. As a consequence of these societal changes, behavior patterns such as eating habits have also changed. As females with dual careers have less time to spend in the household, a market for the “pre-washed, pre-chopped, pre-packaged lettuce” has exponentially grown from being non-existent in the early 90’s to being a $1 billion market today. Evidently this is just one example of many showing the interdependency of societal trends and changes in the marketplace. The question at hand is: would a chemical engineer in charge of designing and manufacturing a product unit (e.g. for lettuce pre-packaging) build enough expansion capacity to cope with the rapidly growing demand or at least challenged the marketing and planning function with projecting future demand? Would this engineer undertake appropriate studying/research and in anticipation of future needs build ahead of demand? So when the market is booming, the production unit is already up and running, thus

promoting this particular organization to the comfort of market leadership. Would this engineer summarize the research undertaken and present it to senior management? These are the types of questions and challenges future engineers will be faced with.

Another example of globalization and challenges in today's work place is taken out of the automotive industry. For a BMW 3 series, circa 40% of the components are coming from about 18 different countries [7].

Figure 1.3. Components of a BMW 3 Series

For an engineer this constellation of countries poses many challenges, not only from a logistics but also from a social point of view as one would have to communicate worldwide with all kinds of suppliers to organize the "just in time" delivery.

Similar to previous industrial revolutions, a tremendous shift within markets and societal trends is provoking a revisit of the engineering curriculum. The task at hand is to undertake this major challenge once again, now with an ever-increasing work pace and shortened response time to tomorrow's challenges.

Current societal, political and economical changes are impacting the workplace directly and immediately. As a consequence, the skill set of the employees has changed dramatically and will continue to change. As full-time jobs and work engagements in the classical sense potentially become a privilege [8] employees have to watch out the skill-set trends needed to be competitive in a global marketplace. In the following, the potential outline of the skill set of the chemical engineer of tomorrow is examined in more detail.

1.2 Skill-Set of the Future

In the previous chapter, the dynamics of a fast changing world and consequently a fast changing work environment have been described. As a counter measure, the chemical engineering education has to be adjusted to the current/future needs as the engineers' prime task is that of improving and developing productivity of industries in general.

Over the past years there has been quite some dissatisfaction expressed regarding the level of education of chemical engineers, either by the industry or by governmental authorities [9].

It is a common belief in today's economy that the competitiveness of an industrialized nation depends to a great extent on its social and technological capability for innovation and the ability to create "sustainable growth" [10]. Chemical engineers are primarily an attribute of advanced and industrialized societies, which in turn implies that these societies/nations are highly competitive.

The official definition of a nation's competitiveness as provided by the OECD (Organization for Economic Cooperation and Development) is "the degree to which a country can, under free and fair market conditions, produce goods and services which meet the test of international markets, while simultaneously maintaining and expanding the real incomes of its people over the long term". Economists of the 20th century like Schumpeter, Solow, Porter, etc. [10, 11] have unanimously agreed that entrepreneurship, technical innovation, and increased knowledge with the ability to link these factors are crucial constituents of a nation's competitiveness. To create this competitiveness and even more so to put it into practice and make it sustainable is one of the engineer's prime tasks. In addition, when implementing this task the engineers will be measured against the extent to which their technologies and production is socially and ecologically affordable and sustainable.

When reviewing literature on how the above challenges (for a future global engineer) are addressed, one can find that the USA and Germany play a leading role in driving this development [9]. This does not come as a surprise since these two countries are world-leaders in the area of Chemical Engineering, with Germany enjoying a long standing tradition in engineering science and in exporting products and technologies [10]. Consequently, two transatlantic conferences called "Engineers in the Global Economy" have been organized to address the fundamental issues of chemical engineering education. During these conferences a number of key themes surfaced:

- The profile of the engineer of tomorrow is the one of many talents
- Social competencies are critical
- Universities have to change to address these dynamics
- The change of engineering curricula has to be achieved without neglecting the depths of traditional technical expertise
- The change in demographics (for example male/female) has to be reflected
- All of the above has to be positioned to make the future of Chemical Engineering more attractive, bearing in mind that the chemical industry image ranks low in perception of society [12]

When looking at all the above challenges it becomes evident that there is no easy solution to the questions raised. But the challenge of incorporating social competencies into the chemical engineering curricula seems to be the crucial one. In this context and thereafter a competency can be understood as "a combination of tangible (skills and knowledge) and intangible (social role, self-concept, traits and motives) underlying characteristics of an individual that is causally related to criterion-referenced effective and/or superior performance in a

job situation" [13]. In the following, an approach on how to focus on building the social competencies and how to integrate them into chemical engineering curriculum without loosing perspective on technical expertise is outlined.

1.3 Social Competencies Identification

The industry representatives participating in conferences [9] expressed a need for a number of competencies as a prerequisite for the success of future engineers. Below is a list of some of these competencies:

- Teamwork
- Collaborative active learning
- Communication
- Leadership
- A system perspective
- An understanding and appreciation of diversity of students, faculty, and staff
- An appreciation of different cultures and business practices in a global environment
- Ethical conduct
- A commitment to quality, timeliness, and continuous improvement
- Understanding of the societal economic and environmental impacts of engineering decisions
- Business process competencies
- Foreign languages
- Project management competencies
- Value management
- Entrepreneurial competencies
- Conflict resolution
- Media competence
- Knowledge management competencies
- Change management

Being quite an impressive list, it captures the key themes of focus in future engineering education in addition to conventional technical expertise. When going through this list and reviewing publications on the same subject [14] there seems to be an agreement that the following four social competencies should be included in the future engineering curriculum:

- Teamwork and cooperation
- Human Interaction with Communication
- Leadership
- System thinking

Also, there is a growing agreement that integrating these and other social competencies into the curriculum will fundamentally enhance the ability to acquire technical knowledge, a key part of the hypothesis of this research project. A brief description of these four competencies is provided below:

Teamwork and Cooperation. Given the complexity and speed of today's work environment, there are very few tasks left which can be performed by one

individual exclusively. Consequently the ability to work with other individuals/colleagues is not only a prerequisite, but similar to the other social competencies, is becoming more and more of a competitive advantage. Unfortunately, traditional school curricula do not take that into account as they still focus primarily on individual work as opposed to group work [14]. This pattern is reinforced as part of traditional occidental cultures [15]. Only those engineers who understand their own strengths and weaknesses are able to correlate these to the other team members' skills and are able to solve complex tasks in the most effective way. It is not without reason that companies hiring young graduates spend considerable amount of money on building team competencies during an early stage of their careers [16,17]. To know reconciliation techniques and how to deal with conflicts is important in a world that is turning into a "global village"; organizations start realizing the complexity of cultural diversity. Simple tasks akin to greeting a Japanese senior manager or proposing a business dinner at appropriate time can have an enormous impact on success or failure of a business relationship and its subsequent advancement. Global companies are investing great efforts into educating their workforce in the area of cultural diversity and sensitivity [15]. It is not only socially and ethically correct, it is also productive. In this case in point, companies are learning that there is productivity gain to be had which has not been harvested to its full potential.

Human Interaction with Communication. The further mankind advances to the "age of communication", the more conscious it becomes of the importance of effective communication competencies. Once hired in a large company, people communicate with colleagues both in person and virtually. Given this fact, it is evident that the ability to communicate effectively has tremendous impact on success and productivity of any work unit and ultimately on any given organization [18].

Leadership. The ability to lead other people, particularly in case where there is no direct hierarchal leader engaged is clearly an asset in current and future work environment. Very often the task at hand for a team leader is to engage team mates to solve a complex task within tight deadlines and with limited resources devoid of formal hierarchal authority. Given this challenging task, the ability to lead people effectively is a criterion for success and will ultimately have tremendous impact on career advancement of team leaders and on team performance.

System Thinking. Traditionally organizations have been portrayed in forms of "pyramids" or organizational charts. However, this thinking goes back to the first industrial revolution [19] and for sure then had its validity given the low educational level of the workforce. The current school of thinking within industry, states that organizations have to be looked at as a system or a living organism or else a socio-technical system [20-22]. Consequently changes in one part of an organization affect other parts of that same organization. If a chemical engineer decides to have process improvements implemented, he/she needs to be aware of a series of implications on other work units. That might be as remote as verifying performance specification to check whether the product in its new version will display the same performance patterns as before the process improvements. Thus the understanding of systems interdependency and the ability to forecast organizational behavior pattern changes is yet again a desirable

skill for a global engineer. System thinking is particularly difficult in Chemical Engineering as this faculty is traditionally based on a deterministic view of the world [23].

1.4 Redesigning the Engineering Curriculum

Redesigning the engineering curriculum is an intricate task, as it is not possible to simply add on more subjects to an already filled up curriculum. Numerous failures in that direction [10] have shown that this route does not lead to success. As a result the question of building social competencies without decreasing the technical quality of education of chemical engineers remains open. The potential risk of "overloading" the curriculum is not the only pitfall in this change effort.

A comprehensive research study sponsored by the German Federal Ministry of Education and research [9] reveals the following major pitfalls when academic organizations like universities embark on re-engineering efforts like the one of fundamentally changing a curriculum:

- Speed of re-engineering not adequate and change not radical enough
- Social competencies not integrated, just put on top of existing curriculum
- Not enough leadership to drive change
- Unavailability of change management expertise
- University curricula are not reflecting today's trends and demands
- Inadequate preparation and acceptance for change in roles
- New learning not sustainable
- Inadequate training and education
- Interaction between university management and legislation not dynamic enough
- Universities too disconnected from the market

In order to increase chances for success, it is desirable to translate the learning from the above mentioned trials into design principles, which should be adhered to:

- The social competencies should be integrated
- The social competencies should enhance technical learning
- The re-design should incorporate supporting systems, structures and processes
- During the re-design new faculty culture should be created
- The necessary education of faculty members should be an integral part of the change
- The involvement of key stakeholders is critical

Contrary to the less successful approaches mentioned before, there are encouraging pilots and tests which are trying to incorporate social skill building by integrating these topics into existing curriculum [10]. These approaches look very promising as they try to improve technical education through social competencies, an approach which is endorsed by this research project.
The more successful route to re-engineer the curriculum is creating project tasks, whereby the task as such is a conventional engineering problem. However, the

way to solve it involves designing an educational model where past successful approaches [24-27] could be integrated and their continuous development sustained. Different learning resources and teaching styles have to be used in order to make that approach successful. Lastly this route is only successful if the culture, i.e. organizational behavior of the total faculty changes simultaneously. In the following section a description of previous approaches pursued at the School of Chemical Engineering in Tarragona (ETSEQ) is provided.

1.5 The ETSEQ Approach

The School of Chemical Engineering (ETSEQ) of the University Rovira Virgili at Tarragona has offered, since 1993, a five-year undergraduate Chemical Engineering program with emphasis on both the acquisition of knowledge and the development of organizational oriented values and competencies [28]. Thus, teamwork, communication, leadership, cultural diversity and system thinking, and organizational behavior, together with management by project, quality management and creative thinking have been considered in the curriculum and fostered through active learning methodologies. The development of such methodologies has required extensive field testing. Over the past fifteen years, different approaches and strategies to attain and maintain the involvement of professors and students in team-oriented, effective teaching activities, such as early-design projects have been introduced [24-26]. The development of early-design mini-projects in Tarragona by groups of students working cooperatively without an external leader has encountered the same difficulties as those reported for the first-year chemical engineering team projects carried out at Imperial College of London [28]. These are:

1) Roles are not distributed among members and agreement for the election of a leader within the team is seldom reached
2) Groups are not able to organize time properly and prioritize work correctly. Deadlines, if established, are often ignored
3) Lack of planning and late motivation of group members leads to a typical concentration of work during the last two weeks of the semester
4) Queries are to be resolved mostly by the professor, which is not an efficient approach, instead of being thoroughly discussed first by the group
5) Low attendance and lack of punctuality are common in meetings held outside class hours
6) Teamwork often results in duplication of tasks and poor checking of results
7) Friction between group members develops, and solving interpersonal conflicts with external mediation is a difficult task
8) The participation of individuals in group activities is uneven, and communication is ineffective and inefficient
9) Information collected by members is not available when needed by the group
10) Division of labor is often inequitable, and the more gifted students soon become frustrated
11) No clear criteria are established to grade peers

The above issues and complaints highlight the difference between a group of people put to work together and a team of students learning cooperatively while working together towards a common goal. As a result, several alternatives previously reported for effective engineering education were considered to

improve the outcome of early design projects at ETSEQ and move toward the concept of the global engineer [29–31]. Examples of these alternatives are:

- implementation of design projects [28,32–35]
- vertical integration of these projects throughout the curriculum [36,37]
- use of Total Quality Management (TQM) concepts and tools to improve teaching and learning [38–41]
- introduction of the latter in cooperative learning workshops [42,43]
- horizontal integration of several subjects of the engineering curriculum [35,44]

None of these proposals, however, addressed the question of the simultaneous horizontal and vertical integration of engineering education with the corresponding involvement of professors and students of different years in the undergraduate academic organization.

The holistic approach for engineering education adopted at the ETSEQ to implement effective teaching and self-sustainable curriculum improvement strategies across the academic organization, is summarized in Figure 1.4. This ETSEQ approach, which should be the basis for the development of a competency based educational model, encompasses the above mentioned methods for effective education and goes one step beyond. It integrates several first and fourth year subjects into a common design project. Teams of first year students are led by one fourth year student enrolled in the elective Project Management Practice course so that engineering skills, including project and quality management, are introduced from year one of undergraduate studies without decreasing the weight of sciences and mathematics [45]. In addition, the role of fourth year students as project managers and team leaders, and the establishment of adequate rules, foster active learning and professors' involvement (see reference 26). The learning environment that evolves is also appropriate to deal with the diversity of learning and teaching styles observed in students and professors [46].

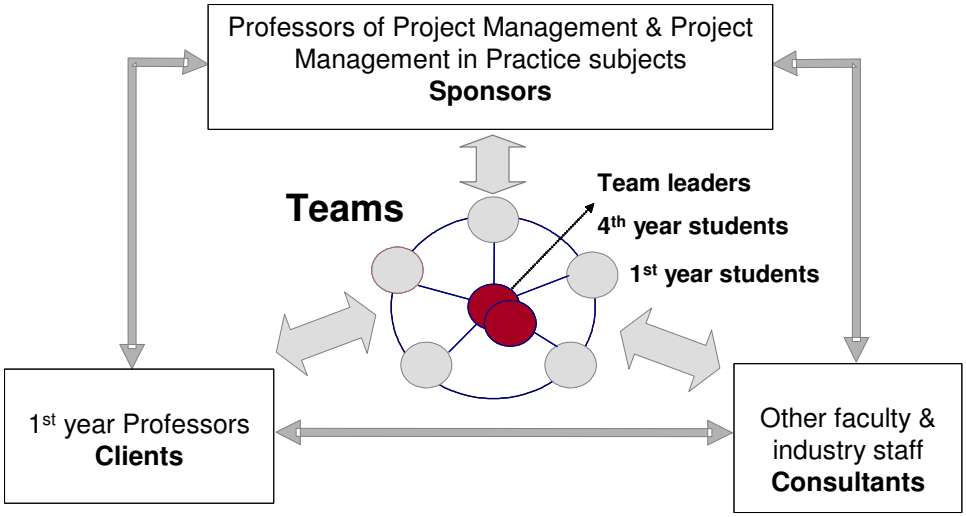

Figure 1.4. Integrated Design Project Organization at the ETSEQ

The above figure illustrates how the project organization involves 1st and 4th year students (vertical integration) and several 1st year courses (horizontal

integration). It is worthwhile to emphasize that the deployment of the vertically and horizontally integrated design project responded to a long term strategic plan for the ETSEQ to improve the quality of education with effective teaching throughout the curriculum,1 while keeping the interest and enthusiasm of faculty as a team [47]. As mentioned in subsection 1.4, reengineering the curriculum should involve, in the case of the ETSEQ, the introduction of competencies into the 1st and 4th year integrated design project illustrated in figure 1.4, and the simultaneous extension of the approach into the other academic years of the chemical engineering curriculum.

1.6 General Purpose

The purpose of this thesis is to develop a competency-based educational model that could be field tested and implemented at the ETSEQ. Since such a model requires the development of social competencies without hindering technical competence, a partnership with Dow Chemical Ibérica was established in 1997 to assist in the required organizational change. The current endeavor, together with the historical deployment of student centered instructional approaches applied at the ETSEQ, is highlighted in Figure 1.5.

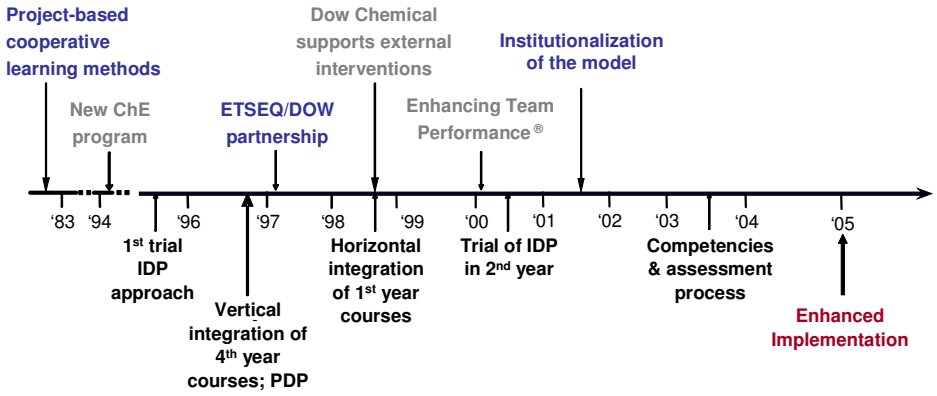

Figure 1.5. Landmarks of Integrated Design Projects (IDP) at the ETSEQ

Chapter 2 describes the background, underlying hypothesis and framework that support the implementation of a competency educational model, where technical foundation, business competence and social competencies are all simultaneously considered. The partnership with Dow Chemical Ibérica facilitated the adoption of external interventions to support social competency development. Since the ETSEQ educational tradition was that of integrated projects, the teamwork competency was chosen to introduce social competencies into the educational system and to field-test the convenience of external interventions. Chapter 3 describes and evaluates how effective the delivery of an external intervention dedicated to teamwork, such as "Enhancing Team Performance"© [48] can be, when taught to 1st and 4th year students working in the integrated design project of figure 1.4. The information provided by the evaluation of this external intervention supported the development of the competency-based educational model given in Chapter 4.

Chapter 4 presents the model adopted and provides the rationale for the ten social competencies, including the four mentioned above, that have been selected as key enablers to learn science and engineering, and for the successful operation of the educational model. How the whole model gravitates around client orientation and follows an experiential learning approach, including integrated design projects, competency-oriented external interventions, and the competency assessment process is also described in this chapter. The implementation journey and the corresponding change management effort made so far at the ETSEQ with the facilitation of professional consultants from Dow Chemical Iberica (from here on in referred to as Dow) is also provided. Moreover, a preliminary evaluation of the competency profile of our graduating students carried out by Dow is presented. Finally, concluding remarks and the recommendations to assure the complete and successful implementation of the new model at the ETSEQ are presented in Chapter 5.

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CHAPTER 2

Vertical and Horizontal Integration of Education

2.1 Background

Industry has repeatedly and clearly demanded of higher education institutions to explicitly broaden the scope of undergraduate engineering education objectives [1-3]. The globalization process has intensified this trend and corporations currently consider social competencies such as client orientation, teamwork, and leadership, as valuable as technical expertise and know-how in first job hiring for engineers. The profile of an engineer in the fast growing technology market is also evolving towards that of an entrepreneur and, as a consequence, basic management skills are essential for the engineering profession.

The ABET's Engineering Criteria 2000 [4], the U.S. standard for accreditation, explicitly requires that engineering programs demonstrate that their graduates possess communication, multidisciplinary teamwork, and lifelong learning skills. The Industrial Research and Development Advisory Committee (IRDAC) has adopted a similar stand, when advising the European Commission on the revision of higher education European programs; the Bologna Process specifically calls for a greater investment in new basic skills such as digital literacy, learning to learn, social competencies, entrepreneurial skills, and language learning [5]. On the other hand, the concern at the university level is how can engineering curricula accommodate all these additional learning requirements without extending studies or losing depth?[6] The task at hand is to vigorously and comprehensively reform the curricula and overcome the Taylorist paradigm [7] of fragmented curricula, organised within disciplinary boundaries. The challenge is to reengineer programs, including the teaching processes, in such a way that science and engineering knowledge and skills can be acquired together with social competencies.

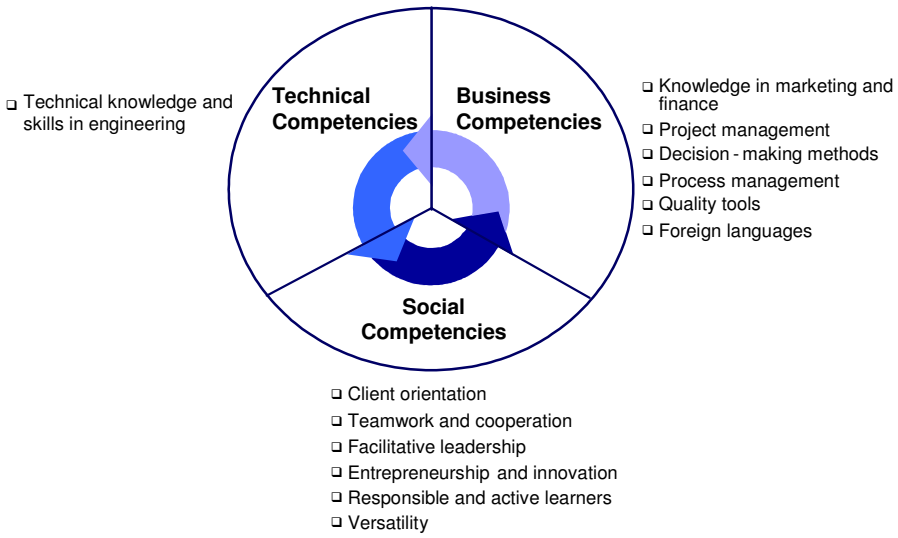

Figure 2.1. Underlying Ablities for a Global Chemical Engineer*

* Survey of chemical manufacturers in greater Tarragona in 1994

Figure 2.1 illustrates in a brief and comprehensive manner the abilities that then best described a global engineer, classified in term of technical foundation, business competence and social competencies. The challenge was to embed into the chemical engineering curriculum the competencies given in Figure 2.1. Project based and cooperative learning methodologies were both considered, since they would enable students to acquire technical and scientific knowledge and to simultaneously develop the social competencies needed in real life work settings [1], i.e., while solving real life problems in collaboration with others. During the first semester of the 1995-96 academic year (see Figure 1.5), the so-called integrated design project (IDP) was tested in the first year of the ChE program [8]. This approach combined the two learning methodologies mentioned above with the particularity that the 1st year students worked in teams led by 4th year students enrolled in a project design practice course (PDP), which meant an indirect way of integrating knowledge and processes vertically. Initially the IDP integrated horizontally only two 1st year engineering science subjects and was very restricted in scope. The basic IDP layout is depicted in Figure 1.4. The fact that 1st year professors acted as clients of the projects is a key factor in the current study, as discussed in the following subsections.

This chapter describes the underlying preliminary hypothesis and framework that supported the adoption and implementation of a competency educational model, where technical foundation, business competence and social competencies could all be simultaneously considered. Figure 2.1 illustrates the underlying abilities of these three supporting pillars.

2.2 Preliminary Steps Towards a Competency Based Model

The current research project started with the following hypothesis:

- The social environment generated by the IDP model should be adequate to deploy social competencies in a natural way
- The role of clients should be central in the new competency based system as it was so in IDP model, since students are driven by performance evaluation
- Social competencies should enhance students' mid term learning and through way of integration with the educational system increase their productivity, without hindering technical and scientific content

In order to prove this hypothesis the necessary external interventions were adopted accordingly. The analysis of the above hypothesis led to the conclusion that is was essential, both for the IDP model and for the transition towards a competency based educational organization, to consolidate teamwork and test the impact of the industry recognized external intervention "Enhancing Team Performance ©" [9]. Also, it was decided that initially some of the competencies needed, could be grouped under the category of coaching competencies [10]. Annex A includes a copy of the paper that resulted from this initial work, and which was presented at the FIE Conference in 2002.

In order to validate these statements, the following mandate was initially put forward:

- Establish a partnership with Dow Chemical Ibérica, with the support of the Dow Chemical Company where the author was a former employee, to obtain change management technology, external interventions and training materials, consultancy and facilitation
- Integrate the design of social competency building into an overall change management effort
- Prototype and test the effectiveness of the social intervention “Enhancing Team Performance ©“ related to teamwork
- Define a model framework to deploy and evaluate the impact of this intervention and the rest of interventions that will finally be adopted
- Test the initial model at the School of Chemical Engineering in Tarragona, Spain for validity and further development

2.3 The Academic Organization Selected

A number of factors lead to the selection of the Chemical Engineering School of Tarragona (ETSEQ), Spain as the best candidate to obtain evidence and to develop and test the competency based educational model. Dow Chemical had a long standing fruitful collaboration with the ETSEQ that started back in 1977. Based on that alliance, it became reasonable to assume that both parties would be interested in the research project. In addition, the colleagues from Dow Chemical Ibérica in Tarragona are well recognized within the corporation for their help and support. Later on it will be discussed how invaluable the local resources were in assisting the project. The students and the university faculty shared that same level of enthusiasm. The ETSEQ has a long standing tradition of innovating ways to teach and to involve faculty in effective teaching methodologies [8,11-13]. Based on that culture, a significant effort was made in order to accelerate and upgrade the new way of educating future chemical engineers. This effort was appreciated all the more given the fact that the concept of reengineering and empowerment is quite recent [14].

Not too many business organizations around have conducted successful reengineering in a sustainable manner, let alone applications in non profit organizations like the academia. Thus, the current effort in curriculum development is a forefront runner in the area of implementing sophisticated novel business concepts in an academic organization. This fact calls for appreciation of the pioneer work of a team of professors, who started this journey in the mid-1980s. Their effort received professional acclaim starting 1997, when the department of Chemical Engineering decided to use outside expertise, particularly in the form of industry consulting and support as a way of intensifying and structuring the department’s approach towards an improved engineering curriculum. The proposal of this joint university-industry research project was a perfect match, as it combined the strengths of the business organization (change management expertise) with the strengths of the school (vision, change readiness, change leadership and infrastructure). The foundation of the school’s reengineered curriculum is the so-called “integrated project methodology” work, which was already established in the early 90’s [8,11,12], as highlighted in Figure 1.5.

2.4 The Change Management Technology

The shift in academic organization required by the implementation of a competency based model, with external interventions, was supported by a suitable change management technology. For obvious reasons the “Dow Global Change Management Framework” was adopted, as it is a robust and well established technology [15]. It is summarized in Figure 2.2.

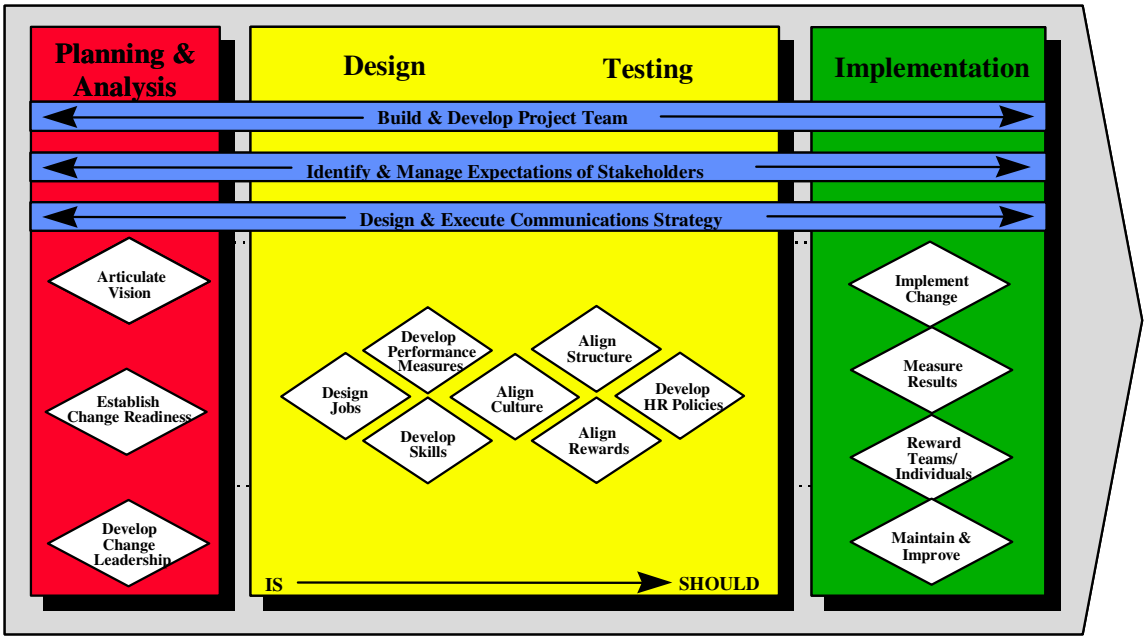

Figure 2.2. Dow Global Change Management Framework

The Dow technology described in Figure 2.2 provides an excellent framework for conducting any given major reengineering, be it for business or a non profit organization, like academia. Instead of looking just at the micro objective of “competency building”, this model suggests an integrated view looking at different components and their interdependencies. The key message here is to build vision, change readiness, and appropriate leadership to drive any change process up front. The use of this technology definitely increases success chances in the change effort, as it helps avoiding some of the pitfalls mentioned earlier in chapter 1.

Throughout this research project the change management framework will be referenced, as it provides an excellent road map to design, test, and implement the social interventions and evaluate their effectiveness.

2.4.1 Building the Vision

As the change management technology prescribes, the first task in any major change initiative is to “articulate vision”. In order to do so, the current strategy of the School of Chemical Engineering was revisited [16]. As it was too narrow in scope, two workshops were conducted [17]. Professional change management consultants from the Dow Chemical Company, including the author, facilitated these sessions, with faculty, staff and school managers participating. The outcome of these workshops is condensed in the following figure 2.3.

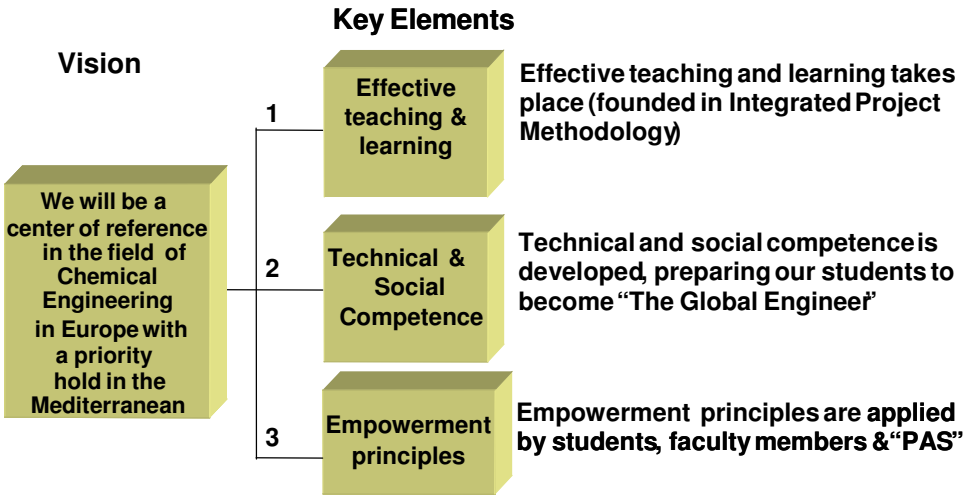

Figure 2.3. Strategy and Key Elements

The revised strategy currently contains a compelling vision statement, key elements and operational definitions. As such, it provides a framework for the competency based model implementation. Values were also adopted; they are listed in chapter 4. To clarify each key element in Figure 2.3, further detail was communicated to all people involved at the ETSEQ and was also provided to all stakeholders. These details are included below for completeness:

- Effective Teaching and Learning. We recognize that there are different ways of teaching and learning. Not only will we assess our current teaching methods, but also explore and apply new methods, such as integrated learning, experiential skill building, learning by doing, etc. The integrated project methodology will be intensified and enhanced by injecting new teaching technologies
- Technical and Social Competence. Historically the focus has been on technical skills. However, the future trend requires a simultaneous build up of social skills. The present task is to build technical competence through the development of social competencies. The focus will initially fall on teamwork with emphasis on coaching, due to the specific needs of the 1st and 4th year IDP (which was in place when the current work started: the paper included in Annex A covers the coaching effort by the author, with the support of the professors involved)
- Empowerment Principles. Our decision making processes are reliable, effective and transparent. We will delegate authority down to the lowest possible level. All students are an integral part of the processes of our school. The prerequisite to succeed with above work is leadership at all levels

As stated earlier, this research intended to build up on existing work and infrastructure as much as possible. Hence social competency building was synchronized with the integrated project methodology. The next level of detail was added to key element number two "Technical and Social Competence" in Figure 2.4. This resulted in an operational framework to design and execute the road map for implementation given in Figure 2.4. The road map for implementation incorporates elements from the European Foundation for Quality

Management (EFQM) and gets inputs from the "Enhancing Team Performance©" surveys and from the empowerment assessment process, which would be implemented when the model is completely deployed with respect to IDPs and external interventions.

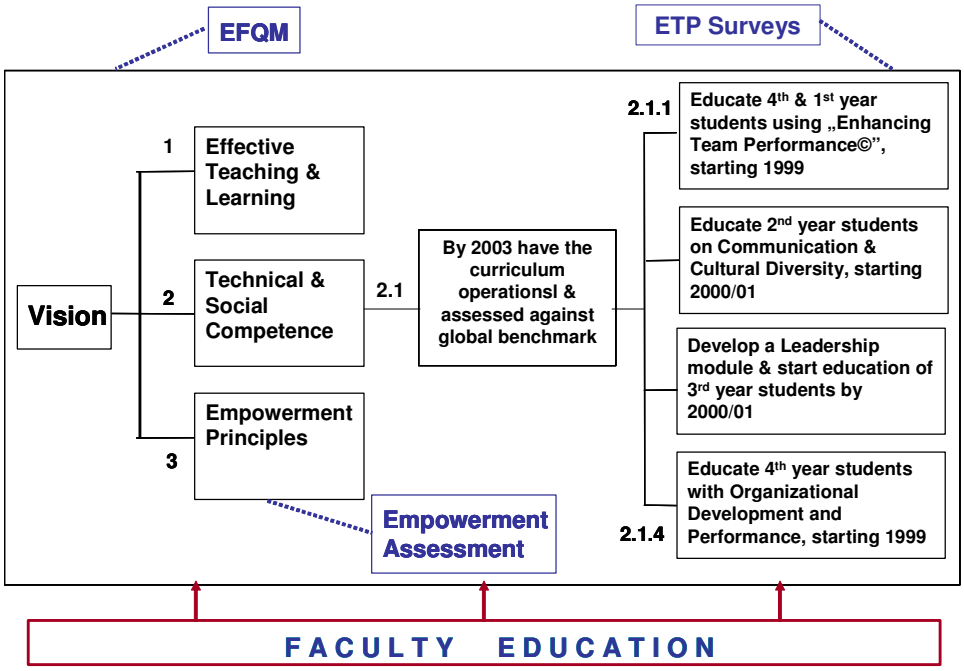

Figure 2.4. Roadmap for Implementation

The plan currently put forward contains detailed objectives and plans, as well as milestones and measures for success. The preliminary evaluation process and its corresponding measures will be explained in more detail in chapter 4.

As a note aside, putting this strategy to work with the faculty has definitely increased "change readiness", and helped to build up 'change leadership' – the prerequisites for successful change. The next step is specifying how to build these social skills and integrate them into existing curriculum.

2.4.2 Building Competencies and Identifying Transformations

After intensive research and screening of future industry and societal needs and trends [1], and taking into consideration the dominant client satisfaction scheme, adopted for the IDP model depicted in Figure 1.4 (see ref. 8 for further details), it was decided that the four competencies mentioned and discussed in subsection 1.3 (teamwork and cooperation, human interaction, leadership, and system thinking) should gravitate around the central competency, client orientation. Also, the need to satisfy clients should sequentially suggest any other missing social competencies. This process of selection, which is explained in detail and justified in chapter 4, led to the inclusion of five additional competencies: versatility, entrepreneurship and innovation, responsible and active learners, organizational development and performance, and organizational leadership.

Once the decision was taken to focus on these nine social competencies, the task at hand became allocating the set of external interventions needed to incorporate them into existing integrated project methodology, which in turn should be spread across all engineering curriculum beyond the 1st and 4th year project. The next task was to prioritize the external interventions. It was then decided that teamwork and cooperation were essential and they were selected and used to assess the external intervention scheme as well as students' opinions about the emerging new educational model. It should be realized that:

- Teamwork enables learning and building of competencies in general
- Teamwork is a concept, which is easy to comprehend in all cultures [unlike Organizational Development or Facilitative Leadership)
- Teamwork helps reducing conflict and increases effectiveness

Besides these generic factors, there was yet another important decision making factor. The TRACOM Group generously offered their support and made available their excellent learning resource called "Enhancing Team Performance©" [9]. Ultimately, this was the decisive factor in defining teamwork as initial external intervention. This learning resource was delivered first in form of a workshop and is described next.

2.5 The Fundamental Intervention Teamwork and Cooperation

In order to substantiate the hypothesis of this research (see chapters 2 and 4), an intervention plan was put forward allowing to measure the baseline, introduce the team building intervention, measure the effects of that intervention, and draw correlations with performance improvements. In other words, a completed cycle of "Plan-Do-Check-Act" [18] was conducted for the social skill of "teamwork and cooperation". For the remaining eight competencies, supporting external interventions are proposed, using a similar pattern. In chapter 4, where the new competrency based educational model is presented and discussed, all external interventions are outlined and fitted into the curriculum. The learning resource selected for teamwork and cooperation was "Enhancing Team Performance©" [9], kindly supplied by the TRACOM Group. This methodology is widely used throughout industry and has a longstanding record of success (see for example http://tracomcorp.com).

"Enhancing Team Performance©" is set up as a supporting process in modular form, taught by certified trainers and coaches according to the standards of this vendor. The learning resource itself is comprised out of an introduction module, called Fundamentals, followed by nine additional modules, which are built up on one another:

- Common Purpose
- Team Capabilities
- Change
- Team Norms
- Communication/Conflict
- Recognition/Reward
- Team Operating Procedures

- New Member Integration
- Evaluation

Along with the intervention comes a survey, which is normally used to assess the dynamics and consequently the performance of a given team [9]. Initially a decision has been taken not to use this survey. The reason for that is the fact that the project teams were mearly in the process of formation. That meant that team leaders and team members were not able to answer the questions in a meaningful manner (e.g. “How well is your team performing”). It was proposed to use the vendor survey, once the teams have been established and functioning.

To assess the baseline, follow the development and monitor the journey of the project teams, a series of surveys were developed. The surveys designed are shown in Annex B. In chapter 3 a closer look is taken at the process of survey validation, based on practices and knowledge in this area [19].

One of the key issues when designing social interventions is integration of compentency building activities into the curriculum regular work, alongside a structured approach in the area of change management. The importance of this approach has been already highlighted above. In support of that approach and to sustain it, the following measures concerning the delivery of the intervention were taken. In compliance with an agreement [20] regarding permission to use “Enhancing Team Performance©” by the TRACOM Group, tutorial sessions were initiated with the aim of educating professors and school staff by exposing them to the material in a two day workshop. Because of language issues and a subsequent need for simultaneous translation, professional expertise was kindly supplied by the Dow Tarragona team. Not only are they certified coaches of “Enhancing Team Performance©”, they are also fluent in Catalan - the official language of this Spanish province, Catalunya. In these co-facilitated sessions, participants were exposed to the principles of ten modules of “Enhancing Team Performance©” as well as facilitating the material. That was quite a unique undertaking, as some of the professors have been exposed for the first time in their professional career to some very different methods of teaching, e.g. by means of using experiential team building exercises [21]. Again, it is noteworthy to mention that this exercise supported the necessary culture/behavior change as required by the change management process described before. In a cascading manner over periods of months, other professors (joined by faculty members like PhD students) were exposed to this methodology. At this point in time it is fair to say that by then the department of Chemical Engineering possessed sound knowledge of the teamwork methodology and was on its way to building strong social competencies as a cultural habit.

The faculty members who had already received the tutoring, had to educate in turn the team leaders and team members of the integrated project. A plan on how to spread the teamwork competency across the 1st and 4th year students during the first acedemic year could now be designed and executed.

After a general two day introduction at the beginning of the new academic year, a better tailored tutorial took place for all the new students. Being based on needs and requests of project teams the various modules of “Enhancing Team Performance©” were injected into the work of integrated project methodology. It

is important to mention that the trained “Enhancing Team Performance©” coaches supported the project teams on an on-going basis as skill building would not be otherwise sustainable. It can be noticed during the surveys evaluation stage that the ability to communicate effectively and handle conflicts (as issues arise) is of fundamental importance and has to be delt with on continuous basis. That explains the need for the process coaches to be available and accessible at all times, as otherwise team members would go back to their original individualistic behavior, rendering team work skill building unsuccessfull.

The surveys evaluation clearly points out the importance of on-going coaching (chapter 4). In chapter 5, where future improvements are discussed, it is underlined yet again that professional team coaching on continuous basis is vital to ensure that there is no erosion of growing supportive team behaviors. Or, as Igor Strawinsky put it: “Knowledge which is not used and applied does not exist” [22]. Overall research unanimously supports the above recommendation [23]. Figure 2.5 illustrates the correlation between learning investment and competency building, and performance increase.

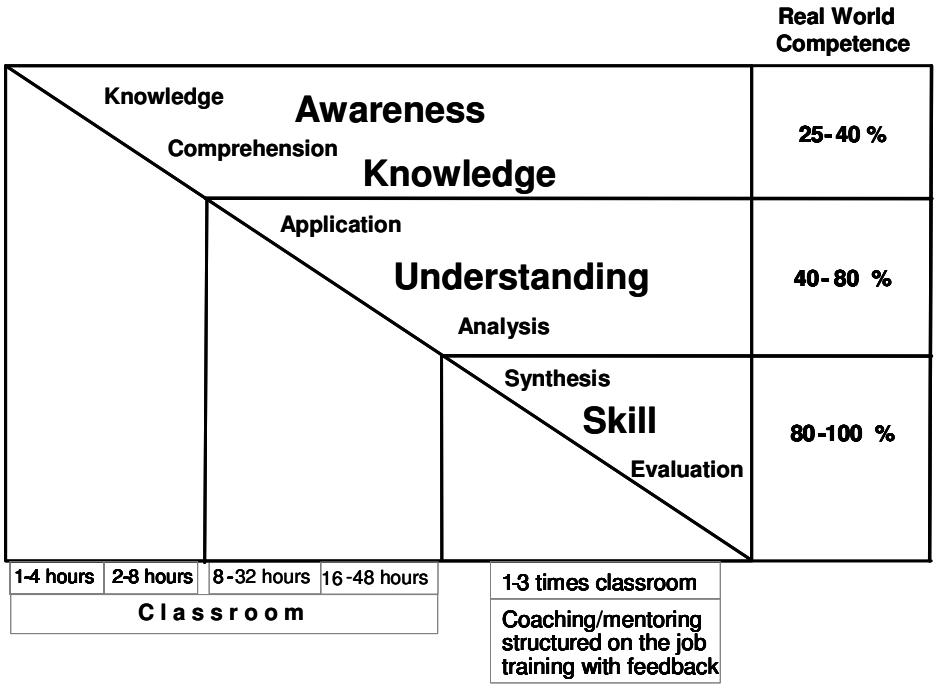

Figure 2.5. Correlation of Competency Building and Performance

2.6 Transformational Changes and Learning

In addition to the considerations made earlier about building social competencies and identifying transformational changes, the ten competencies selected should be examined from the learning processes point of view, together with the changes, that should simultaneously take place at all levels within the educational system. These aspects are discussed next.

The concept of organizational change as used in this research refers to planned, organization wide change. The ultimate objective is to create a model, whereby organizational transformation happens in the least disruptive way and delivers sustainable results. This is an ambitious task, as very often the models are either

exceedingly theoretical and lack implementation capabilities [24] or merely describe trial and error effort with difficulties to extrapolate results to other organizations. The present research tries to bridge these two approaches by using robust models with heavy emphasis on learning, gained from nearly a decade of implementation work. This work has been primarily carried out by the Dow Chemical Company, whereby the results obtained involved literally thousands of employees from all kinds of countries, cultures, nationalities, religions and levels in the organization. It is therefore valid to assume that the experiences, results and conclusions can be projected onto other organizations with a high likelihood of success, as the testing over this decade guarantees implementation.

2.6.1 Transformations and Competencies

Any organization is ultimately centered on purpose, which can be generally described as “achieving client satisfaction”. While serving this purpose, an embedded dilemma is manifested. As the client’s needs change, the organization has to change as well in order to closely follow the client’s movements and to guarantee client satisfaction. Every considerable change in client needs prompts organizational transformation. Figure 2.6 illustrates the phenomenon within the framework of the current study.

Figure 2.6. Client Satisfaction and Transformations

A change in client needs should trigger a change in the individual behavior in given organization. Research supports the assumption that the only thing which can be changed in an organization is the individual with his/her attitudes and perspectives [25]. Change always happens at the individual level. The change of individual behavior triggers organizational transformation. Once organizational transformation has taken place, the new way to work has to be institutionalized in order to ensure sustainability of changes. Erosion would be detrimental to the required changes, as the organization gradually slides back to the ‘status quo’ or the starting point of the change initiative. However the above concentric spiral with its dynamics requires a number of skills to achieve the desired result.

For each of the three levels of transformation given in Figure 2.6:

- individual
- organizational
- institutional

a competency-building process is needed. The set of competencies must concentrically emerge with the purpose to satisfy clients. The first competency required for this purpose at the individual level is versatility. An individual within a client service organization must be able to perceive change in client needs and change accordingly. Productive performance during change requires versatility as the individual is likely to be catapulted out of one's comfort zone. To cope with inflicted stress, a high degree of versatility is needed, as one has to adapt by changing one's views, perspectives, assumptions and behaviors.

The next skill under scrutiny is entrepreneurship and innovation. Versatility has brought about capacity to adapt to change. It now has to be followed by creative ideas which are required to respond to the new challenges imposed by the client. On institutional level entrepreneurship will aid translating creative ideas to tangible business opportunities.

The next layer of the concentric model is system thinking. Business opportunities have to be put into perspective and the whole system of individual and organizational interaction has to be reconsidered. Critical reflection of one's position in relation to the new system will consequently trigger new learning. It is most likely that a number of skills will become obsolete and will have to be replaced by new skills. The skill transformation calls for responsible and active learners or else no change will happen. Gradually a theme of "life long learning" [26] emerges on the business horizon. This notion is quite a challenge in itself as it conflicts with traditional way of looking at education. A prevailing belief goes that once graduation is behind, there is "only work to be done". The last circle of individual transformation – facilitative leadership - leads to the sphere of organizational transformation. Facilitative leadership is a pivotal point, whereby the impact evolves from individual into collective scale. The individual affected has completed the personal transformation cycle and is now skilled and ready to spark changes in others.

Organizational transformation initially starts within the smallest nucleus of the organization, which typically happens to be a team or a small group. The team reinforces the changes with cooperation and collectively analyses the client needs. When several teams or small groups interact, the level of complexity increases exponentially [27]. This calls for a higher skill level of human interaction. As change grows, the likelihood of miss communication and errors by default is usual. A good skill set of human interaction, aids in minimizing these side effects of change. This concludes the final circle of organizational transformation.

Now as the individuals and the organization are mutually aligned against the new client needs, the attained changes have to be institutionalized. This happens by injecting three critical skills into the organization: Organizational Development, Organizational Performance and Organizational Leadership. The first institutional skill is work management. The relevant procedures and system documentation have to be updated, so that the new operating discipline reflects the client needs.

Interaction across organization has to be reflected in business and work processes, which are aimed at client needs. Figure 2.7, which is repeated as Figure 4.2 in Chapter 4, where it is discussed in detail, illustrates how the individuals within organization and the organization itself are aligned by the appropriate process management [28]. The last circle in Institutional Transformation is Organizational Leadership. The senior management of any given organization has to ensure that the transformation is complete and translated into results. The latter has to initiate an appropriate evaluation cycle to validate the degree of transformation on the three levels against client satisfaction. Furthermore, intelligent tracking mechanisms are needed to ensure continuous improvement and monitoring of the client needs in order to stay up-to-date and connected.

Figure 2.7. Concentric Structure of Competencies Centred at Client Orientation.

In the above figure, the gray levels identify sequentially outward the individual, organizational and institutional transformations (figure 2.6), required to attain the central client satisfaction and the development of the ten selected competencies.

2.6.3 Transformation through Structured Education

The discourse of the previous sections clearly points out to the need of a large amount of education and competency building to achieve sustainable transformation. With the aim of being efficient, the taxonomy of educational objectives needs to be followed [29,30]. The well organized learning process suggests a hierarchy of six levels, as described below:

1. Knowledge – getting familiar with and memorizing information

2. Comprehension – paraphrasing text; explaining concepts in jargon-free terms

3. Application – applying course material to find solutions to uncomplicated problems

4. Analysis – solving complex problems; developing process models and simulations; troubleshooting equipment and system problems

5. Synthesis – designing experiments, devices, processes and products

6. Evaluations – finding an alternative and justifying the choice; optimizing process; making judgments about the environmental impact of engineering decisions; resolving ethical dilemmas

Throughout this research the above taxonomy has been followed. Initially, knowledge in form of "Enhancing Team Performance©" training was conveyed. Comprehension was tested through various surveys. Throughout the duration of the integrated project the knowledge application has been validated. The analysis took place over the survey period and the integrated project work, bringing about improvements which resulted in enhancements – a characteristic. typical to the synthesis stage. Finally, the overall evaluation happened in form of surveys, judging the outcome of the integrated project, as well as providing recommendations for future work as documented in chapter 5.

By the token of application of the above taxonomy, the ABET accreditation criteria is equally fulfilled [4]. For that reason, it is viable that the School of Chemical Engineering of Tarragona applies for the official accreditation of ABET.

2.7 Creating Support for Change

There is a fundamental need in any organization for implementing structured approaches towards a major change. Consequently, the necessary infrastructure for successful implementation of the current proposal for the ETSEQ had to be consciously created. The followign four items were considered:

- Develop Change Leadership. In a series of workshops, faculty members and above all professors, have been exposed to the change management process and its application. During this exercise, the participants realized how much of a change that would mean to the way of "running business" or in other words "teaching". In addition, a number of selected professors and PhD students were assigned a stronger leadership role in order to enable the changes. However, maintaining the leadership level to reengineer the curriculum and sustain the changes, will yet require considerable effort. As a supporting measure for the above, university management reviews (i.e. dean, etc.) were organized not only to assure top leadership support, but also to provide resources (in form of PhD students, graduate students, and credits for professors, when participating in the new way to teach) for the necessary culture change
- Build and Develop Project Team. As discussed above, a small group of professors/PhD students were additionally educated to perform the role of a

project team. The group meets on regular basis to review progress and provide improvement plans to the school to maintain the momentum

- Identify and Manage Expectations of Stakeholders. The ultimate objective is engaging the total organization, or in this specific case, the total school. In order to do so, upfront education sessions have been provided at the beginning of the new academic year, so that the students were informed by their professors/leaders concerning the plan forward. For that purpose, two-day teamwork skill building introduction sessions ("Enhancing Team Performance©") have been set up to develop a common foundation throughout the entire school
- Design and Execute Communication Strategy. It would be an exageration to state that there was clear and well articulated communication strategy. However, all the above efforts of education and communication have definitely resulted in an increased awareness and support of this reengineering project

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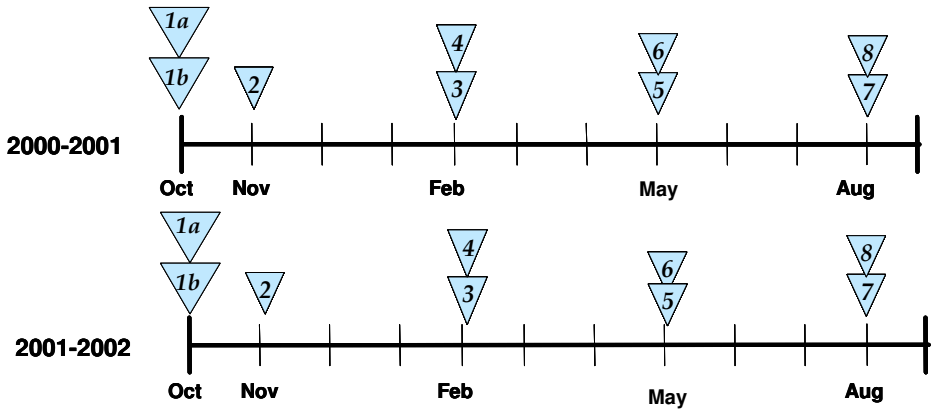
Chapter 3

Experiments, Evaluations and Measures

3.1 Design of the Experiment

The design of the surveying experiment followed the standard procedures of behavioral science research [1,2]. Initially, a base line was established before the intervention took place. Subsequently, sample points were planned at different times to track the impact of the event. A decision was taken to design a specific survey tool in order to reflect the uniqueness of this research. The full survey catalogue is attached in Appendix B while Appendix C includes the improved ones. The graph below indicates how the original experiment was designed.



1a – baseline survey for team members

1b – baseline survey for team leaders/knowledge managers

2 – receiving the intervention

3 – team members 3 months after the intervention

4 – team leaders/knowledge managers 3 months after the intervention

5 – team members 6 months after the intervention

6 – team leaders/knowledge managers 6 months after the intervention

7 – team members 9 months after the intervention

8 – team leader/knowledge manager 9 months after the intervention

Figure 3.1. Initial planning for surveying baselines and student opinions

The academic year started in September/October. This is when the students (team members - 1st year students; team leaders and knowledge managers – 4th year students) had to respond to survey number 1, i.e. the baseline assessment. Consecutively, the same populations received the intervention (in this case "Enhancing Team Performance©"). This is reflected in the chart, as sampling point number 2. Immediately at the end of the intervention students had to fill out another survey. Survey number 2 has the prime purpose of getting feedback on content and delivery.

The next sample point was planned to take place approximately 3 months later (sampling point number 3 and 4). Here differentiation between team members and team leaders/knowledge managers is in place. The reason for this segmentation is to observe whether there are any differences in perception

depending on roles. In addition it was intended to see whether any variation of team leader's and knowledge manager's behavior reflected on the team members. The segmentation was also valid for the next chart point, which was planned to take place after six months (sampling point number 5 and 6). At this point in time it was of interest to find out which part of education had the greatest impact, to identify areas of improvement and to look for first signs of sustainability or retention [2]. The last sampling point was planned for 9 months after receiving the intervention, targeted at long term sustainability and the extent to which the skills were built.

For various reasons, the original design of the survey process and its sample points was not sustainable and had to be revised, as shown in Figure 3.2. It would be adequate to admit that the logistical effort to translate (from English into Catalan), distribute, fill-out, track, collect, evaluate, and translate back (from Catalan into English) was underestimated.

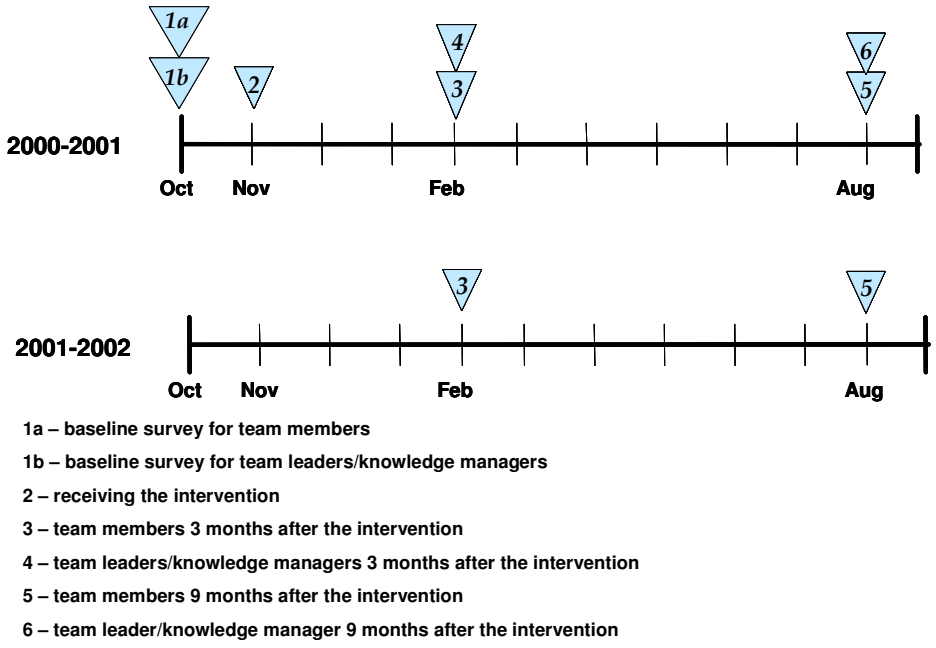


Figure 3.2. Revised planning of surveying baselines and students' opinions

Figure 3.2 indicates that following the first round of surveys it became evident that the original pace at which relative progress of competency building should be observed was not sustainable. In fact it was possible to obtain the baseline survey for team members and team leaders/knowledge managers only in the first academic year 2000/01. The intervention took place 1 month after the baseline survey and was followed by the survey of 3 months for both sets of population, and then finally 9 months yet again for both sets of the population. The evaluation of the 2000/01 survey results that follows, focuses on the periods after the baseline survey reviews were carried out. The majority of the argument is centered on 3 and 9 months survey comparison for team members and team leaders/knowledge managers. The scenario at the beginning of the second academic year 2001/02 was also altered by dropping the baseline surveys and focusing exclusively on the 3 month and 9 month survey comparison. The

experiment resulted in quite a number of recommendations used to create a better suited and simple survey, as outlined in chapter 5.

The preliminary findings of this research stem from the analysis of survey results. Conclusions are drawn by linking the qualitative outcome with project and individual marks of the students. Further research is needed to solidify evaluations and to be able to correlate in a statistically sound manner this and other interventions, and the subsequent behavior change brought about (see recommendations and proposed additional measures in chapter 5).

The translation, preparation, distribution, analysis, and synthesis of the surveys were undertaken under the supervision of the ETSEQ. Since filling out the surveys was a voluntary action (the survey was completely anonymous) it took quite some effort to encourage students to do extra work. Given this fact, the overall response rate was extremely high, above 90% on average. The surveys results are presented below in a graphical bar chart format illustrated in Figure 3.3.

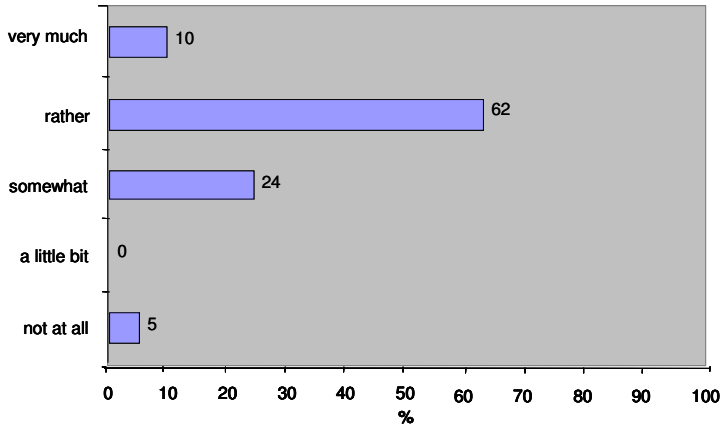


Figure 3.3. Example of the graphical representation of results

Figures 3.4 and 3.5 indicate the extent to which various questions had been answered by students in 2000/01 and 2001/02. As one can see from these two charts, the questions dealing with future solutions/comments/suggestions (questions number 2, 3, 4, 5, 32, and 39) were responded least by students. This is another indication that in ideal case scenario future surveys should not emphasize comments or reflective answers, but rather focus on multiple choice questions (see recommendations in chapter 5).

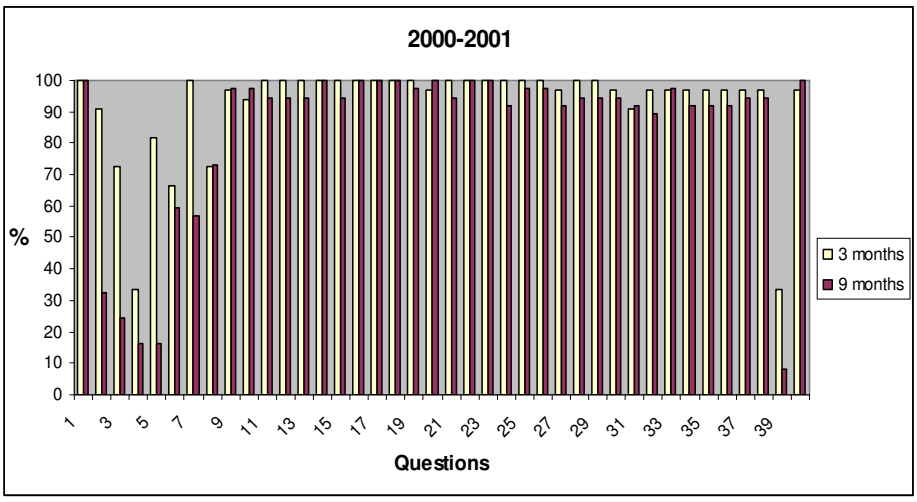


Figure 3.4. Survey questions answered in 2000/2001

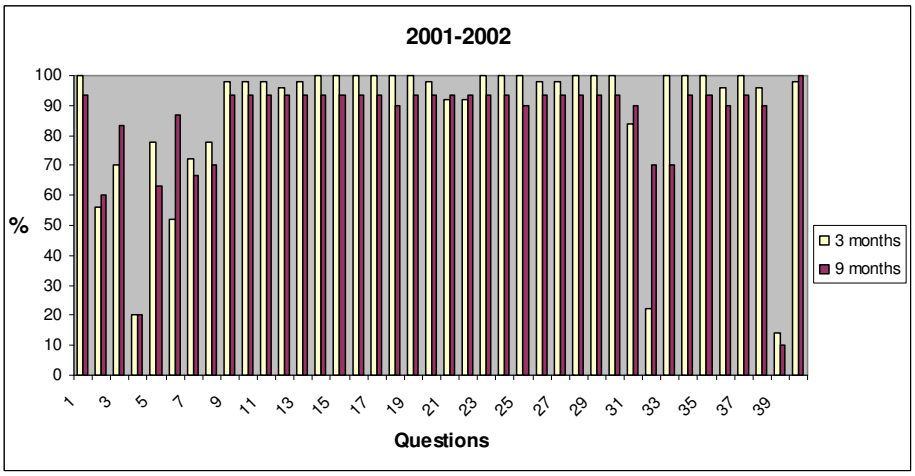


Figure 3.5. Survey questions answered in 2001/02

3.2 Evaluation of Surveys

3.2.1 Baseline Assessment in 2000/01

Previous experience of working in teams was limited in both sets of populations, team members (left graph) and team leaders/knowledge managers (right graph).

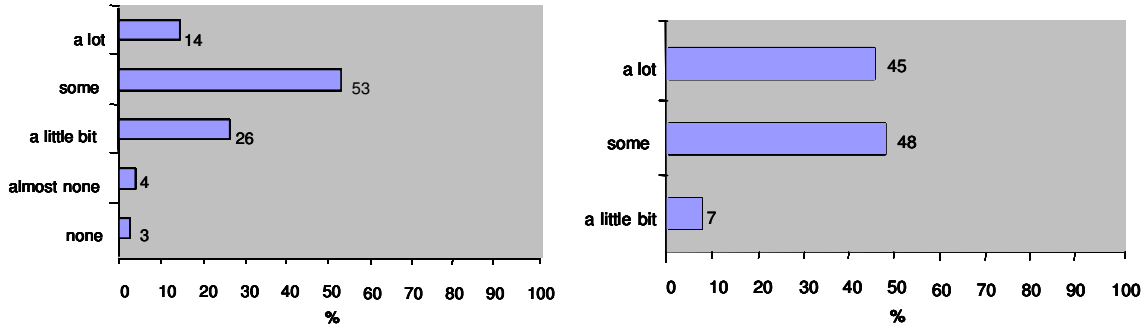


Figure 3.6. Experience of working in a team. Left - team members; right - leaders

It becomes apparent from Figure 3.6 that the integrated project was a true opportunity to practice teamwork in a more structured manner. Also, it is quite surprising that the majority of team leaders, who did have previous experience of working in a team in the 1st year projects, state that they only had some experience in working in a team. The reason for that is the de-motivation caused by the lack of well established IDP in 2nd and 3rd year of their studies.

The effects of the impact of the 1st year IDP on team leaders is clearly reflected in Figure 3.7. A large number of students, 74 of them, pointed out that they acquired experience of teamwork through the projects at university, while 27 did so at home or in team sport activities. It should be noted that in the academic year 2000/01 there were many students enrolled in the 4th year project practice course and, thus, 117 answered the survey. However, not all of them were involved in 1st year IDP teams, neither as leaders or knowledge managers. Other projects were set in place to accommodate this peak of participation in 4th year enrollment.

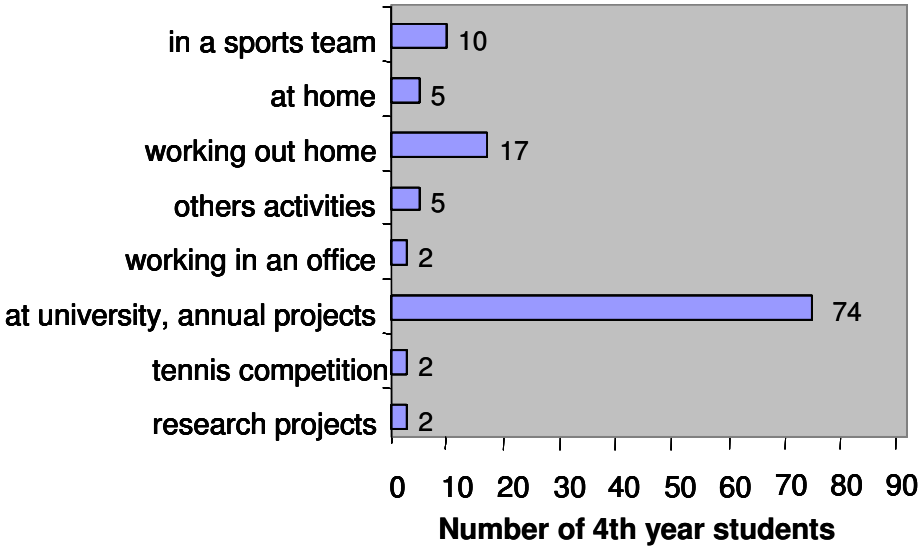


Figure 3.7. Experience of working in a team (leaders)

Team members manifested that in their pre university teamwork experience they found the greatest difficulty in the team capabilities (25%), followed by conflict resolution (18%), communication (13%) and performance evaluation (11%), as shown in Figure 3.8. When 4th year students were asked about the challenges of teamwork that they expected, there is a clear pattern in Figure 3.9 leaning towards conflict resolution (24%) and communication (21%), followed by team capabilities (17%), operating procedures (17%) and dealing with change (10%).

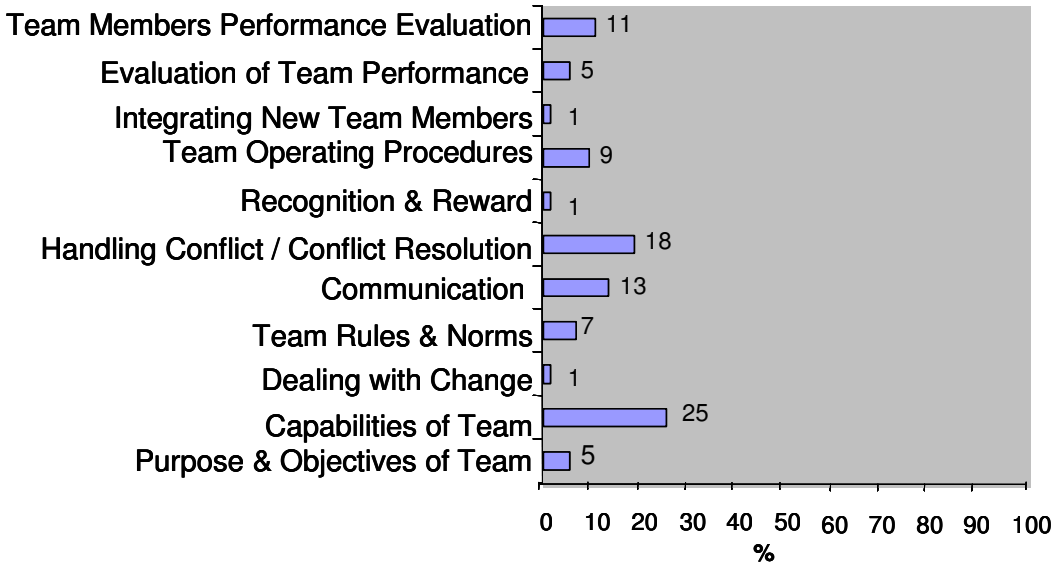


Figure 3.8. Areas of greatest difficulties expected by team members

Comparison of Figures 3.8 and 3.9 shows that team leaders and knowledge managers are more specific in identifying/forecasting problems/difficulties as 89% of them anticipate the above 5 areas of difficulty among the 11 options. A similar but more diffuse pattern is detected in the 1st year students. They seem to be more concerned about performance evaluation of team members, which is of no surprise given the individualistic approach of junior, high and baccalaureate education in Catalunya.

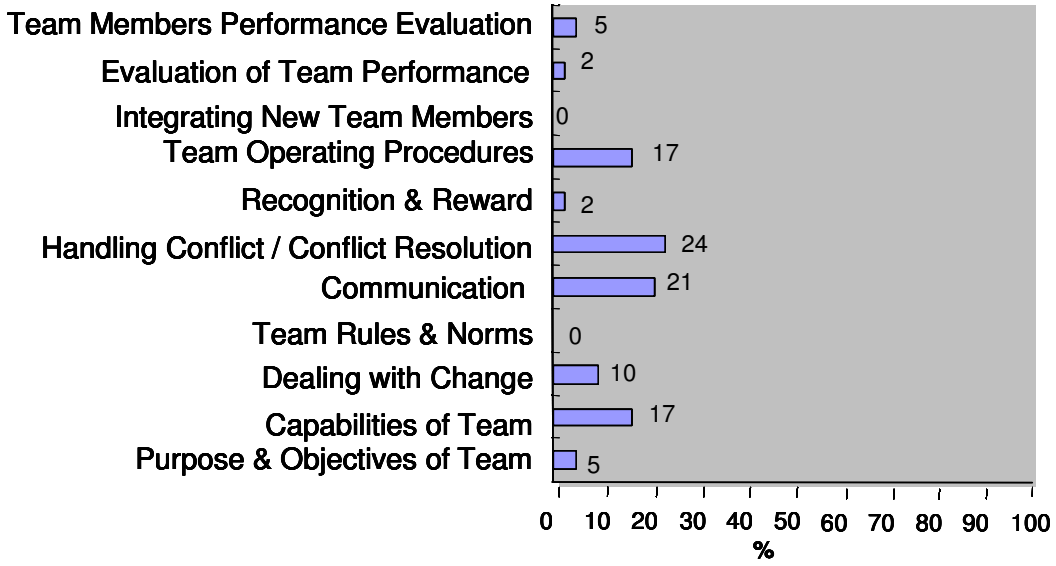


Figure 3.9. Anticipated areas of difficulty by team leaders/knowledge managers

Interestingly enough, there is quite a difference in replies when asked the preferred style of delivery to improve the competency set. Team members, to a large extent (80%) in Figure 3.10, prefer interactive and experiential learning, followed by coaching support. They had not yet experienced the effort required to build a team and to change from am individual centered working space to teamwork.

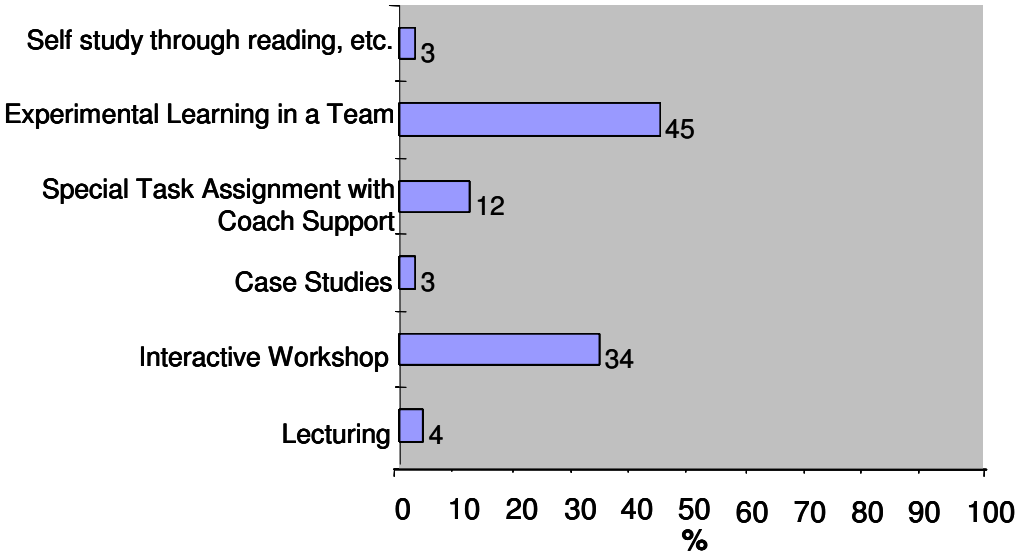


Figure 3.10. Training/learning method preferred by team members

To the contrary, team leaders and knowledge managers favor lecturing, followed by coaching in Figure 3.11. In informal discussions with 4th year students they manifested very clearly that they did not understand why they were asked to work in teams and in well defined/structured IDP, such as in the 1st and 4th year project scheme of Figure 1.4, if afterwards they had to return to conventional lecturing format in most of the academic activities of the 2nd and 3rd year of the chemical engineering program.

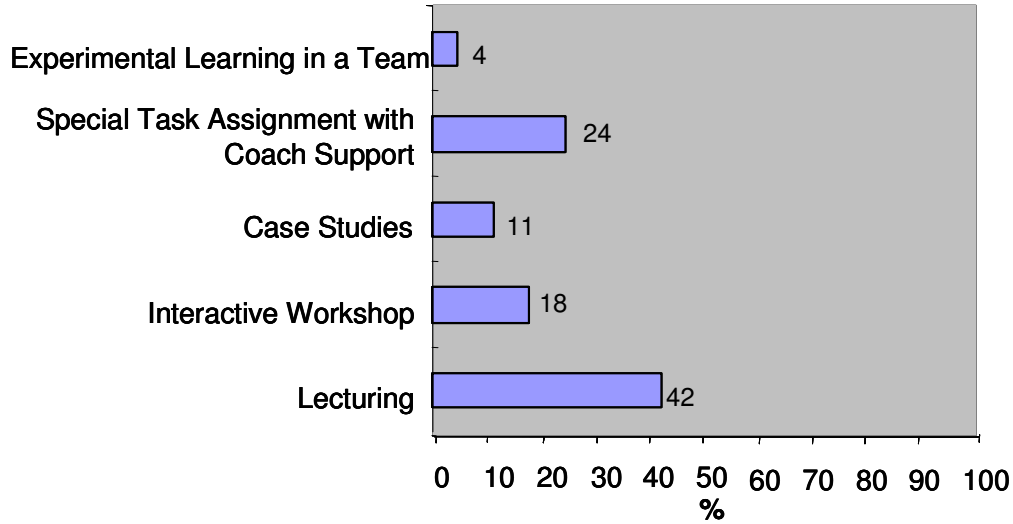


Figure 3.11. Training/learning methods preferred by team leaders/ knowledge managers

The above results also correlate with empirical data [3] obtained by business organizations, like the Dow Chemical Company, stating that over time if not properly coached (see also recommendations in chapter 5), team leaders tend to lean towards a hierarchal role and forget how it feels to be on the “receiving end”.

When investigating further, the self perception of team leaders and knowledge managers is that of wanting to be creative and visionary, and leading by example,

as shown in Figure 3.12. They also want to have an informal and independent leadership style, as depicted in Figure 3.13.

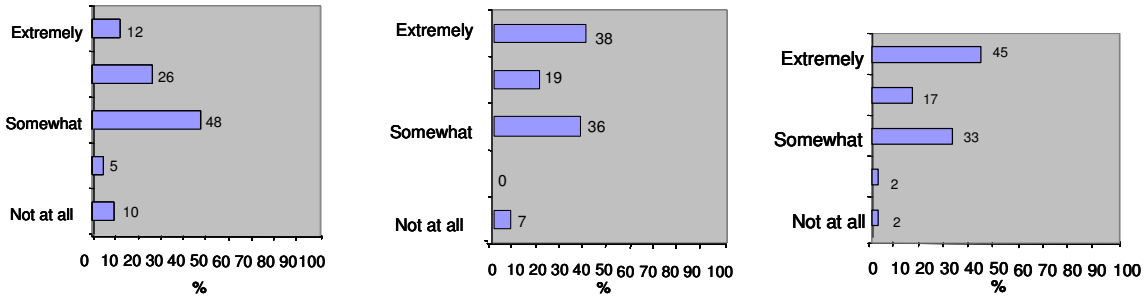


Figure 3.12. The perception of leaders and knowledge managers in regards to creativity, vision and capability of leading by example, respectively

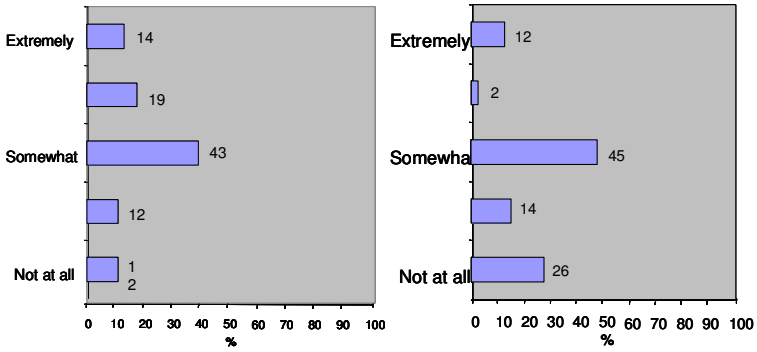


Figure 3.13. Perceived styles in team leaders and knowledge managers

That same population of 4th year leaders and knowledge managers claims that their role should also be people oriented and driven by performance and reward, as respectively shown in Figure 3.14.

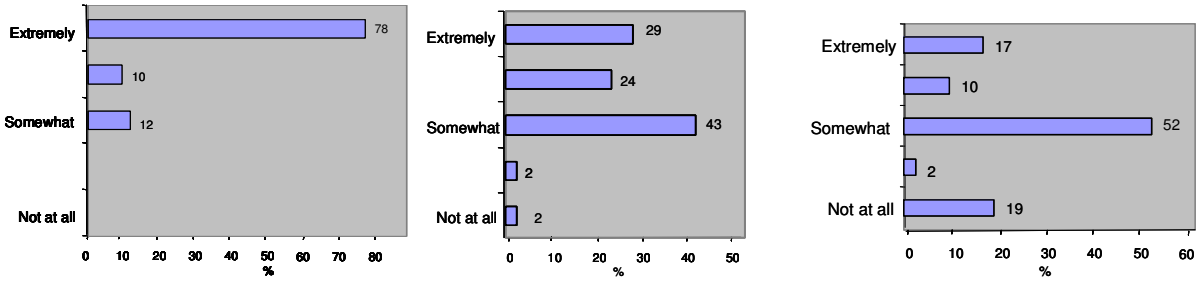


Figure 3.14. Perception of role orientation by 4th year students towards people, performance, and reward respectively

Again, these trends are congruent with other research data [4] on defining the role of a team leader. Research also supports certain characteristics and behaviors which increase team performance [5].

3.2.2 Survey 2 in 2000/01. Team Members after the Intervention

Survey number 2 was taken right after the delivery of the intervention “Enhancing Team Performance©”. As illustrated in figure 3.15, the overwhelming majority of participants perceived this intervention as rather helpful.

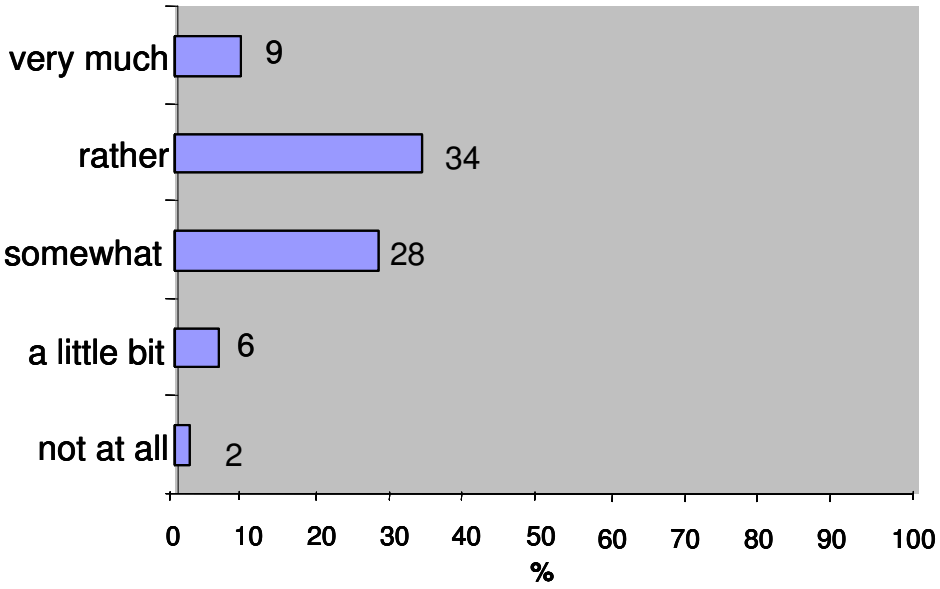


Figure 3.15. How helpful is “Enhancing Team Performance©”?

Communication and conflict resolution are confirmed again as two of the areas of higher concern since 43% of students think that “Communication and Conflict” is the most valuable module of the intervention, as shown in Figure 3.16. It will be seen later on (see chapter 5) that the positive correlation between handling conflicts and team effectiveness is proven again [6].

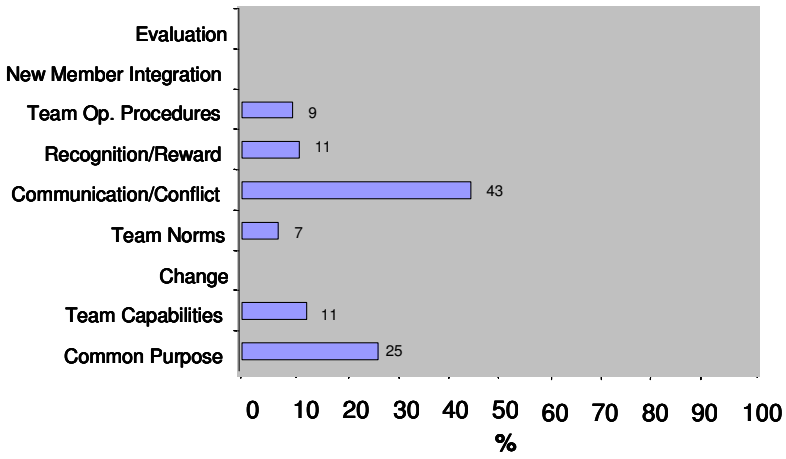
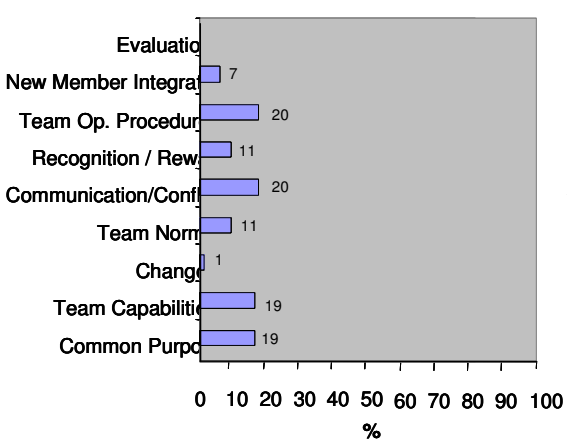
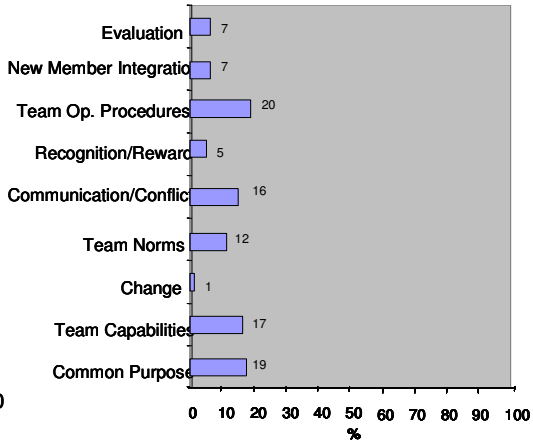


Figure 3.16. Rating of first most valuable module in “Enhancing Team Performance©”

In the list of priorities given in Figure 3.16 the module “Common Purpose” is ranked as number two (25%), followed at the same level by “Team Capabilities” and “Team Operating Procedures” (11%). The ratings in Figure 3.17 for the second most important module confirms “Common Purpose” while in third place appear “Team Operational Procedures”, “Common Purpose”, “Team Capabilities” and “Communication and Conflict” practically tied at about 18%.

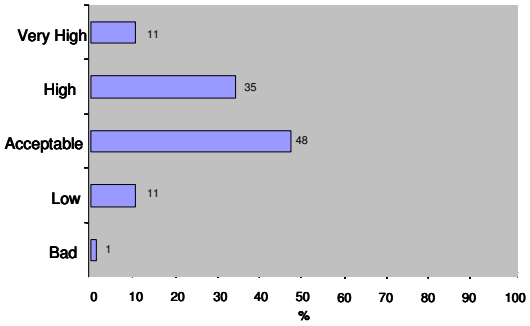


The second most important

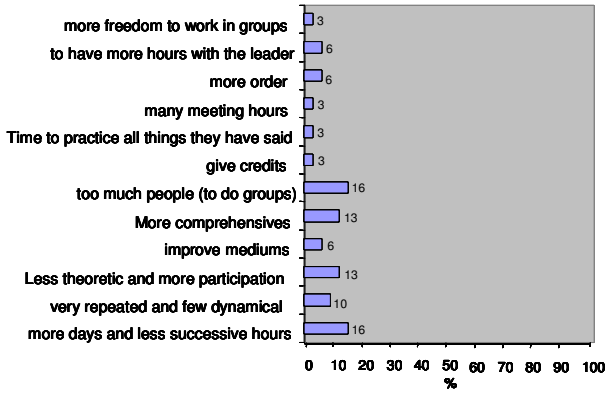


The third most important

Figure 3.17. Ratings for the second and third most important modules in "Enhancing Team Performance©"



Effectiveness



Negative items

Figure 3.18. Effectiveness and suggestions for improving the delivery process

The effectiveness of the delivery of the intervention is rated on the high side, as shown in Figure 3.18. Once more, the above data correlates with similar research and confirms the pattern of key principles to enhance team effectiveness [7,8]. When it comes to effectiveness of delivery, the majority of recipients seem to be satisfied. However there are some areas for improvement, as listed also in Figure 3.18. Possible scenarios will be presented in chapter 5 on how to improve "Enhancing Team Performance©", using the recommendations in this figure.

When asked about preferred working styles, it becomes clear that working in teams is not very common across the surveyed population, which reflects to a certain extent cultural patterns [9]. The results are shown in Figure 3.19.

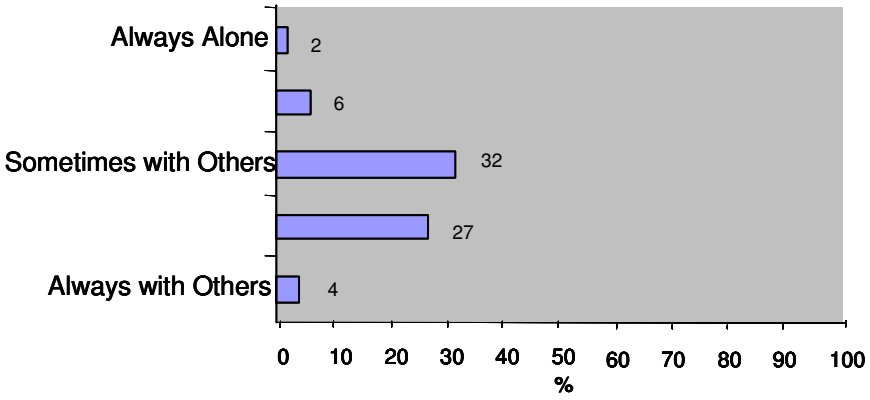


Figure 3.19. Preferred styles of peer interaction prior to university

3.2.3 Surveys 3 & 4 in 2000/01. Team Members 3 and 9 Months after the Intervention

Surveys 3 and 4 represent the core of the survey process, as here one can see progress instigated by the social intervention "Enhancing Team Performance©" and observe whether there are sustainable changes in behavior patterns.

Not surprisingly the module on "Communication and Conflict" is the most critical one, as has been confirmed by numerous other researches [6]. Moreover, the case is confirmed by the Dow organization experience [10]. It is apparent that the ability to communicate and to solve problems constructively are key competencies when driving team performance irrespective of whether it concerns a business or an academic environment, or any other social and collective environment. This is consistent with the current research hypothesis that team or group dynamics is a "basic human phenomenon" irrespective of environment. Indeed, there are cultural patterns which are impacting group phenomenon [9] but not the basic concepts. As a cultural issue, one could consider the increased need for operating procedures, a tribute that has to be linked to the Mediterranean work environment in which this research is operating [9].

When asked which module of the "Enhancing Team Performance©" training helped most the work so far, team members attribute initially high importance to the modules "Communication and Conflict", "Common Purpose", "Team Capabilities" and either "Team Norms" or "Team Operating Procedures". The perception that these modules are very helpful increases over time, as indicated by the 9 months results in Figure 3.20. Similar trends were obtained when rating the second and third most helpful modules. The results in Figure 3.20 are consistent with research in this area [8].

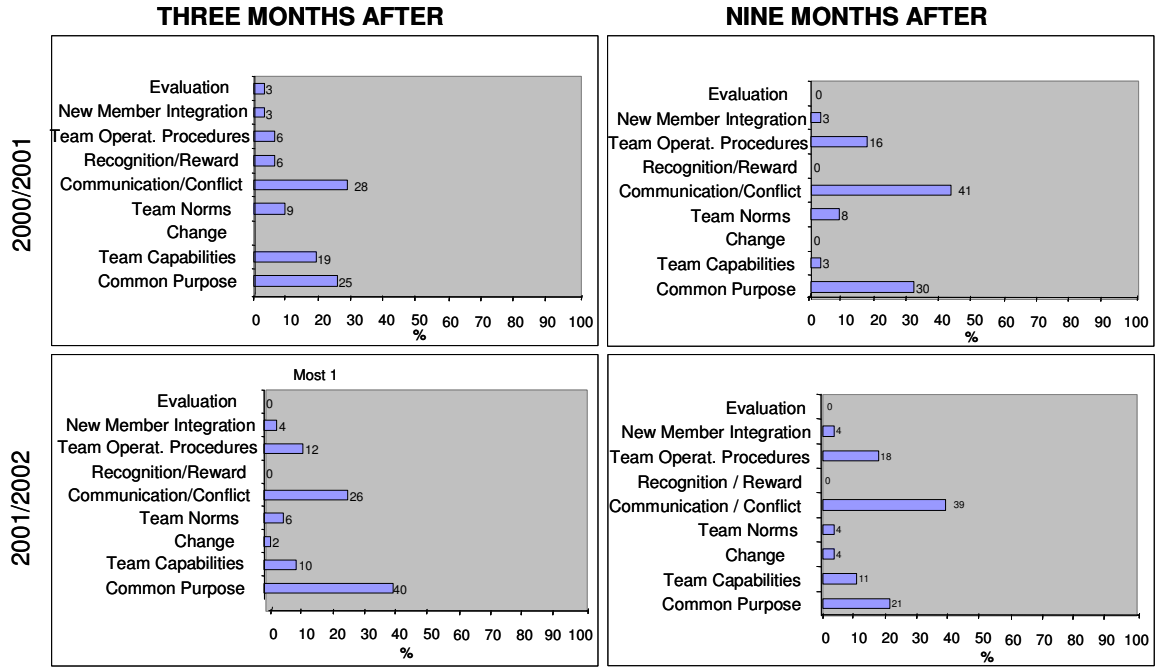


Figure 3.20. The most helpful module as rated by 1st year students

The answers in Figure 3.21 on how the most importantly ranked item from Figure 3.20 helped them, indicate that delivery of the social intervention clearly correlates with the ability to perform a certain task. In this case, the most important task is to finish the integrated project. It is noteworthy that after 9 months the students realize the critical nature of the project and the importance of social intervention in aiding the project performance. Consequently, time pressure forces collaboration and in a way, serves as an aid to a certain extent.

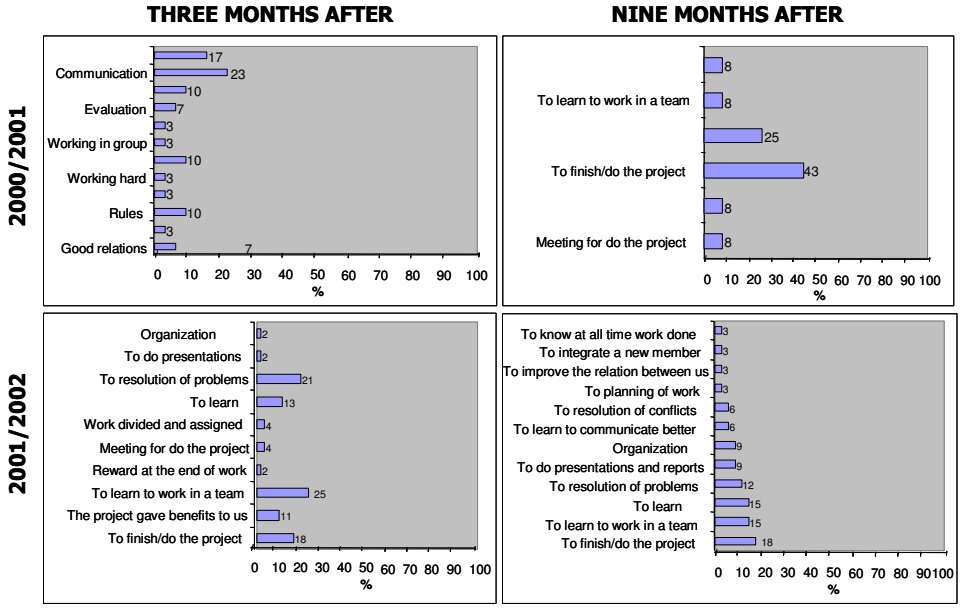


Figure 3.21. Specific examples on how helpful modules assisted students

When it comes to the students' need for additional help, Figure 3.22 shows that the majority would like to see more support when it comes to "difficult subjects". When asking students what that meant, they primarily look for additional knowledge (a task for the knowledge manager), and also for additional

competency building in this area. That would mean applying specific knowledge to the integrated project, and also expanding beyond traditional ways of studying, contrary to lecturing in a classroom (a task for the team leader). Over the surveying period, the need for additional help moves from generic declaration to more specific descriptions, akin to asking for more on “Communication and Conflict” to “improve the relationship between team members”. That in itself is a sign of an improved trust amongst the team and as a consequence, a qualitative indicator for the success of the social intervention.

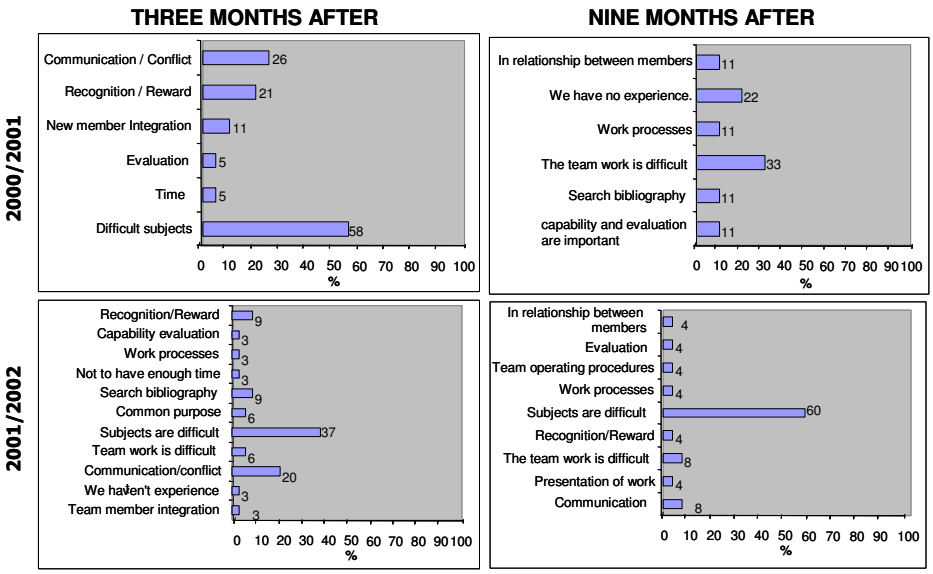


Figure 3.22. Areas in need of additional help

This is also supported by Figure 3.23 in form of the answers provided when asked for potential solutions.

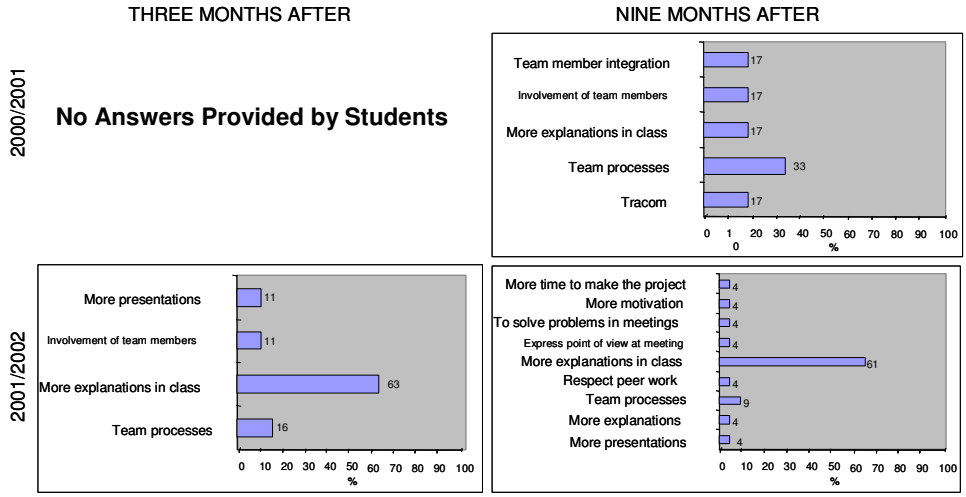


Figure 3.23. Potential solutions suggested by students

When asked where to put additional emphasis on education along the process, i.e., what issues do students think that were not yet covered, the students’ answers in Figure 3.24 were very consistent with what was stated at the

beginning: Communication, Conflict and Team Capabilities. One can observe that Reward & Recognition shows up which also confirms that the teambuilding process is working as team members are thinking about how to reward and recognize each other [8].

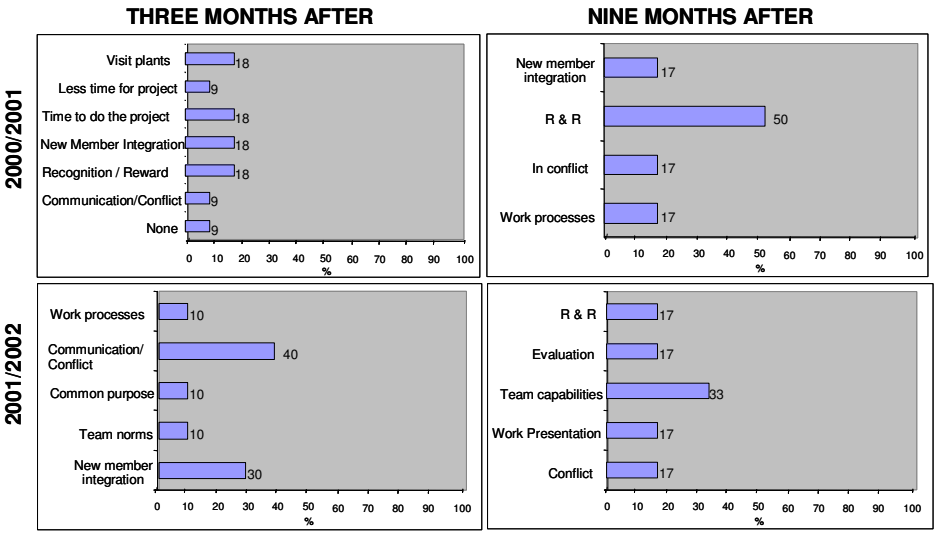


Figure 3.24. Uncovered issues where students need help

Figure 3.25 explores the students' work patterns when working as individuals. One can detect a shift in pattern when at the beginning of the studies, students were focused on reports and information search while at a later point in studies, problem solving and related issues become of greater importance.

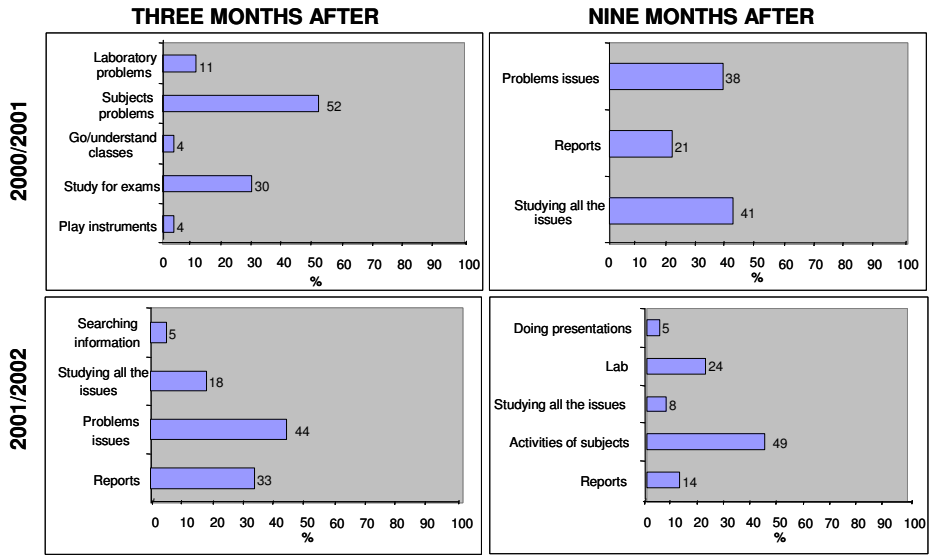


Figure 3.25. None team work related activities that students mention when asked to list two carried out on their own

Other research [10] supports this trend and confirms the students' increased awareness regarding evaluation as critical part of good project work. Students also mentioned that project, subject and laboratory activities are the three ones, where they had an explicit plan for expected tangible results. The impact of self evaluation remains inconclusive. While there is no obvious change in pattern

concerning the task of evaluation, one can detect a pattern change when it comes to ownership. Figure 3.26 indicates that students assume greater responsibility overtime, hence greater ownership of obtained results, which serves as clear indication of the progress towards the team building process [8]. The answers reported in Figure 3.26 were given when asked if the students' responsibility for results obtained had changed in respect to prior to university. A similar change in pattern with time was also observed when analyzing work planning activities.

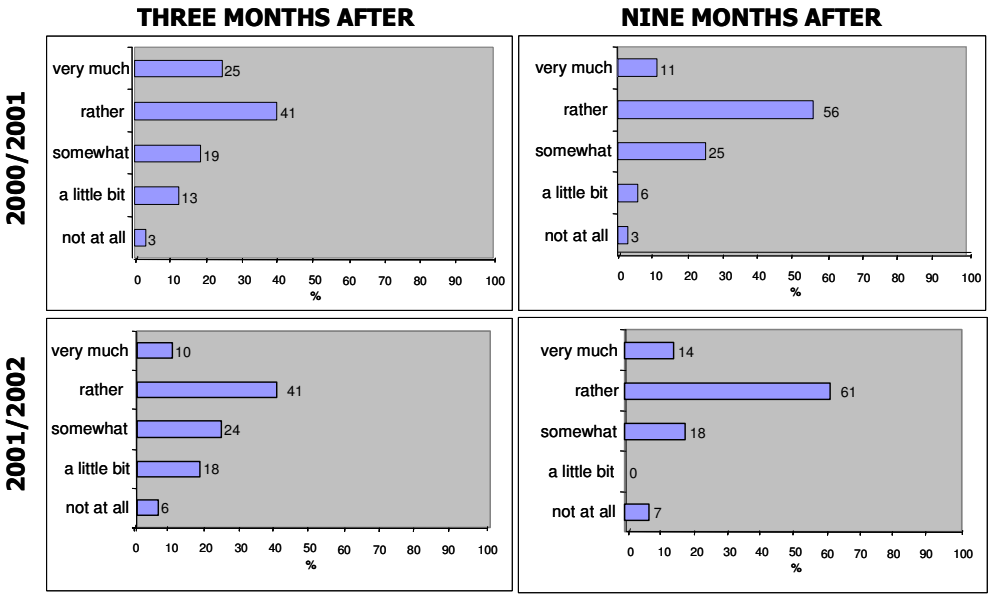


Figure 3.26. Shift of attitude towards ownership of results

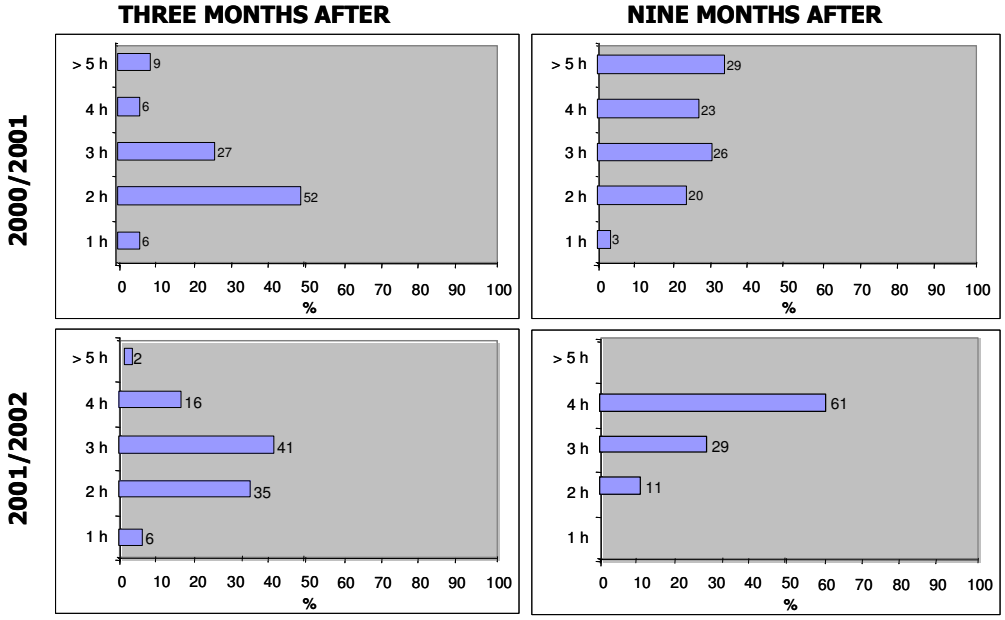


Figure 3.27. Interaction of team members with the team leader

The relationships within teams are analyzed in Figures 3.27-29. The weekly hours dedicated to meet with team leaders and knowledge managers increase significantly with time after the intervention, as shown in Figures 3.27 and 3,28.

While these are positive trends, they still represent an area for improvement. Apparently, as deadlines for the integrated project get closer, team members realize how much work still needs to be done and consequently call the leader for help. In the recommendations for future improvements (see chapter 5) measures are proposed on how member and leader interaction could be triggered much earlier. By doing so the team benefit would be increased, in addition the team would become more mature and consequently more sustainable in its performance. The same mechanics apply to interaction with the knowledge manager. Here, an earlier transfer of knowledge would be also desirable (see chapter 5). In conclusion, additional skill building for team leaders and knowledge managers is required.

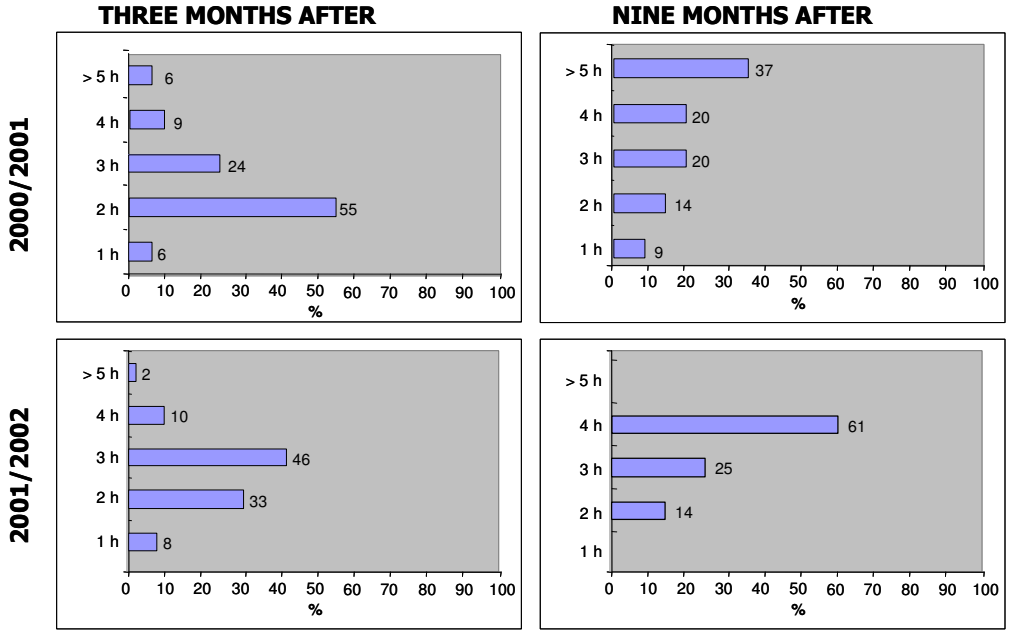


Figure 3.28. Interaction of team members with the knowledge manager

There is also a considerable increase in frequency of talking to peers, as depicted in Figure 3.29, but still more dialogue would be desirable. Perhaps roles between team leader, knowledge manager, and team members were not fully understood and consequently led to confusion and loss of productivity within the team. Again, this is addressed in chapter 5.

Naturally, the increase in time spent with peers shown in Figure 3.29 translates into more team meeting time. Results not presented here also show a corresponding increase in the percentage of the total time of team meetings that is dedicated to discussions with peers. The significant shift towards more than 5 hours per week spent in meetings with peers observed in Figure 3.29 indicates that teams are moving from a leader directed to a leader centered one (see also Figure 4.1). “Enhancing Team Performance©,” which aims at this change, is a robust learning resource, since it drives improvement despite occasional absence of “management support” represented by non coaching professors. The difficulty will be further addressed as an area for improvement in chapter 5.

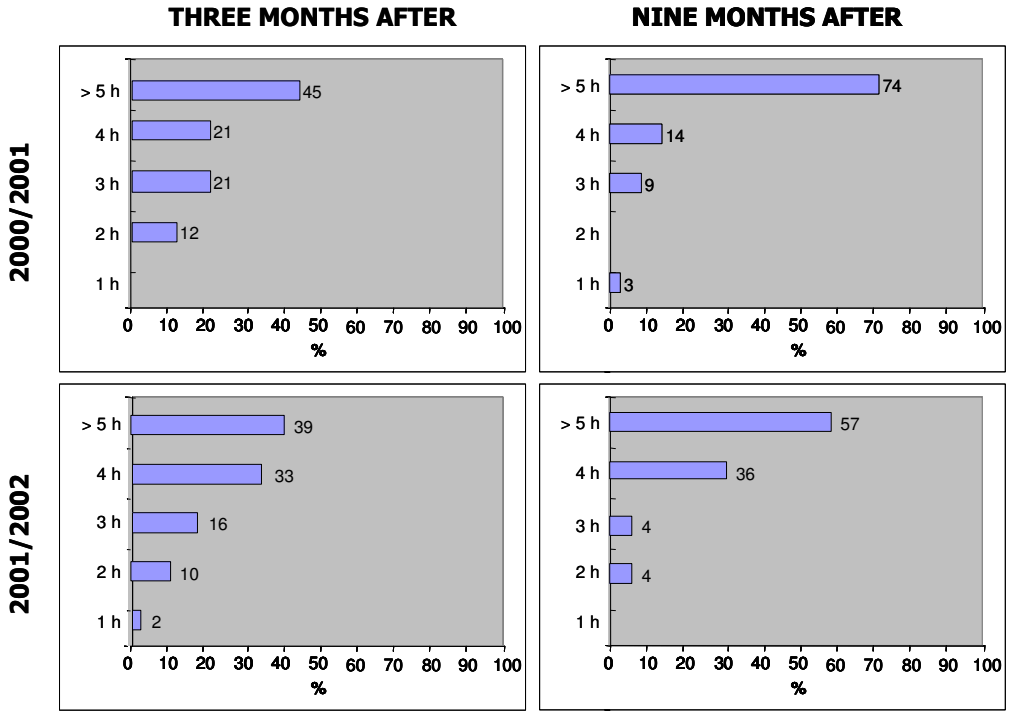


Figure 3.29. Frequency of peer interaction

In responses to question on percentages of total time allocated to team meetings that were dedicated to scientific or technical discussions, summarized in Figure 3.30, one can notice an increase in the intensity of discussing scientific or technical matters as the deadline for the integrated project gets closer. The fulfillment of deadlines precipitates discussions and the decision making process for the final report and poster.

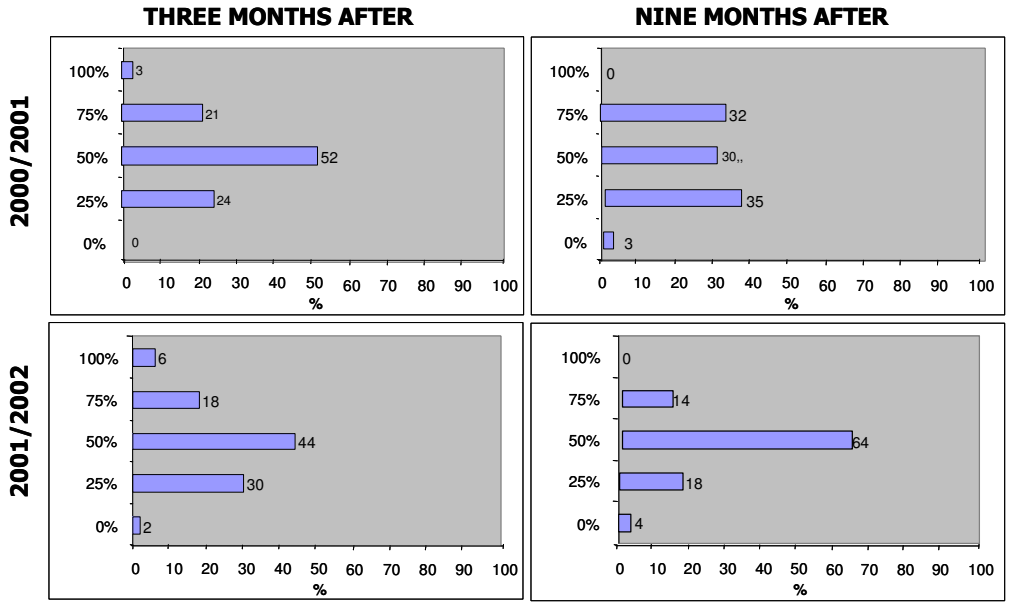


Figure 3.30. Team meeting time dedicated to discuss scientific and technical matters

As one would expect from a good team building process, both team members and their leader recognize the need to spend an appropriate amount of time

discussing issues related to their team in order to build productive “team hygiene” [8]. Results not shown here indicate that the time dedicated by teams to discuss organizational matters remains unchanged at about 25% of the total time allocated to team meetings during the IDP period.

While there is a considerable and sustainable change in team patterns, no change in individual patterns has been detected, as highlighted in Figure 3.31 for the particular attitudinal aspect of listening or talking in meetings. At a first glance, the results in this figure appear to be logical, as “Enhancing Team Performance©” is primarily an intervention focused on team behavior and not so much on individual behavior. Individual behavior can be ultimately changed only when working with a team and under leadership over an extended period of time [8,11]. Individual learning is further addressed in the areas for future improvement (see chapter 5), since reflection of team patterns on the individual is critical and should result in greater individual learning than that reflected in Figure 3.31. As a preview, it can be concluded that it takes work on individual, team and organizational level to change behavior in a significant and sustainable way.

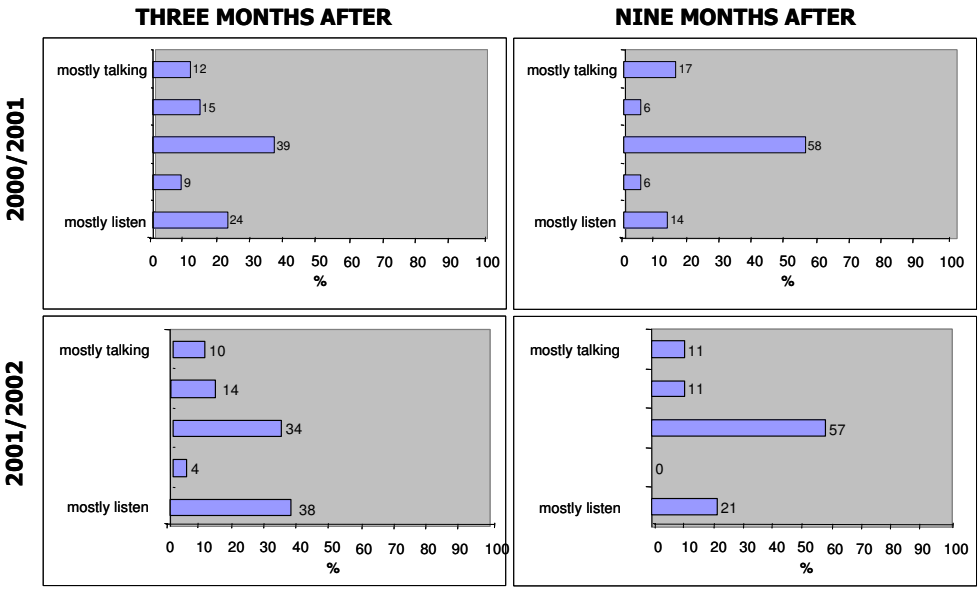


Figure 3.31. Example of team members’ evolution in respect to individual behavior change during team meetings

Other responses not presented here showed that no significant change in the way participants attempt to contribute to the purpose of the team is detectable over time. This fact could lead to the conclusion that the principles of effective teamwork are not fully engrained. Based on theory and research [8] one would expect an eventual reduction in the effort needed to discuss the purpose of the team. This is because the purpose of the team has become fully evident and is accepted by all team members. This pattern also seemed to be true for the contribution of team members to planning and realization of projects by teams. Nevertheless, a positive change in behavior was observed with respect to the evaluation of causes for success or failure in teamwork. Participants were much more engaged in follow-up and analysis of results after the intervention and as project deadline got nearer.

Figure 3.32 elaborates on the activities taking place between team leader and the team. It is apparent that resolving conflicts and communication are the key issues. Therefore team leaders should transform their role towards coaching, as team members clearly need help in this direction (see paper in Appendix A).

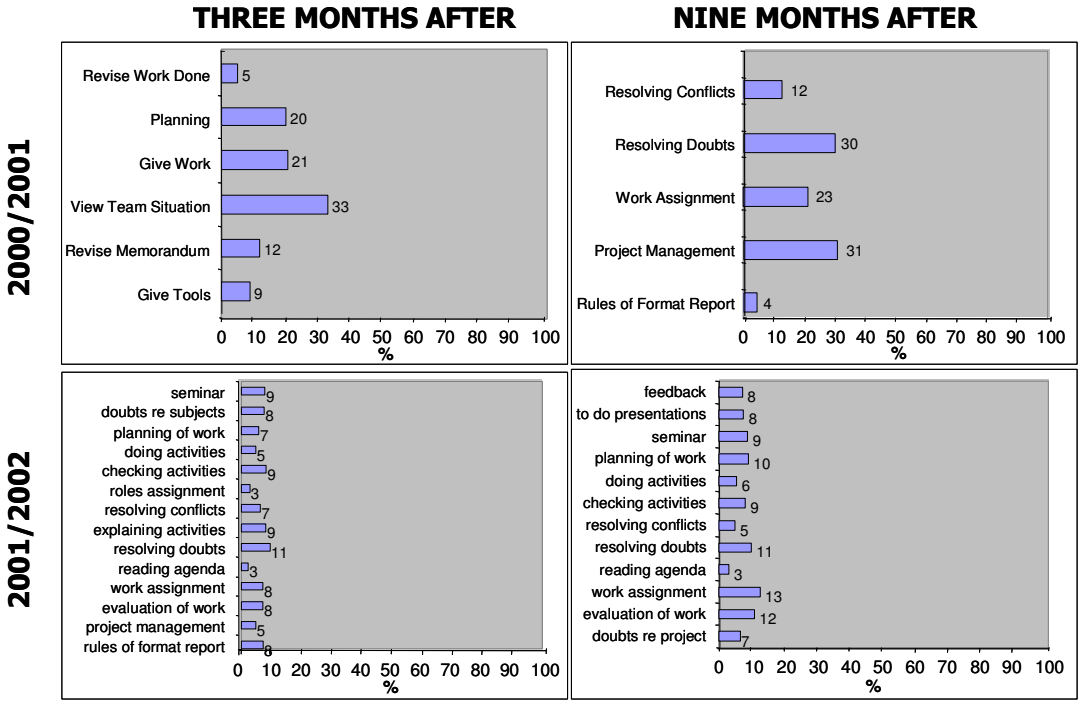


Figure 3.32. Most relevant activities carried out by team members with team leaders

The pattern in Figure 3.32 was also applicable to the knowledge manager, reconfirming that conflict resolution and question clarification are crucial elements of the project. The above findings are equivalent to the industrial work place. The business model organization for this research, The Dow Chemical Company, has a “social coach” and a “work process coach” (or technical coach). Both roles are absolutely vital to developing team skills and translating them into team performance [12]. Here the congruency between the academic organization and the business organization is very consistent. It can be stated, that irrespective of the nature of organization, social skills are best introduced when integrated as part of a process over at least a six months period with consistent coaching and support (enabling infrastructure) in place [13]. Besides the above mentioned recommendation (see chapter 5) a better structured dialogue among team members regarding role clarity is recommended. Despite role clarification being an important issue during any change in work pattern, it is still not adequately addressed in general [14]. In addition, there is too much focus on lecturing, which is consistent with the preferred style of teaching by team leaders and knowledge managers. Earlier in this chapter it has been referenced that this represents a conflict with the preference of the team.

Replies in Figure 3.33 concerning individual responsibility for work assignments, demonstrate high commitment to project work to begin with. That commitment increases somewhat overtime - yet not as much as desired. This represents an area for improvement, in form of a follow up intervention for the team as well as

additional education for team leader and knowledge manager to enhance their coaching skills (see chapter 5).

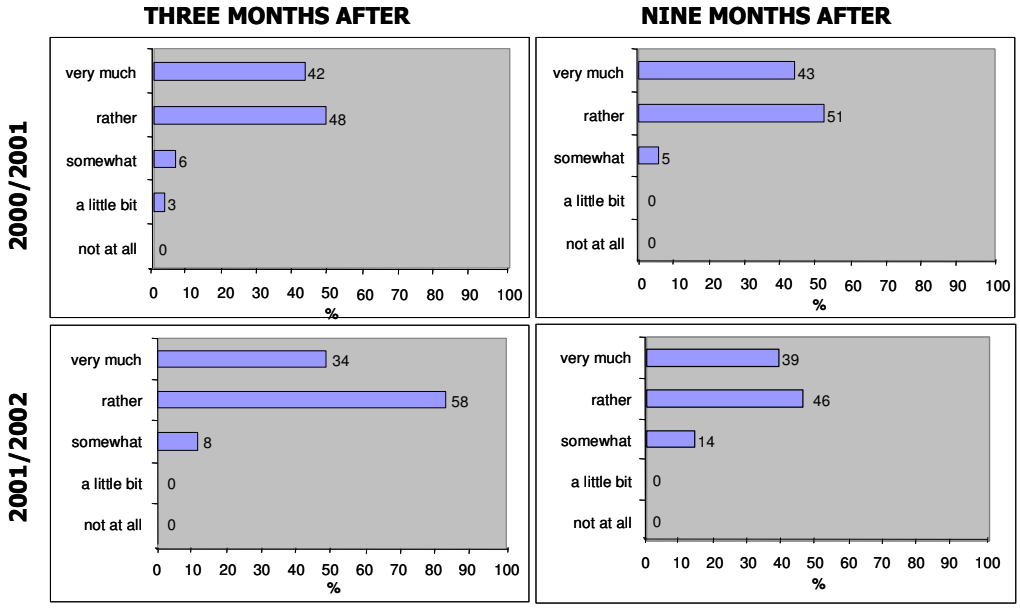


Figure 3.33. Commitment to project work in respect to work assigned to each team member by the team

The initial high commitment was also manifested by the fact that students hardly ever missed classes or team meetings. Also, there was an over time decrease in missing a team project deadline. Improved team skills and commitment to the team could be a possible explanation for this behavior.

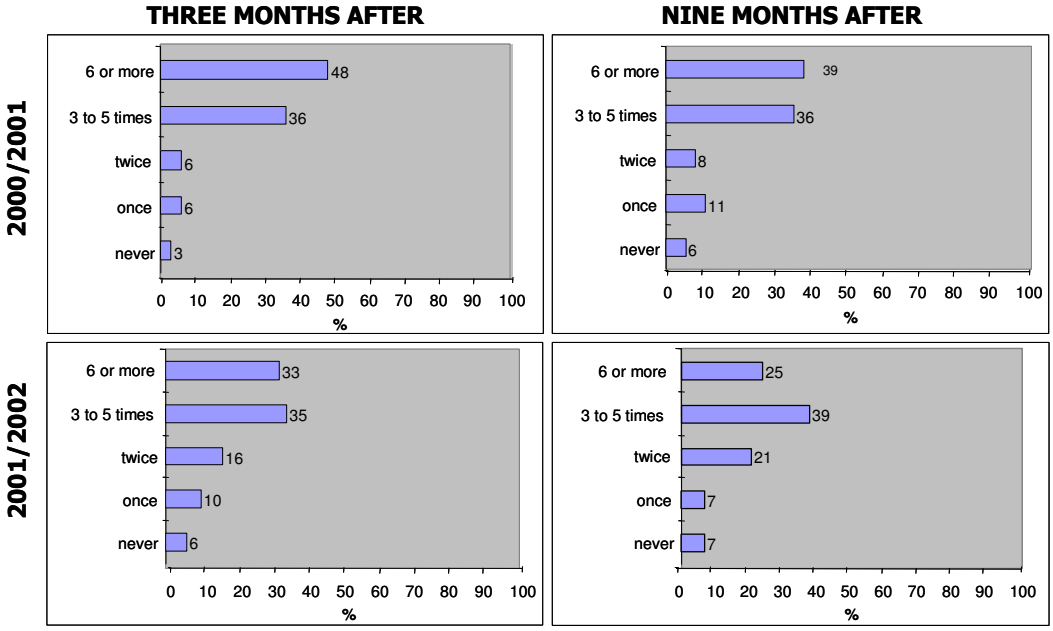


Figure 3.34. The frequency of peers helping their team members

The frequency of interaction between peers and the support they give to each other seems to be pretty constant over time in Figure 3.34. The high level of collaboration could potentially be attributed to the cultural pattern in this part of

the world [9]. Other questions on collaboration among team members confirmed a positive shift towards an increase in collaboration - an ingredient for team success. With respect to the opportunity to 'cross fertilize' by learning from each other, results showed that learning from peers still represented an area for improvement, as collaboration and sharing amongst team members has not yet reached its optimal level. It is acknowledged by various sources of research [15] that learning, sharing, and building on each other's knowledge amongst adults is difficult. This phenomenon is addressed in chapter 5 with recommendations for future improvements put forward.

When team members were asked how much they had learned from the discussions and interaction with the knowledge manager, they responded that the role of knowledge manager is a very helpful and an effective one, as summarized in Figure 3.35. One could speculate that at the beginning of the project a number of team members had already identified the knowledge manager as a source of information. Over time, more team members realize the value of the knowledge manager and apparently use this learning resource effectively. Despite that, the full potential of the knowledge manager role is not yet exhausted.

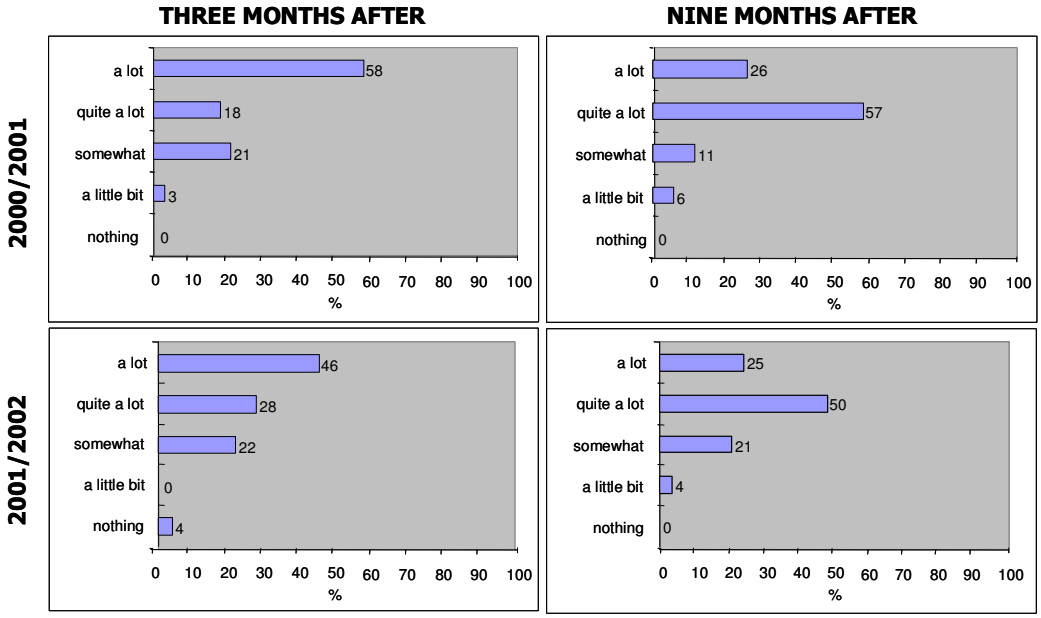


Figure 3.35. The role of the knowledge manager in each team

The fact that the potential of the knowledge manager role can still be enhanced is shown by the pattern in Figure 3.36, which illustrates that the resources outside of one's team (team members and knowledge managers from other teams) have not been utilized by a significant portion of the surveyed population. A majority of team members rarely interact with other teams in search for information or to establish partnerships.

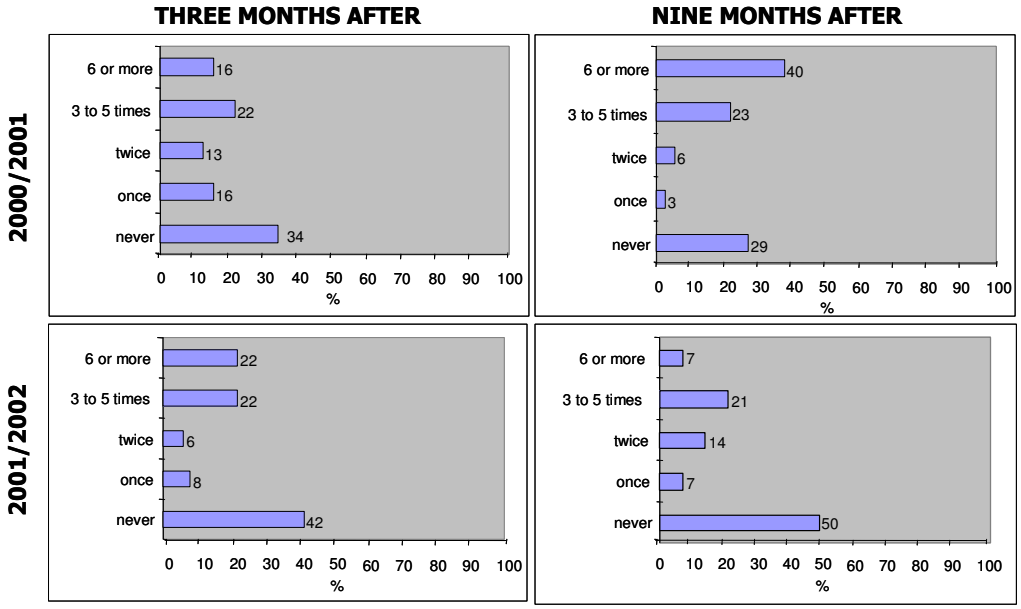


Figure 3.36. Cross team communication and interaction

Role rotation between team members is examined in figure 3.37. The test confirms that role change on a rotating basis is difficult to accomplish both within an academic and a business organization environment [16]. At the ETSEQ the number of rotations does not seem to increase with time after the intervention, remaining at about 80% and 60% for two or more rotations in 2000/01 and 2001/02, respectively.

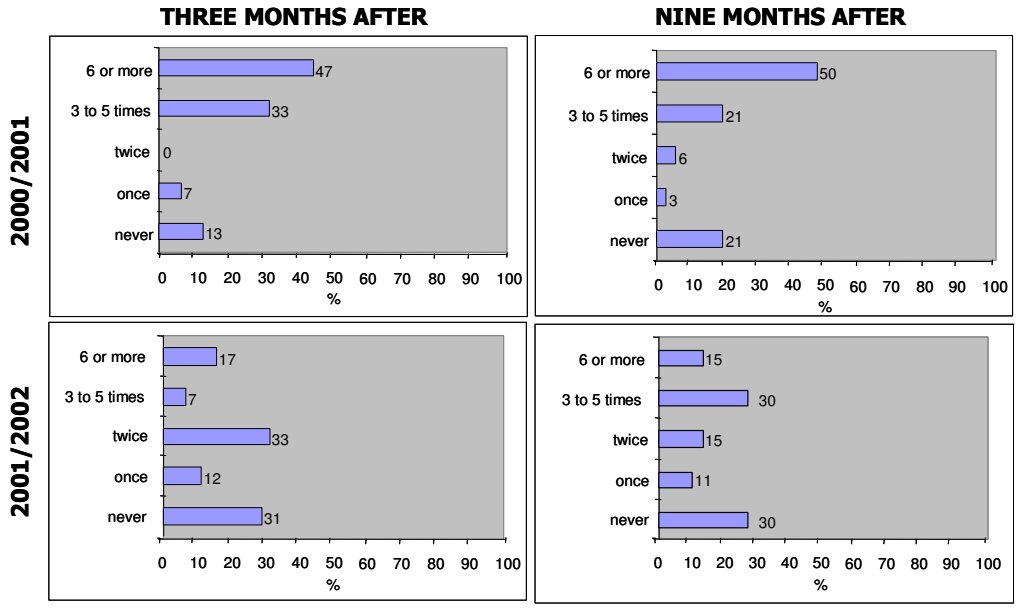


Figure 3.37. Frequency of role rotation within a team

Research has stressed the fact that self evaluation is vital for cognitive reflection and changes in behavior towards higher levels of performance [17]. In this connection it is pleasing to note in Figure 3.38 that qualitative or quantitative self evaluation of students' own work increases with time after the intervention.

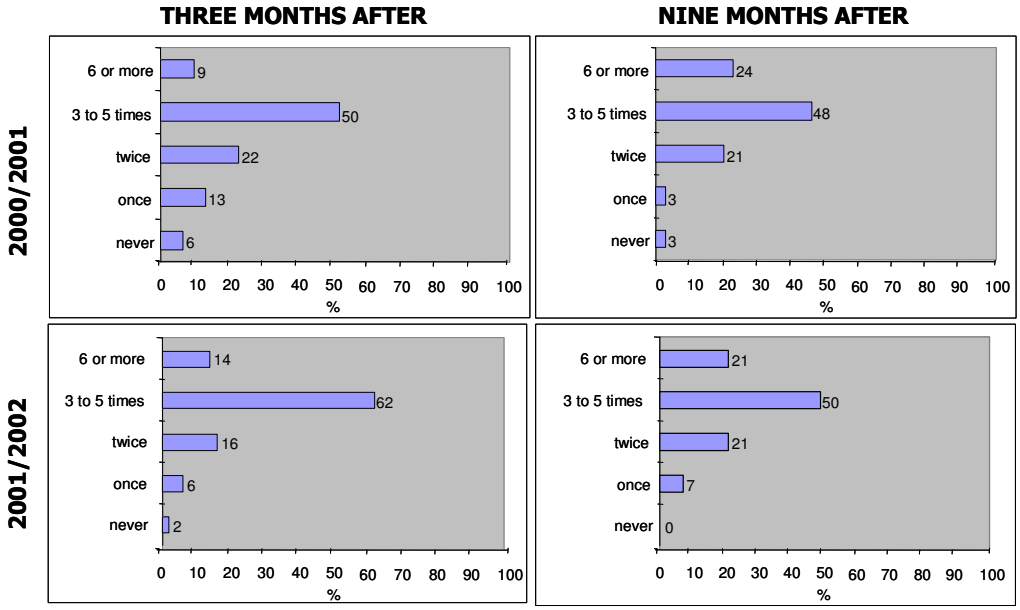


Figure 3.38. Number of qualitative or quantitative evaluations of one's own work carried out over 3 month period. Related to the 1st and 4th year IDP

The positive trend of increased self evaluation in Figure 3.38 is confirmed in Figure 3.39 in responses to the question: how many times have you qualitatively or quantitatively evaluated the work of the other team members during the past 3 months concerning the 1st and 4th year IDP? A significant pattern change towards evaluation of other team members has taken place according to Figure 3.39. This could be interpreted as a sign of increased trust among team members.

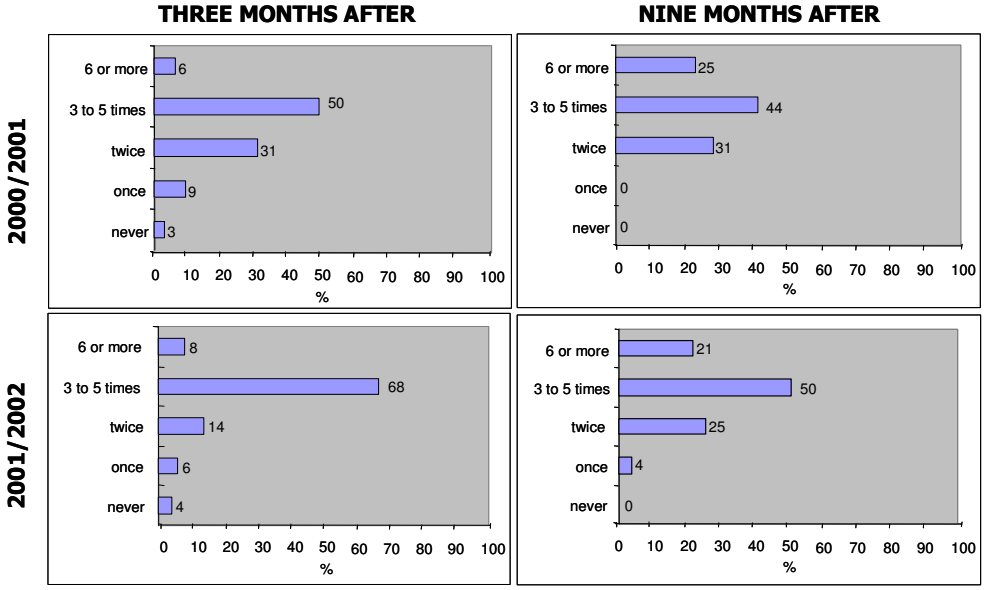


Figure 3.39. Number of qualitative or quantitative evaluations of peer work carried out over 3 month period. Related to the 1st and 4th year IDP

As observed in Figure 3.40 from the responses to question: how many times have you evaluated the team leader during the past 3 months, team leader evaluation takes place much more frequently as the project moves forward. These

encouraging results also indicate that with more coaching skills in place (see Appendix A) the improvement in evaluation could be increased further.

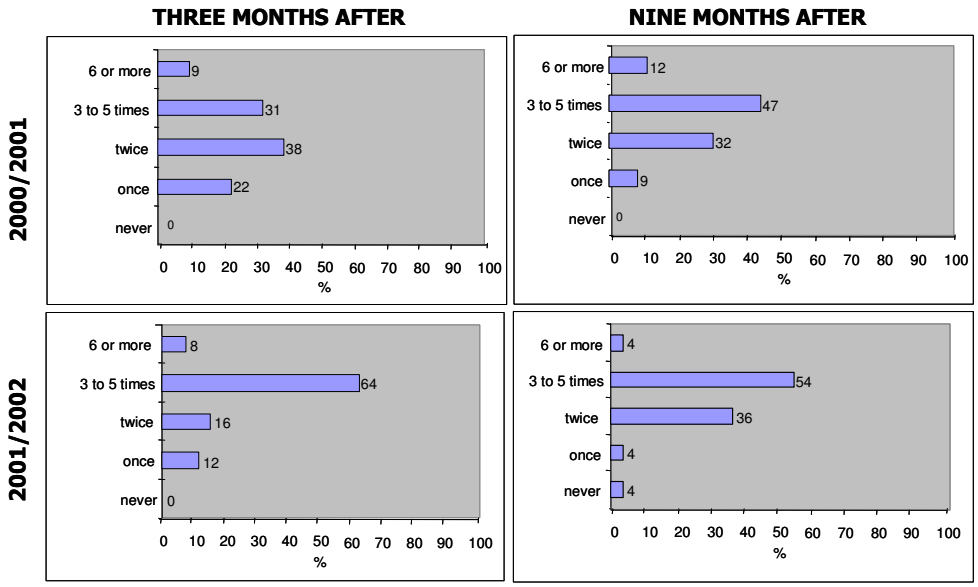


Figure 3.40. Number of qualitative or quantitative evaluations of team leaders by team members carried out over the 3 month period.
Related to the 1st and 4th year IDP

Similar positive trends were observed in the area of evaluating the role of knowledge managers, as well as in the recording and analysis of deviations of completed work. Also, the surveys confirmed a definite advance in the area of collaboration, i.e. sharing increases with project development.

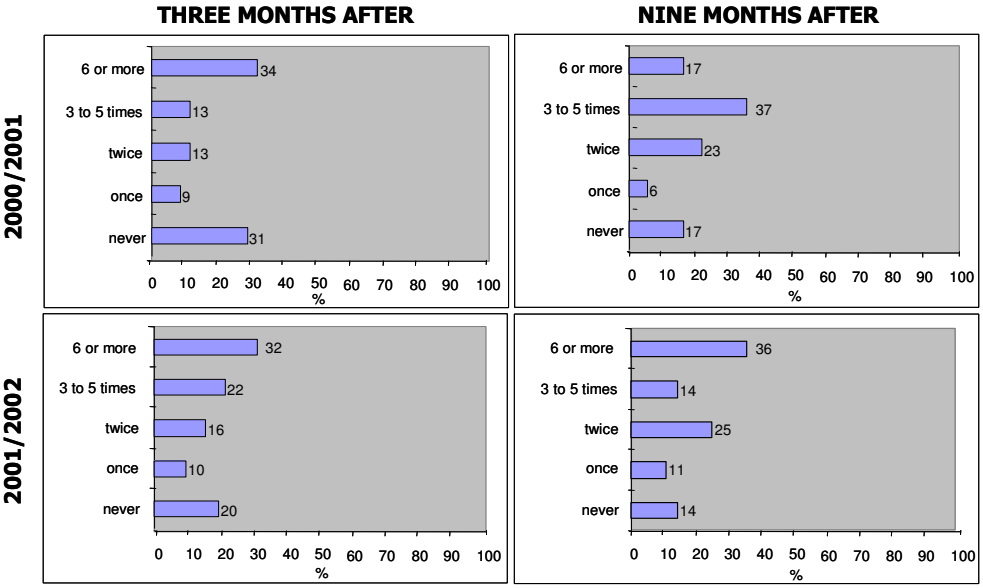


Figure 3.41. Peer work review

Figure 3.41 shows that the number of times that team members were asked to review and check the work performed by a peer increases significantly with time. In general, team cohesiveness improves along the project and there is a growing understanding that the level of interdependence and the level of shared

responsibility for results are ever higher [7]. This is clearly reflected in Figure 3.42, where most students state that they very much perceive the project teamwork as an “all float or all sink” situation.

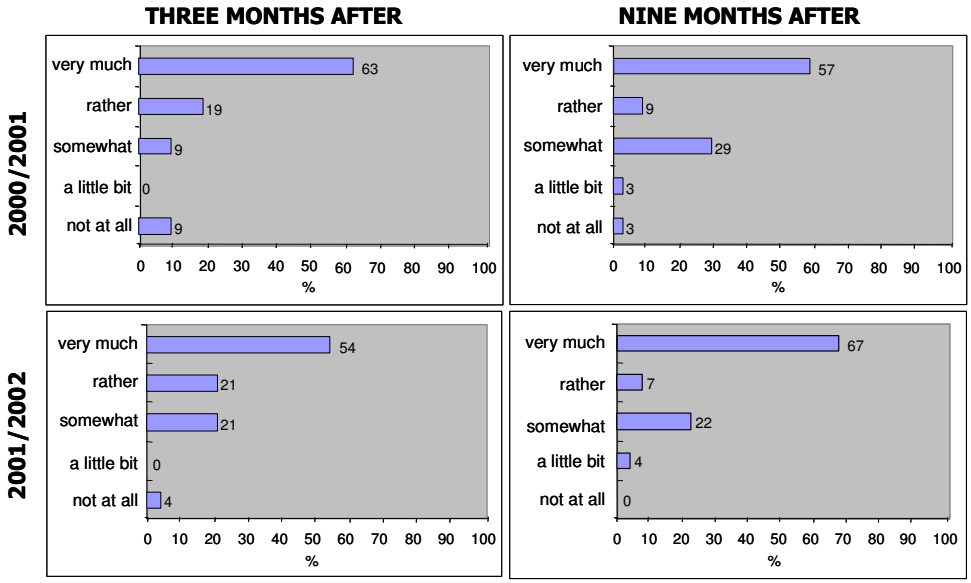


Figure 3.42. Interdependence within a team in terms of students’ perception of teamwork as an “all float or all sink” situation

Feedback comments obtained from the surveyed population can be clustered as follows:

- Better explanation of the framework around the whole intervention
- Structuring work and consequently workload
- More support concerning coaching and education
- More formal recognition of the project team and its work (obtaining more credits for the project work)

	THREE MONTHS AFTER	NINE MONTHS AFTER
2000/2001	✓ Don't like this kind of surveys and the new distribution of subgroups. ✓ I haven't adapt to the new team. ✓ Questions not very clear. ✓ Teacher work in project not evaluated. ✓ Team work is good. ✓ Too many work and few time.	✓ Team work is positive to achieve a big performance.It's is very difficult to achieve. ✓ We've spent too many time doing the project and it isn't rewarded with the qualifications. ✓ The work of one members depends on the work of the others members.
2001/2002	✓ We've spent a lot of time doing the project and it isn't rewarded with the qualifications. ✓ The work of one member depends on the work of the others members. ✓ The project is positive to obtain more knowledge and experience.	✓ The team work helps to put our ideas in common and to prepare us for future projects. ✓ The knowledge that we have to acquire are very elevated, therefore, is necessary to consider the curriculum from which we come.

Figure 3.43. Comments and suggestions

Gender distribution in the surveyed population is conducive for teamwork, as there is no dominance of any gender as confirmed in Figure 3.44. A high percentage of female students support team work, as research indicates that women have higher social competencies [18], a skill contributing towards teamwork.

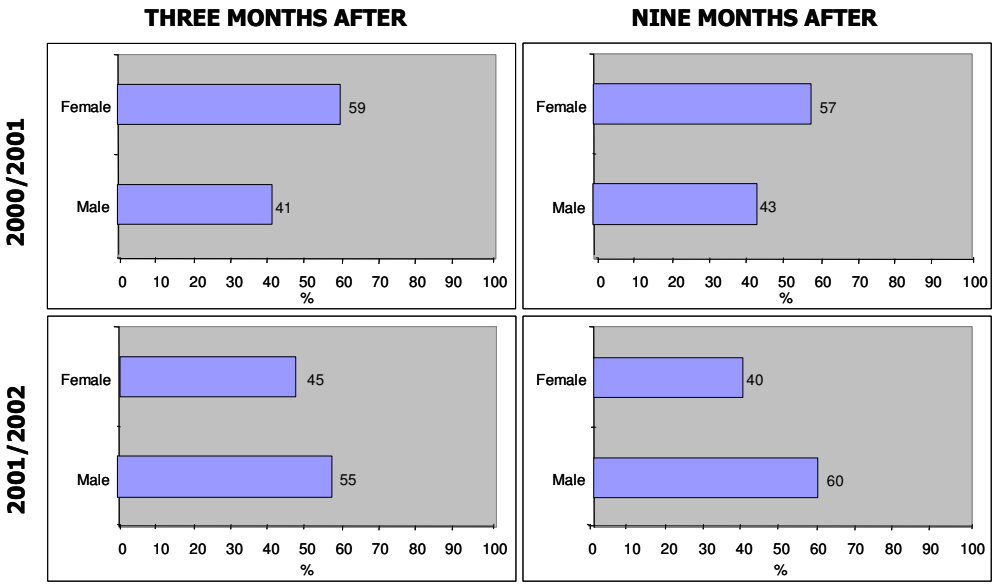


Figure 3.44. Gender of the surveyed population (NB: Gender composition change is due to changes in course registration)

As students are still at an early stage of their adulthood, there is a high probability of guiding them towards successful team orientation, as it has to be realized that abilities to learn become more limited with age [15]. The dominant age in Figure 3.45 is 17-20 year old students.

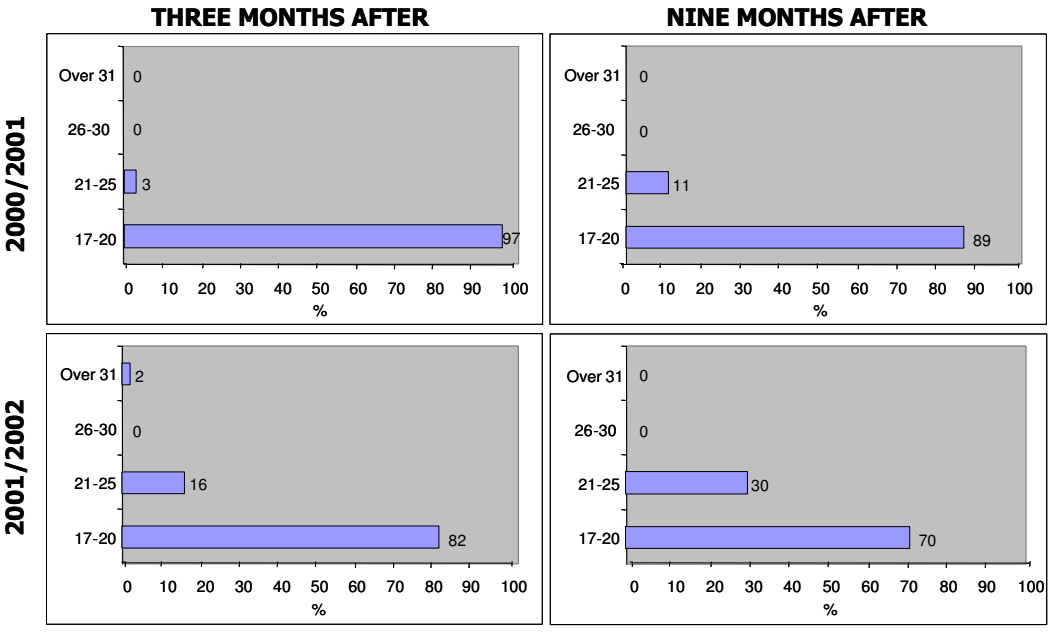


Figure 3.45. Age of the surveyed population

Figure 3.46 reveals that the overwhelming majority of students sought to study Chemical Engineering, i.e. it was their first choice of higher education. This calls for a high degree of commitment to begin with, which is an asset to build on, as it represents a high level of intrinsic motivation.

Figure 3.46. First choice of studies among the surveyed population in 2001/02

3.2.4 Survey 5 in 2000/01. Team Leader and Knowledge Manager 3 and 9 Months after the Intervention

In this subsection the survey results based on team leader and knowledge manager questionnaires are discussed. Due to the number of constraints mentioned at the beginning this chapter, it was only possible to run this set during the academic year of 2000/01. When looking at Figure 3.47, team leaders and knowledge managers (from now on team managers) reconfirm that common purpose and communication and conflict are fundamental ingredients of successful team functioning. Initially, there is no meaningful teamwork possible without common purpose. It is also known, that the ability to communicate and resolve conflicts constructively is directly proportional to team performance [8]. The topic of “New Member Integration” is of high priority for team managers. That does not come as a surprise, as the teams have to accommodate for a certain fluctuation in the course composition brought about by new students or those repeating the course.

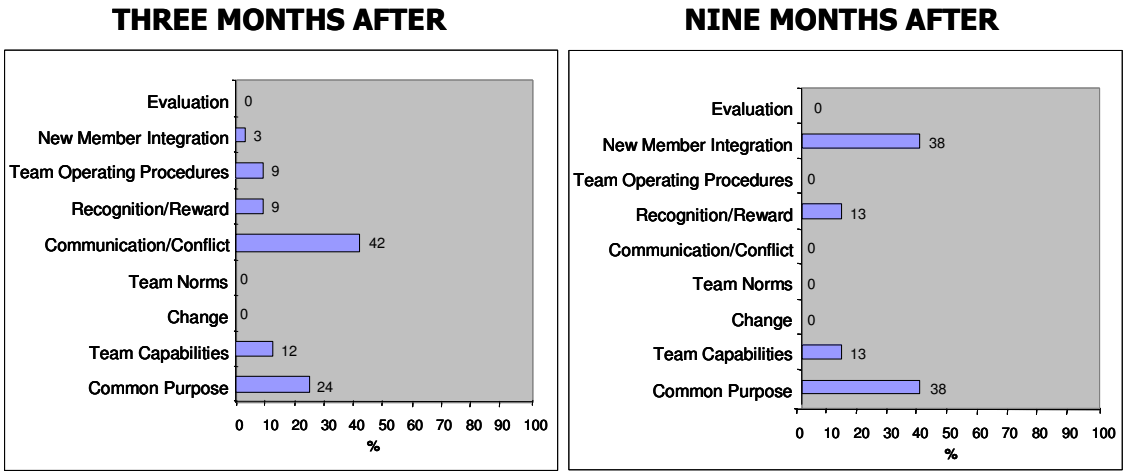


Figure 3.47. Most helpful module according to team managers

The importance of team education is validated by Figure 3.48, where team managers quote how the different training modules have helped them. It was stressed earlier that social skill building results in higher motivation and conflict resolution, which in turn increases productivity [7]. Over time integrating team members and finishing the project become the two highest priorities (38% each).

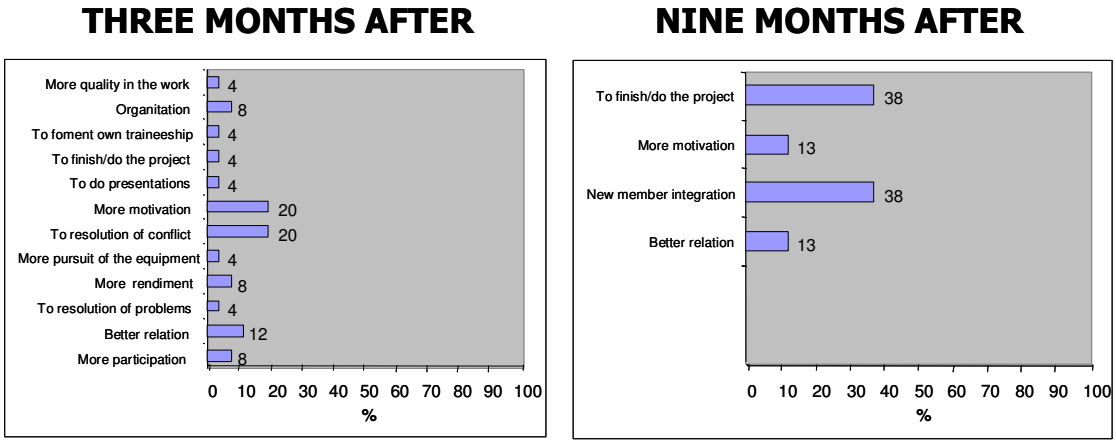


Figure 3.48. How high priority items have helped managers in the project

Figure 3.49 displays the evolution of project work in surfacing the team managers' greatest difficulties when working in teams. It appears logical that over time the issues of team operating procedures, team capabilities, and evaluation of team performance, become increasingly critical. When it comes to evaluation of team performance, understanding the critical issues and growing realization of their importance by team members is documented in their responses (see Figures 3.38 and 3.41). The topic of team capabilities is worthwhile exploring in further detail. It is not uncommon for team managers to underestimate team capabilities [19]. Future improvement plans point to the fact that team managers should be equipped with better skills and higher levels of knowledge to capitalize on team capabilities more effectively (see chapter 5). Again, education and skill building on both sides (managers and team) is critical. It is noteworthy that the word 'education' is of Latin origin and has an original meaning of 'leading out' [20].

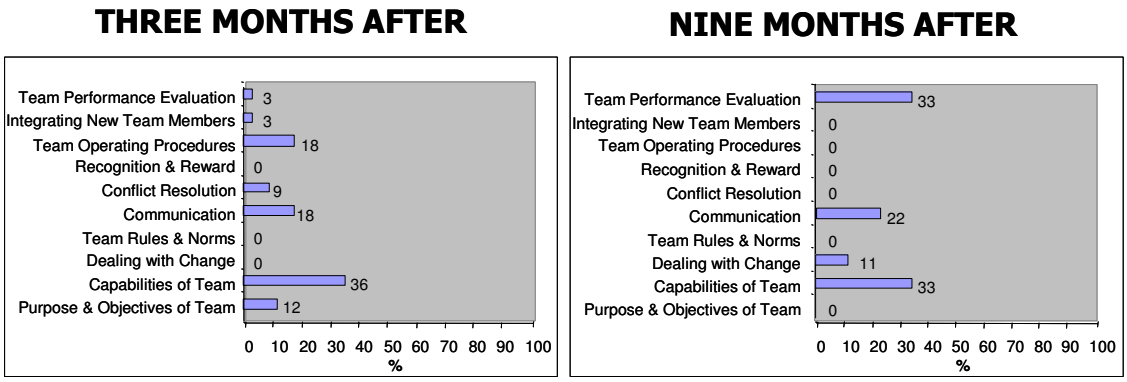


Figure 3.49. Greatest difficulties experienced by team managers during the IDP

When asked in which area the team managers needed additional help, again the communication and conflict issue comes up, as shown in Figure 3.50. There is an obvious need for on-going skill building in that area. Additionally, constructively dealing with feedback is perceived as important. When asked to suggest solutions for the areas identified in Figure 3.50, the team managers responded with the items as illustrated Figure 3.51. One could conclude from the results of these two figures that the ability to deal with feedback is directly linked to the ability to communicate and resolve conflict constructively. Team managers asked for additional training using the The TRACOM Group materials in “Enhancing Team Performance”©.

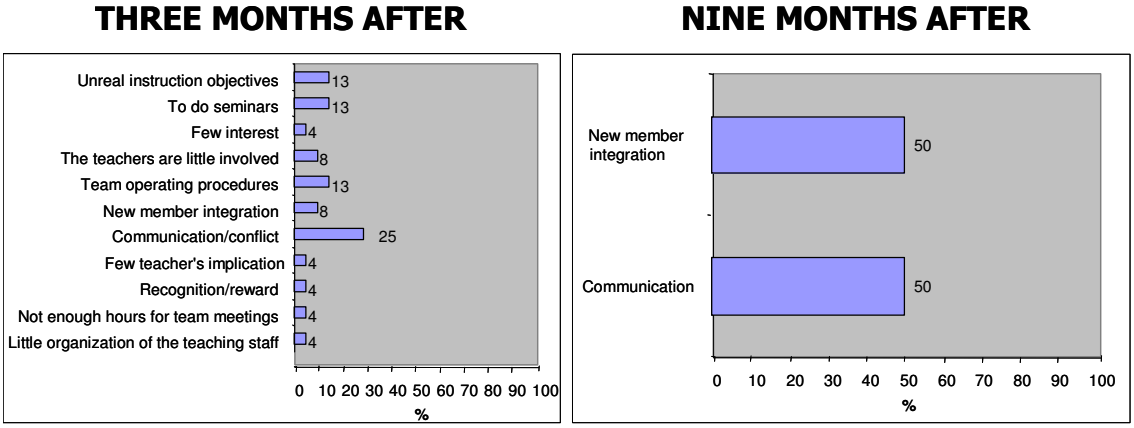


Figure 3.50. Areas that needed additional help according to team managers

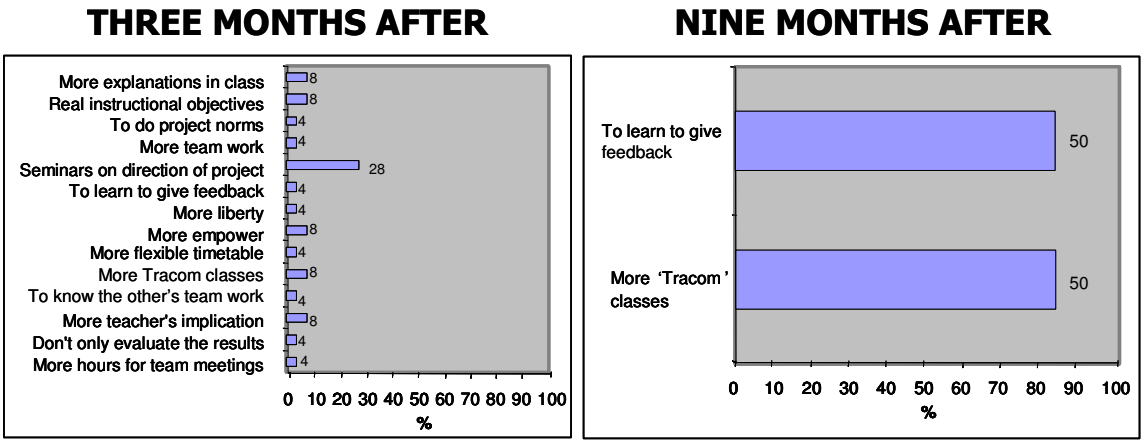


Figure 3.51. Potential improvement areas provided by team managers

Figure 3.52 deals with management style as perceived by team managers. It can be noticed that the "somewhat" category was particularly often used by the participants – an indication of some form of being indecisive. Apparently, the respondents avoid categorizing themselves, which is not uncommon in surveys. Employment of additional communication tools and further education would help to break the being indecisive pattern. One of the methods used in industry quite commonly is the "360° feedback", which gives a better insight into how a leader is perceived by his/her environment [21].

Figures 3.52 and 3.53 show that team managers claim that they are "informal", "inspirational" but also "methodical" in their style and role.

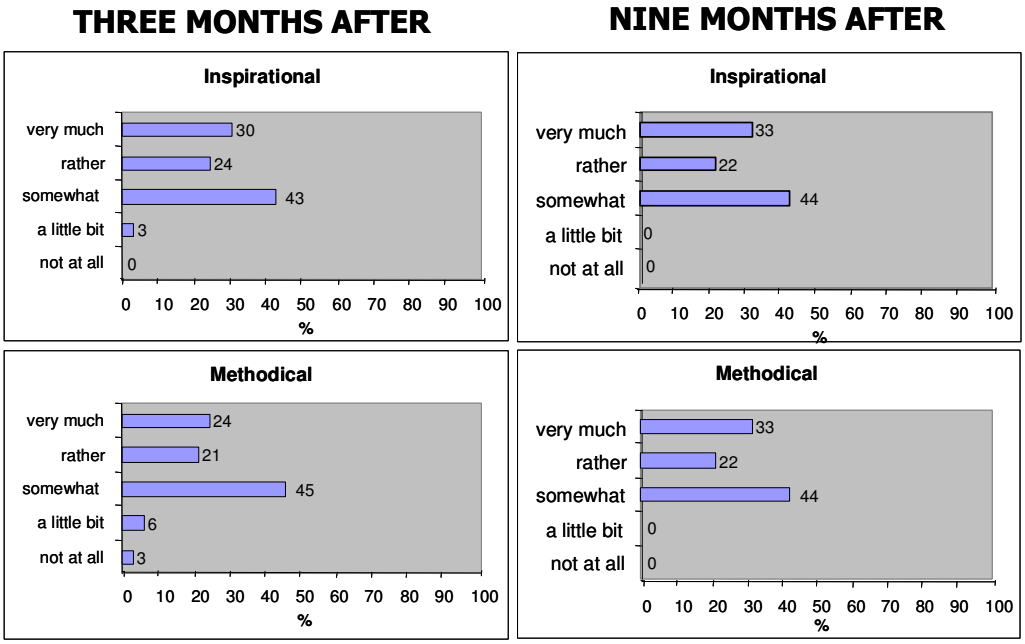


Figure 3.52. Management styles among team managers

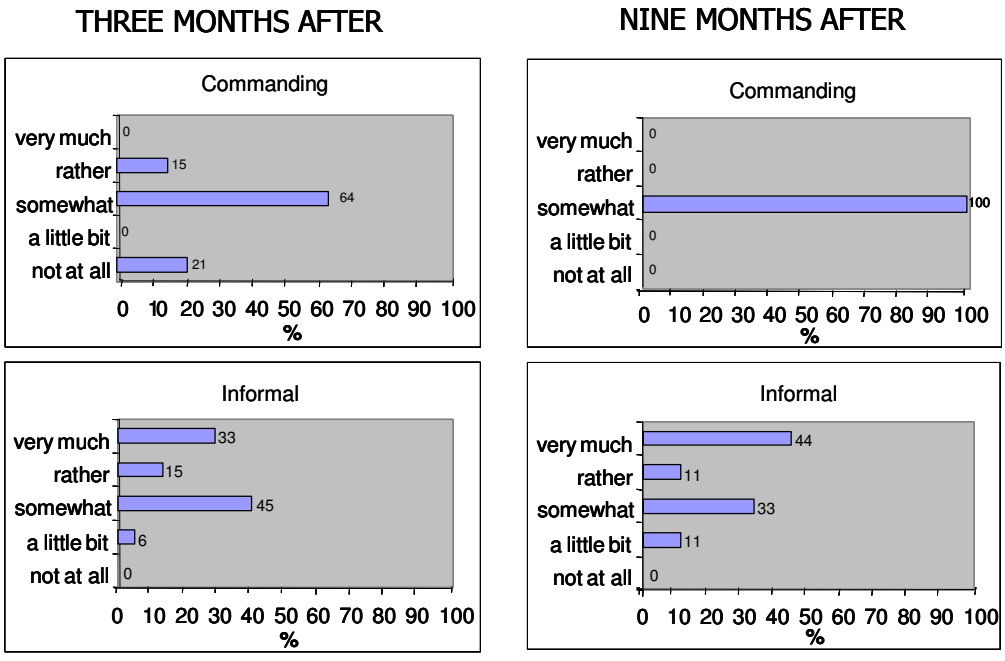


Figure 3.53. Team manager role description: commanding vs. informal

Team managers also portray themselves as people oriented, as depicted in Figure 3.54. It should be explored further whether the act of shifting from performance driven to people oriented has to do with the myth that good people leaders can not be performance focused. [22]

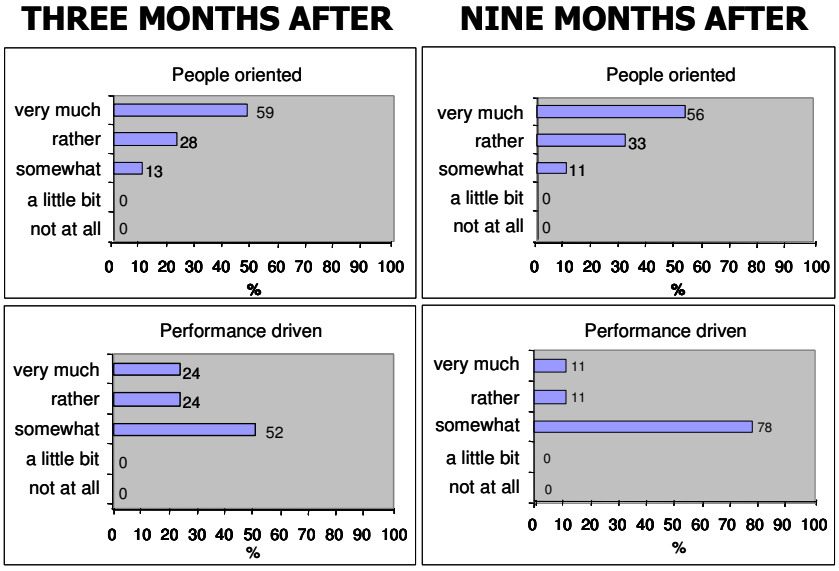


Figure 3.54. Team manager role description: people oriented vs. performance driven

All team managers a tendency to motivate with rewards, as shown in Figure 3.55. One of the critical leader tools is reward and recognition [23, 24]. This is the area where leaders generally struggle as a result of underestimating the importance of recognizing the team. Here it is also important to realize, that the potential of intrinsic motivation generated by meaningful work is generally underestimated. Some of the more modern thinking on recognition calls for team managers to be “removers of barriers” as employees are in general already motivated [23].

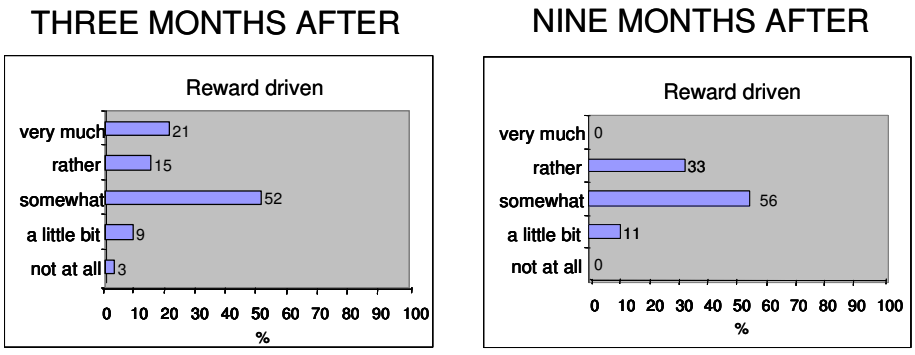


Figure 3.55. Motivation and rewards and recognition

When team managers were asked if they were mostly listening or mostly talking during team meetings, they perceive themselves as mostly talking, as depicted in Figure 3.56. This self perception is in conflict with responses regarding people orientation in Figure 3.54. One would expect good leaders to be good listeners. In areas for improvement (see chapter 5) proposals are made on how to obtain a more critical self reflection. This self reflection should translate into behavior

changed of team managers resulting in more empowerment of the team members [12].

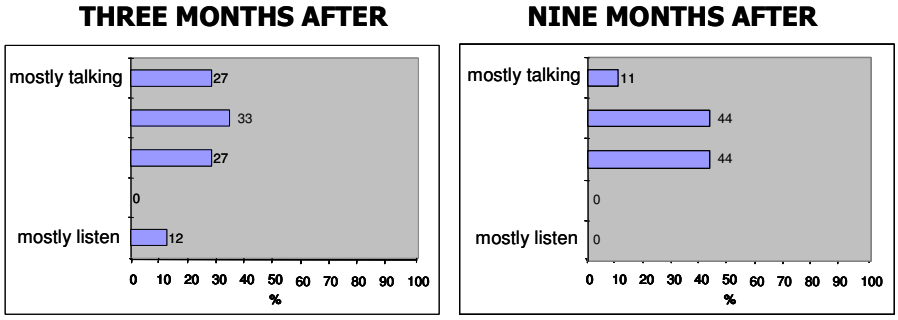


Figure 3.56. Team manager style: mostly listening vs. mostly talking

When it comes to evaluation of activities and their analysis, the trend is positive over the surveying period, as shown in Figure 3.57. This is congruent with the perception of the team members, as expressed in Figures 3.38 through 3.41. It can be concluded from the results in Figure 3.57 that team managers are shifting to monthly evaluation cycle, while team members are picking more responsibility for evaluation.

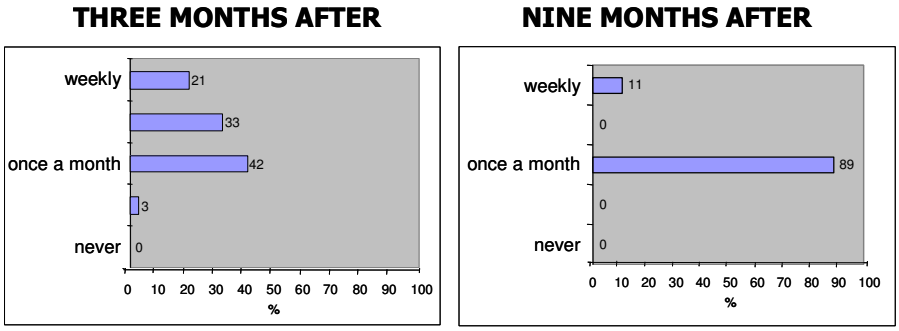


Figure 3.57. Frequency of evaluation of one's team's activities

A call for empowerment is present in the responses given in Figure 3.58 to the question: what are the most relevant activities carried out in team meetings by team managers and the time (%) dedicated to each of them. After 9 months into the project, planning and work assignment should be done primarily by team members and not by team managers as shown in Figure 3.58. Hence, this represents an opportunity for improvement (see chapter 5).

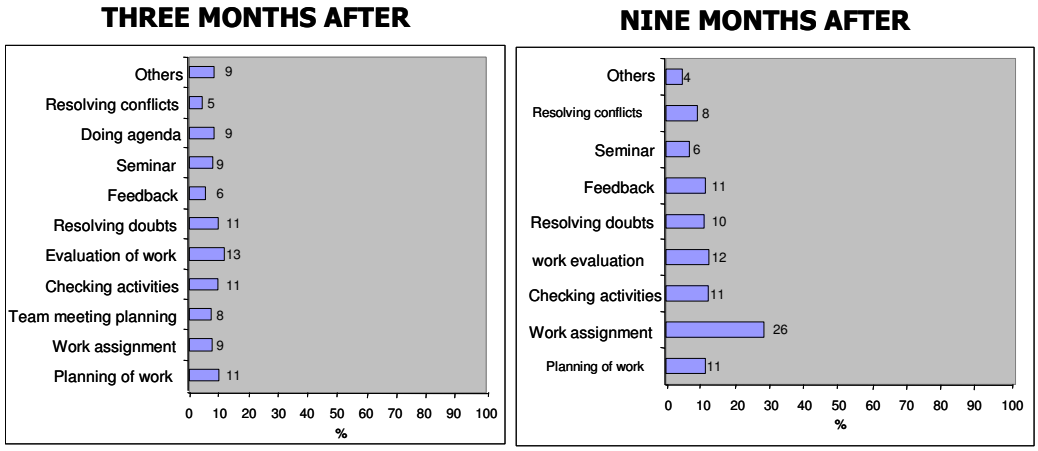


Figure 3.58. Most relevant activities carried out by team managers in meetings during the past 3 months and the time (%) dedicated to each of the activities

Like with the team member questionnaires, the demographic data was evaluated. It revealed that 1/3 of team managers were females, while the remaining 2/3 were males, with an age distribution of between 21-25 years.

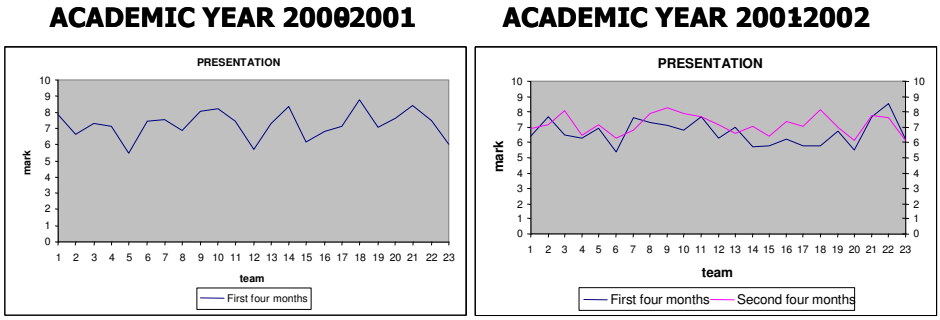
3.3 Correlation between Education and Performance

This section reports on the first attempt to investigate the correlation between social education and academic performance. It has to be understood that this correlation stands as evidence in support of the hypothesis that social competencies enhance learning and consequently, productivity. The students' integrated project is evaluated on the grounds of both teamwork and individual performance. The team component is assessed through reports presented by each team, as well as by poster presentations, which are rated in front of an audience. Team rating is followed up by an individual evaluation, whereby each team member undertakes a skill based interview.

In the following, various ratings from different academic years are presented and discussed. The results attached are only qualitative in nature at this point in time and do not currently allow a final and definite confirmation of the hypothesis. Further research is needed in order to filter out noise factors, and to gather more data over larger periods of time. The model presented in Chapter 4 should allow for evaluation of both social and technical competences.

3.3.1 Comparison of Poster Presentation Marks

In the following graph the respective marks for the two academic years surveyed are presented. Because of the reasons explained earlier, there is only the graph for the first 4 months of the rating period for the academic year 2000/01. Twenty three teams were evaluated and the ratings per team as well as the average numbers are indicated. There is no statistically significant difference between observations.

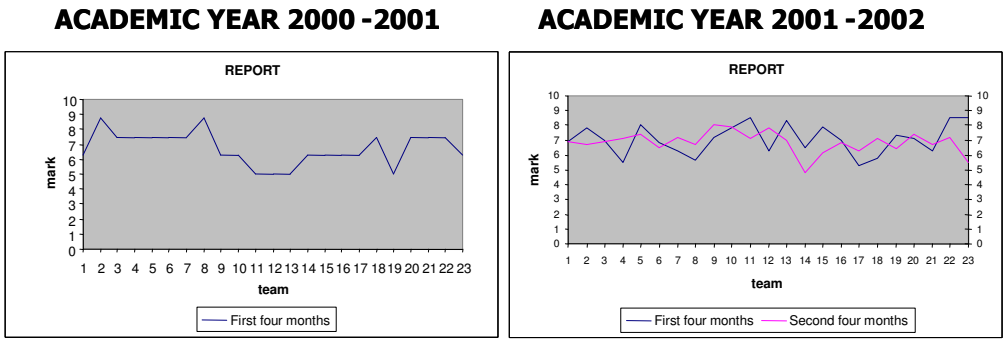


	2000-2001 ACADEMIC YEAR		2001-2002 ACADEMIC YEAR	
ITEM	First four months	Second four months	First four months	Second four months
Number of teams	23		23	23
Average mark	7.25		6.65	**7.18**

Figure 3.59. Poster presentation marks comparison

3.3.2 Comparison of Team Report Marks

When comparing the marks for the final project report in Figure 3.60, it seems that the performance is definitely better for the academic year 2001/02. This improvement is attributed to the social competencies introduced into the teams. This performance increase is also reflected in the survey responses, whereby they indicate higher meeting frequency, more open discussions, more evaluation of performance in the team and better interaction between all participants.

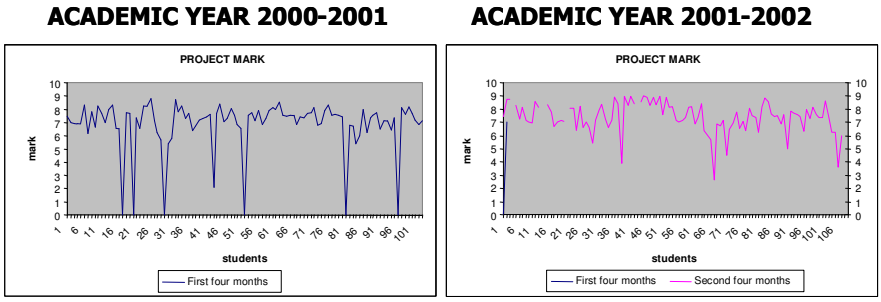


	2000-2001 ACADEMIC YEAR		2001-2002 ACADEMIC YEAR	
ITEM	First four months	Second four months	First four months	Second four months
Number of teams	23		23	23
Average mark	6.74		**7.05**	6.85

Figure 3.60. Team report marks comparison

3.3.3 Comparison of Individual Marks

The positive trend of Figure 3.60 for the presentation marks is amplified when looking at individual marks. As put forward in the hypothesis, changes in team patterns are projected to individual team members while impacting their behavior in a positive way. It appears that for the second round of the educated and surveyed target population, the results clearly outperform those of previous year. An additional contributing factor might also be the higher motivation level to begin with, since more students for the academic year 2001/02 had Chemical Engineering as their first choice of study.



	2000-2001 ACADEMIC YEAR		2001-2002 ACADEMIC YEAR	
ITEM	First four months	Second four months	First four months	Second four months
Number of students	103		109	107
Average mark	6.48		6.97	7.03

Figure 3.61. Comparison of individual marks

3.3.4 Expansion of Target Population

Initially, the target population of this research was the ETSEQ population exclusively, as this program was introduced by the faculty of Chemical Engineering (Enginyeria Quimica - EQ). However, during the 2nd year (academic year 2001/02) also students from the ETIQI (Enginyeria Tecnica Industrial – ETIQI) were exposed to the "Enhancing Team Performance©" course. This one time extension of the target population allowed some comparative analysis, which is presented below.

Comparison between the ETSEQ (EQ) and ETIQI student groups shows that over the first 4 months the students of ETIQI received only higher marks in the area of reports (see Figure 3.62).

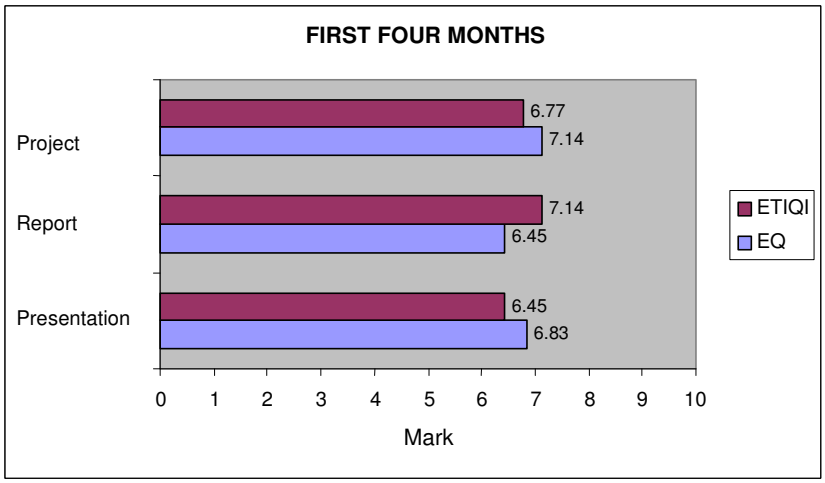


Figure 3.62. Comparison (first 4 months)

In the second 4 months the students of the ETSEQ (EQ) clearly outperformed students of the ETIQI faculty in all three categories, as shown in Figure 3.63. This would allow the preliminary conclusion, that the infrastructure around the social skill building is critical as it makes performance improvement sustainable. One time education seems to generate – if at all – only a short term improvement,

however not sustainable. Again, more research and statistical analysis is needed to solidify these observations and ultimately confirm the preliminary conclusions. It is suggested to expand this research by defining a control group, which would allow statistical proof of the hypothesis.

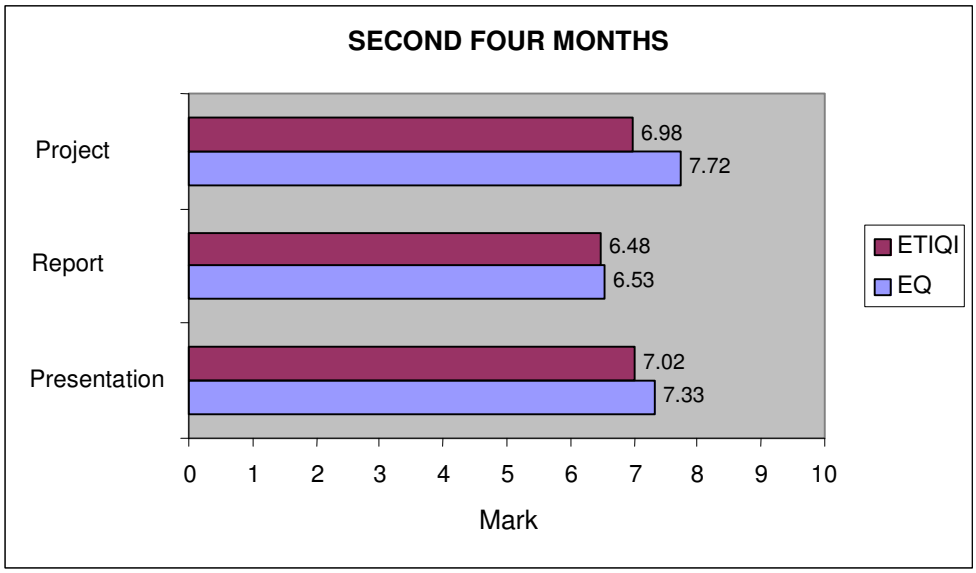


Figure 3.63. Faculty Marks Comparison (second four months)

3.4 Concluding Remarks

With the survey responses and the preliminary analysis of the correlation between social competencies and academic performance, there seems to be a qualitative evidence to confirm the hypothesis: Building of social competencies – in this case team building – enhances the learning and drives towards higher performance. This social competency is integrated into the technical curriculum of the ETSEQ as an external intervention and, thus, it is not reducing the time dedicated to technical subjects. It also becomes apparent that technical competence is, if not enhanced, fostered by social competence as proved by the higher marks of the integrated project. It can be concluded that the proposed design of the social competency building is working satisfactorily and delivering against expectations. With the proposed recommendations for improvements and additional data sets it should be possible to prove the hypothesis in a statistically sound fashion and at the same time improve performance and make these gains sustainable.

The surveys also indicate that the current sep up, with the 1st and 4th year as the only integrated design project approach embedded into the chemical engineering curriculum is very vulnerable. If there is no further integration of the methodology into the curriculum, the result is a decrease in students' trust, as they realize that their efforts are relatively useless in the 2nd and 3rd years. This is aggravated by the fact that the final goal of reaching higher levels of empowerment for teams and individuals cannot be reached in one step. It takes considerable and consistent effort over the entire curriculum to move from leader directed organization in the 1st year towards a fully self directed/empowered team in the 5th year. The momentum generated by the success of the 1st and 4th year IDP

scheme (see Figure 1.4), jointly with the information gathered from the field testing of the external intervention “Enhancing Team Performance”©, has been used to conceive, develop, deploy and initially evaluate the new competency-based educational model that is presented in the following Chapter 4. The model summarizes and builds upon the landmarks of IDP at the ETSEQ depicted in Figure 1.5. The partnership established with Dow Chemical Ibérica, with the indirect support of the Dow Chemical Company, received in terms of manpower, training technologies and materials, was an important turning point in the journey of the ETSEQ towards and empowered institution. It is now the task of the top leadership of the school to take this model to the next level.

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Chapter 4

The Competency Based Educational Model

4.1 Background

The success of the horizontal and vertical integration of knowledge and resources carried out during the academic year 1995/96 (see Figure 1.4), together with the results of Enhancing Team Performance© (ETP) reported in Chapter 3 led to the educational model depicted in Figure 4.1. This model extends the IDP scheme explained before throughout the 5 years of chemical engineering curriculum. External interventions together with ETP modules have been planned for delivery in each year of the program: (see Figure 4.1)

- to reinforce the initial results obtained with the ETP external intervention in the 1st and 4th year IDP
- to correct the drawbacks identified in the surveys presented and discussed in the previous chapter

The remainder of this chapter is presented in the format of the paper that has been accepted for publication in the International Journal of Engineering Education with an overall rating of 83/100 (see the reviewed comments in Appendix D).

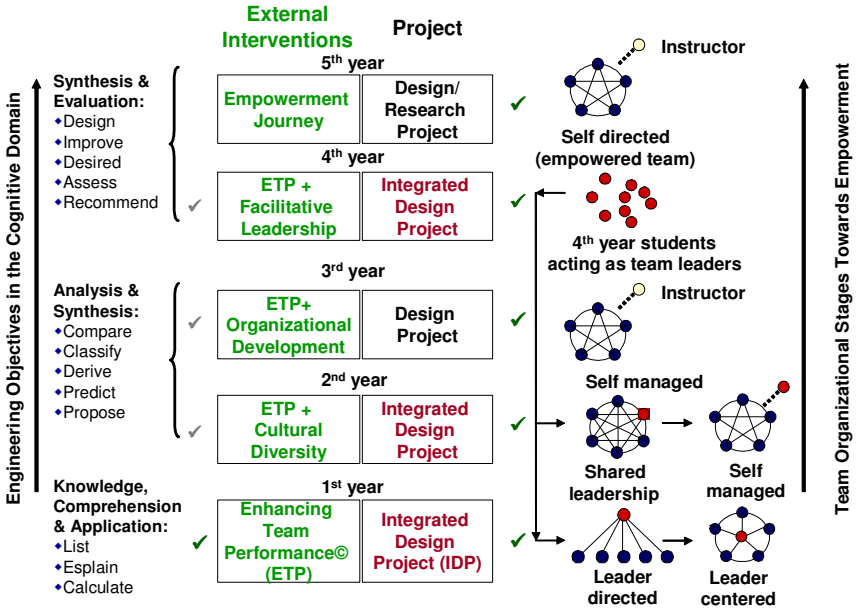

Figure 4.1. The competency based educational model, facilitating the deployment of empowered teams

The fact that the IDP approach started in the 1st year of the ChE program brought forward the opportunity to reinforce the continuous practice, feedback, and positive reinforcement of social competencies throughout the curriculum, and to consider the

possibility of minimizing other less active methodologies such as lecturing and demonstrations [1]. It also posed interesting questions, e.g.:

- Can social competencies enable or enhance technical and scientific competences?
- What were the social competencies most relevant to this purpose and for a professionally successful chemical engineering career?
- Was it possible to disseminate the IDP across the curriculum with a consistent deployment of team organizations leading to the empowerment of individual students and teams?
- How could we involve instructors and professors in the application of the integrated design project approach?
- Did we have the necessary knowledge, educational technologies and resources in our own organization to undergo such a drastic change or did we need help from experts outside of the university system?
- Was it possible to design a model that could incorporate most of these challenging and innovative ideas?

The outcome was a list of hypotheses and requirements for the educational model and an establishment of a partnership with the Dow Chemical Company to obtain expertise in change management as well as human and technical resources.

4.2 The Model

4.2.1 Hypothesis

There is numerous indirect evidence in the study of mankind (i.e. study of prehistory, evolutionary anthropology and psychology), that communication of information and learning among hominids takes place through social development [2]. In fact, both technical and natural selection played a role in the evolution of the Homo sapiens over the past 2,500,000 years. Social learning and social cognition theories provide direct evidence that learning through the consequences of one's actions, which is a tedious and hazardous process of trial and error, can be shortened through social modeling of knowledge and competencies, which has a prominent role in human motivation, thought, and action [3-5]. Also, self efficacy or the beliefs of one's capabilities to organize and execute the courses of action required to manage prospective situations, is key to developing self regulatory strategies, motivation and achievement (in academic settings) [6].

Consequently, the first hypothesis was that social competencies should (not compete with but) enhance the construction of scientific knowledge and the acquisition of technical competence even over the short time scale of the duration of undergraduate education, if consistently and experimentally worked out all the way through the curriculum. This could be accomplished smoothly with IDPs carried out with students working in teams, as indicated by experiences of the research associates [7-10]. This hypothesis has been already stated in Chapter 3, where preliminary analysis of its validity, based on the results of the surveys, has been presented.

The second hypothesis was that empowerment of individual students and teams could be accomplished simultaneously within the social learning environment, if the model to be implemented would consider the appropriate evolution of team organizational stages, initially from leader directed and leader centered scheme in the 1st year to a self directed organization just before graduation at the 5th year of studies†. Table 4.1# describes these team organizations in terms of responsibilities and activities of team members that have been adopted at the ETSEQ and which has been inspired by the team based organizations considered at Dow. The 19 activities listed in Table 4.1 are exhaustive and fit very well those typically needed to carry out the design projects at the ETSEQ. Within the self directed team organization, deployed at the 3rd and 5th years, respectively, students become progressively empowered, since they are given the right to make decisions and take actions on their own without previous approval by instructors. This authority to act encourages students to further assume responsibility for their actions, which also results in an improvement of the model.

The third hypothesis was that the progressive deployment of the IDP approach, with team organizations matching student skills and needs (see Table 4.1), should facilitate the adoption of a competency based educational model. In the context of the current study, a competency is a combination of tangible (skills and knowledge) and intangible (social role, self concept, traits and motives) underlying characteristics of an individual that is causally related to criterion referenced effective and/or superior performance in a job situation [11].

The fourth and last hypothesis was that faculty and the school system would accept that the educational system did not possess the know-how to manage the cultural change [12]. Such a shift towards the competency based educational model referred to in the previous two hypotheses would require substantial outside expertise and subsequent willingness to partner with a chemical manufacturer, such as the Dow Chemical Company. The fact that the Dow was willing to establish a partnership in 1997 (see Figure 1.5) and to facilitate this process by providing expertise and technologies, such as workshops, on:

- team development
- knowledge/awareness of critical competencies, and
- methodologies to manage change

was assumed to be a sufficient incentive to facilitate and sustain the required change. The workshop materials should support the development of competencies and should be taught as compulsory external interventions initially by consultants and human resource personnel from the Dow Chemical Company and later on by subsequently trained faculty. An external intervention is an extra-curriculum activity which is carried out at specially allocated hours in the academic timetable.

† The surveys in Chapter 3 indicate that this team evolution is needed
# All Tables are included at the end of the chapter

4.2.2 Framework

The four hypotheses stated in the previous subsection led to the educational model depicted schematically in Figure 4.1. The model framework spans dynamically over the 5 years of studies in two domains:

- in the cognitive domain pertaining to science and engineering contents and processes, according to Bloom's taxonomy [13]
- and over different team organization stages towards empowerment

In the context of current work, Bloom's taxonomy has to be understood as expanding over engineering objectives, i.e. beyond the integrated set of the formal operations that any adult, educated person performs in real life. The ticks in Figure 4.1 indicate the current level of implementation, from fully operational (bold tick), under field testing (grey) to pending (no ticks).

The model is based on integrated projects in the 1st, 2nd and 4th years and in projects carried out by self directed teams in the 3rd and 5th years, to assure the right setup and environment for the development of social and professional competencies. Activities carried out during project development and projects closing, which are listed in Table 4.1, require that students clearly identify project clients (mainly activities 1 and 4 in Table 4.1). Thus, client orientation is central in the competency structure adopted, with the rest of 9 competencies emerging as correlative concentric circles characterized by need to act to attain client satisfaction. This is schematized in Figure 4.2 in terms of competencies, with the required individual, organizational and institutional transformations identified by the increasingly lighter levels of grey. The inner circles of competencies in Figure 4.2 pertain more to individuals working in teams and imply the transformation of both individuals (four inner circles with darker grey) and of the organization (three intermediate grey circles). The two outer circles of competencies (lighter grey) reflect more the role of individuals at the institutional level, whereby student empowerment can develop more effectively and be more valued, and all changes institutionalized. Clearly, client orientation (black central target in Figure 4.2) first requires that any individual should adapt to client moves, i.e. be versatile, and subsequently find creative solutions to these new challenges, i.e. be entrepreneurial and innovative. This in turn calls for system thinking, moving in the structure depicted in Figure 4.2, which is self explanatory. The summary of corresponding transformations is depicted in Figure 2.6.

Since social competencies have to grow from a client orientation perspective and be developed by team members simultaneously and in conjunction with regular academic activities, such as lectures, laboratories, seminars, etc., the educational, competency and transformation models respectively shown in Figures 4.1, 4.2 and 2.6 are supported by the set of five hands on, external interventions stated in Figure 4.1. These interventions have been conceived and designed to be delivered by professionals in the field and/or faculty previously trained in the respective topics and on the educational technologies used. The topics of the five external interventions, briefly described in Table 4.2, match both the team organizational stages planned for

each of the five years of studies and the client oriented competency model of Figure 4.2.

The following subsection presents and discusses the ten social competencies that have been adopted at the ETSEQ, which are summarized in the concentric model depicted in Figure 4.2.

Figure 4.2. Concentric structure of competencies aimed at client orientation.

4.2.3 Competencies and Rationale

Table 4.3 lists the ten key competencies, together with their operational definitions, that have been identified at the ETSEQ, and that should also be enablers for technical competence as stated in the hypothesis subsection 4.2.1. The current selection is consistent with the extensive research reported on the trends and changes that influence the economic and social environment in which industry is operating [14-17] and with the experience gained with the implementation and continuous refining of the 1st and 4th year IDP at the ETSEQ [10,18]. The Dow Chemical Company and other chemical corporations have also identified these or equivalent competencies as critical components in their recruiting process. Finally, the set of competencies listed in Table 4.3 is in accordance with the opinion of other educators and policy-maker institutions [19-21].

The know-how developed by The Dow Chemical Company on planned organizational change [22] suggests that the set of competencies of Table 4.3 constitutes a valid and consistent starting point to implement an effective and

sustainable organizational change. Figure 4.2 illustrates the dynamics of this organizational transformation when it is unambiguously aimed at achieving client satisfaction through client orientation. Every significant move of client needs stated in Figure 2.6 prompts three waves of transformation involving the individual, organizational and institutional level. Research supports the assumption that the only relevant component that should be molded (changed) in an organization is individual habits, i.e. the attitudes and perspectives of each individual [22, 23]. Change always starts at the individual level. The change of individuals brings about organizational transformation. Once organizational transformation has taken place, the new way of working has to be institutionalized in order to ensure that the changes are sustained and that no significant erosion takes place. Erosion would be detrimental, as the organization would gradually slide back to the status quo or the starting point of the change initiative.

Table 4.3 summarizes the operational definitions of the competencies adopted at the ETSEQ. Figure 4.2 arranges these competencies in “need to do activities” consistent with client orientation. The central competence of Figure 4.2 and the first in Table 4.3 is client orientation, the one that triggers individual transformation. An individual within a client serving organization must be able to perceive a shift in client needs and to adapt accordingly. Productive performance during change requires versatility, since the individuals are likely to be catapulted out of their comfort zone. To cope with inflicted stress, a high degree of versatility is needed, as one has to adapt by changing one’s views, perspectives, assumptions and behaviors. The next competency under scrutiny is entrepreneurship and innovation. Versatility has brought about capacity to adapt to change. It now has to be followed up with creative ideas to respond to the new challenges posed by the client directly or indirectly through the organization. On an institutional level, entrepreneurship will aid to translate creative ideas into tangible business opportunities. The next layer of the concentric model in Figure 4.2 is system thinking. Business opportunities have to be put into perspective, i.e. the whole system of individual and organizational interactions has to be reconsidered. Critical reflection of one’s position in relation to the new system will consequently trigger new learning. It is most likely that a number of competencies will become obsolete and will have to be replaced by new ones. The skill transformation calls for the responsible and active learner’s competency or else no change will happen. The issue of life long learning emerges clearly on the business horizon [24]. This notion is quite a challenge in itself, as it conflicts with traditional way of looking at education. The perception that after graduation there is only work to be done is changing rapidly. This last circle of individual transformation, responsible and active learners, leads to the first sphere of organizational transformation, which is facilitative leadership. Facilitative leadership is the pivotal point, whereby the impact from individual domain will be translated into collective domain, a process which is only possible through leadership. At this point, the individuals affected have completed the personal transformation cycle and are now skilled and ready to spark and facilitate changes in others. The 4th year students acting as leaders and facilitators in 1st and 2nd year teams assume this pivotal role in the current model, as shown in Figure 4.1.

Organizational transformation initially starts within the smallest nucleus of the organization, which typically happens to be a team or a group. The team reinforces the changes via cooperation and the collective analyses of client needs. This is reflected in the teamwork and cooperation competency. When several teams or small groups interact, the level of complexity increases exponentially [25]. This calls for a higher competency level of human interaction. As change grows, the likelihood of miss communication and errors by default is usual. A good skill set of human interaction minimizes these side effects of change. When individuals communicate and interact well with each other, challenges and barriers become opportunities for everybody in the organization, and the number and size of conflicts decreases. This concludes the intermediate three circles of competencies involved in the transformation of the organization, as shown in Figure 4.2.

Now that the individual and organization levels are mutually aligned to cope with the new scenario of client needs, the changes attained have to be institutionalized. This happens when the individuals acquire the two outer competencies in Figure 4.2: organizational development and performance, and organizational leadership. In our educational organization, work and process management competencies have both been integrated into the competency organizational development and performance, which characterizes individuals that can plan, implement, and evaluate any action within the organization or in smaller empowered teams, as stated in Table 4.3. This ultimately implies continuously updating and disseminating the relevant procedures and system documentation across the organization. In addition, the interaction across the organization has to be reflected in business and work processes that are aimed at satisfying client needs [26]. The last competency of organizational leadership, both in Figure 4.2 and Table 4.3, is characteristic of senior management, i.e. in our case senior students. It ensures that the transformation is complete and yields the expected results. An appropriate evaluation cycle to validate the degree of transformation implied in Figure 4.2 in relation to client satisfaction has to be initiated.

4.3 The Key Competency Model Components

4.3.1 Integrative and Experiential

The experiential learning approach applied at the ETSEQ, which is illustrated in Figure 4.1 and described in sub section 4.2, is IDP. It is based on combination of project based learning [27] and cooperative learning methodologies [28]. Both methodologies are well suited for engineering education, because project management and teamwork are key enablers for any design activity, which is the essence or engineering [29]. A detailed description of the approach as applied to the 1st year of the ChE program at the ETSEQ has been presented elsewhere [10,18]. This subsection focuses on those characteristics of the approach that generate the dynamic concentric transformation wave of Figure 2.6, which is depicted in grey levels in Figure 4.2.

Since client satisfaction plays a pivotal role in, it became apparent from the beginning that clients should be real and accessible to students. Professors responsible for the different courses that participate in the IDP act as clients and are, consequently, the driving force for the transformations of Figures 2.6. The IDP is not a stand alone course. It is a teaching and learning approach that is horizontally implemented in the regular class hours of the existing courses. At the beginning of each semester, professors that teach courses in the first three years of the ChE program select a set of engineering and project oriented instructional objectives in the cognitive domain from their corresponding syllabuses and hand them out to the project teams. The objective is that students achieve the engineering objectives by themselves through the project and, consequently, begin to take on responsibility for their own learning. The level of these objectives varies depending on the year in the ChE program according to Bloom's taxonomy (knowledge, comprehension, application, analysis, synthesis, and evaluation) [13]. While it is expected that first-year students achieve objectives up to the application level in relation to engineering practice, for example process design, the 4th year students should be able to formulate design problems, evaluate the learning approach itself, etc., i.e. reach up the highest level of Bloom's taxonomy in relation to engineering practice. The increase of complexity in the level of instructional engineering objectives over the ChE program is shown on the left side of Figure 4.1. Together with the set of objectives, instructors allocate 25% of their regular class hours to project design and team work. As a result, students work an average of 5 hours per week on the design project.

As in any real world experience, students enrolled in the first three years of the ChE program soon realize that each professor/client is a universe by itself. Some professors know very well in advance which results they want to get from a particular project, while others keep constantly changing their instructional objectives, even when the project is already approaching the closing phase. This dynamic forces the students to put in place effective communication processes with clients, i.e. to develop the client orientation competency, consistently demanded by chemical manufacturers [14]. It also fosters preventive thinking and triggers the preparation of contingency plans.

The model in Figure 4.2 also implies a learning/working environment that facilitates the development of competencies by daily hands on practice, with coaching support in terms of positive reinforcement and feedback. It is very difficult, if not impossible, to develop a competency up to a professional level only by attending a traditional single discipline course. Hence the need to deploy extensively the integrated design project structure over the ChE program. It is noteworthy to realize that this constant simulation of engineering practice makes the competency based educational model also an excellent approach to cope with criterion 4 of the ABET 2000 Criteria Standard: Professional Component [20].

This gradual growth of competencies is exemplified by the systematic development of project teams throughout the program, as illustrated on the right side of Figure 4.1. The experience accumulated during the last decade by The Dow Chemical Company in the development of empowered teams recommends a progressive

transition from leader directed student teams in the 1st semester of the 1st year to self directed teams in the 3rd year of the ChE program. Each of the stages in this empowerment journey entails that students are ready to take on additional responsibility for managing the IDP approach and, eventually, for their own learning. Table 4.1 shows in detail which specific activities are taken on by students as they progress through the different stages towards an empowered team. This team development structure represents an organizational transformation that has to be necessarily supported by the appropriate individual transformation. For example, at the heart of the shift from the traditional single discipline lecturing format to a team based learning approach lies the need that students realize, and hopefully begin to assume personal responsibility and voluntary commitment to their own learning.

One key success factor in this empowerment journey is team leadership. Leadership is a critical component for the success of any team [18]. In addition, any effective organizational transformation requires that facilitative leadership competencies are in place, as indicated in Figure 4.2. Consequently, it was projected that 4th year students, who had already endured a deep individual transformation, would act as facilitative leaders of project teams formed either by 1st year or 2nd year students. The participation of 4th year students as facilitative leaders of 1st and 2nd year project teams is in accordance with social learning theory [4] and self directed change research findings [30]. The latter research claims that people learn interpersonal skills from behavior role modeling. This social modeling of knowledge and competencies can be best realized in teams of peers, because of the prominent role that human motivation, thought and action play in this process. Individuals are open to develop a new competency only when they realize that it is important to do their jobs well, because there exists a discrepancy between the current and the ideal level of competence. Therefore, 4th year students act as role models for 1st and 2nd year students and trigger their motivation to work hard to develop the required competencies. Furthermore, the 4th year students are in a better position than instructors to create a socially “safe” and supportive environment in which to learn, experiment with, and practice new learning methodologies and behaviors. This is a basic feature of the model, since self directed behavior change research strongly suggest that students need to experience high psychological safety to assimilate effectively the integrated design project approach and not to perceive it as a threat. In addition, 1st and 2nd year students see 4th year students as fellows who have already passed successfully through the project experience and who can provide valuable support and coaching and increase the chances of success [31]. The leadership role responsibilities also vary depending on the development stage of the team, as shown in Table 4.1. Finally, it is expected that all 3rd year project teams will reach the self directed stage, where all activities related to the management of the integrated design project approach are carried out by 3rd year students exclusively. This outcome should emerge from the experience of the earlier team organization stages shown in Figure 4.1 and as a result of the specific courses and external interventions expressly designed and delivered with this purpose in mind.

4.3.2 Specific Courses and Interventions

Table 4.2 describes the external interventions that support the educational model and the competency structure presented in Figures 4.1 and 4.2, respectively. Table 4.4 extends this information by including the elective and compulsory courses that sustain the whole system from within. As it has been explained in the previous subsection 4.3.1, teams are the basic organizational unit where students learn and develop social competencies. Therefore, the development of the teamwork and cooperation competency, even though located at the concentric circle number 7 of client orientation in Figure 4.2, is a priority and had to be strategically planned and supported by appropriate training interventions from the 1st year of studies.

The Enhancing Team Performance© (ETP) methodology developed by The TRACOM Group [32] was selected in late 1998 and fully implemented among professors and 1st year students in 2000 as external intervention to support teamwork and cooperation in the ChE program (see chapter 2.5).

The 1st year students are currently trained in the ETP modules:

- Fundamentals
- Change
- Team Operating Procedures
- New Member Integration
- Recognition/Reward (see table 4.4)

Students start working in project teams beginning the 2nd week of the 1st semester of their studies when they are acquainted with critical components, which contribute to optimum team performance. The Fundamentals module conveys, in a workshop format, that leadership, relationships and methods are critical components of optimum team performance. Each of these components contributes the following 3 characteristics:

- common purpose, team capabilities and change for leadership
- team norms, communication/conflict and recognition/reward for relationships
- team operating procedures, new member integration and evaluations for methods

The roles of team members, team managers and organization, together with the balances for leadership (guidance vs. freedom), relationships (support vs. candor), and methods (consistency vs. flexibility) are then analyzed. After that the phases of team formation, solidification and optimum performance are introduced. Finally, the cementing of the 3 components, 9 characteristics and balances by trust results in focus on the leadership component, interdependence in the relationships, and innovation in the methods. The module on Fundamentals increases the ability of students to adapt to the new environment and to decrease dropout. The module Change deals with the nature of change, how humans react to change, and how change impacts leadership, relationships and methods in a team. The process of change management is also analyzed, embedding the following stages:

- problem/opportunity recognition
- agreement on course of action
- action
- evaluation

The leader and member roles are examined. The Change module stresses the importance of being change receptive. It is imparted in a practical manner, since it is applied to manage change that 1st year students undergo. The following ETP© modules: Team Operating Procedures, New Member Integration and Recognition/Reward respectively, expose 1st year students to procedures needed for successful problem solving activities and team meetings; excluding or integrating members; establishing a reward system to recognize accomplishments. This 1st year external training intervention is fully implemented as indicated in Figure 4.1.

2nd year project teams start within a shared leadership team organization in the 1st semester, which evolves into a self directed stage during the 2nd semester, according to the model in Figure 4.1. This means that the responsibilities of the 4th year students leading teams in the 2nd year of IDP shift with respect to those at 1st year in line with Table 4.1. The ETP© Common Purpose module helps 2nd year students to establish their team vision, mission, objectives and action plans. It also helps differentiating commitment and compliance. The 2nd ETP© module Team Norms reinforces the need for norms (initially ground rules) and values within a framework of behavioral expectations. Students become fully aware that they belong to an educational organization that has the purpose to operate as a whole in a similar way and that has values. The team norms and values have to align with those adopted by the school:

1) We are a team where people are the most important part;
2) A commitment to serve the community beyond the expectations of stakeholders;
3) Efficiency, reliability and responsibility;
4) Excellence in the generation and dissemination of knowledge;
5) Entrepreneurship, initiative, dynamism, versatility and adaptability.

In addition to these two ETP© modules on common purpose and norms, which have been already field tested and are fully operational, the external intervention Cultural Diversity (see Table 4.2) is also in the process to be delivered to 2nd year students as a workshop. The purpose of Cultural Diversity is to gain insight in the relationship between cultural patterns and behaviors and actions. The workshop is based on the resource Managing Across Cultures from the Dow Chemical Company. The field testing status is the reason why the 2nd year external interventions are represented by grey color of tick mark in Figure 4.1. Finally, the non compulsory course Communication Techniques for Chemical Engineers is an additional resource that has been available since the early years of implementation of the ChE program to help students in their oral, written and multimedia presentation skills. Students are also introduced to the process of improvisation.

3rd year project teams reach the self directed organizational stage. As shown in Figure 4.1, 3rd year students are on their own to work as a team after having received 2 years of facilitation support from 4th year students. With this critical team organizational change in mind, 2 types of external interventions have been selected. The 1st one incorporates the modules of ETP© that deal with the remaining three modules: Team Capabilities, Communication/Conflict and Evaluation. The second external intervention Organizational Development is complementary to the above and focuses on client orientation and system thinking (see Table 4.2). Together with organizational design, strategy development and implementation, and business processes, this external intervention also introduces students to different management models, such as the EFQM Excellence Model, the ISO 9001:2000 standard, and the ABET 2000 Engineering Criteria so that they can evaluate the competency based educational model and identify their strengths and areas of improvement. The ETP© Team Capabilities module teaches to capitalize on team skills, knowledge, experience and individual differences. The Communication/Conflict module analyses the communication loop, the causes of team tension and conflict, and the standard responses to conflict. The Evaluation module is critical in the concentric competency model of Figure 4.2, since it comprises the three levels of evaluation: customer satisfaction, team performance and individual member performance. It is not surprising that the above three ETP© modules are highly valued by the 3rd year students as the latter have to overcome the organizational barrier of self management as a team. These three ETP© modules have been successfully tested by professors and students and are currently in the field testing stage by the 3rd year students of the ChE program.

The ChE program offers to 4th year students, which are the agents that retro feed into the system the social learning component by acting as leaders and facilitators of 1st and 2nd year teams (see Figure 4.1), two yearly compulsory courses in project management: Project Management (PM) and Project Management in Practice (PMP). The PM course introduces 4th year students to the basic managerial methodologies and competencies, such as project management and facilitative leadership [18]. The PMP course accounts for the hours that they dedicate to lead and facilitate 1st and 2nd year teams. Since the PM course and the previous experiences accumulated by 4th year students in previous ChE classes do not assure the smooth transition to the PMP course, two types of training interventions are in the process of being field tested. The first is the complete set of ETP© modules offered as a ChE elective with the purpose of revisiting the critical components and characteristics of an optimum performing team. The fact that students are credited for this elective course makes this offer very attractive. The second is the external compulsory intervention Facilitative Leadership described in Table 4.2 and which is currently at a pre testing field stage.

Finally, the 5th year external intervention Global Empowerment has been adopted to cope with the outer competencies in the concentric model of Figure 4.2. These management competencies should enable students to develop, implement and improve continuously the management system of any organization. If students have to close their learning process cycle, it is required that they reflect both on the results achieved through the competency based educational model and on the way that

these have been reached. In order to reflect on the latter, it is essential that students can understand the management system of the educational model itself. Only in this way, they will be ready to help assess and review the educational model and complete their empowerment journey, sharing the ownership of the School with faculty and staff. The Global Empowerment course has been designed from the materials of the workshop on Global Empowerment Assessment by the Dow Chemical Company.

4.3.3 Assessment Process

The assessment process has only started at the 1st-4th and 2nd-4th integrated design project (IDP) stages of the model. The initial approach focuses both on "what" work is done and on "how" that work is done by individual students acting in the team organizations depicted in Figure 4.1 and Table 4.2, and in accordance with the practices of Performance Management [33]. The "what" element encompasses the engineering deliverables typical of design projects, which are handed out in the format of a final report and of a public presentation of results to clients, sponsors and social stakeholders in a poster session. The more technically oriented components of the "what" element of the assessment process are evaluated during the closeout phases of the project, one per semester. This evaluation gives rise to a score or mark that is common to and shared by all team members. The "how" element of the assessment encompasses the development and use of the competencies shown in Figure 4.2 and Table 4.3. This element is continuously evaluated through all of the phases of the project, from planning to closeout, resulting in individual student appraisal. Table 4.5 describes in detail how both elements, the "what" and the "how", are evaluated for the specific case of 1st year students participating in the 1st and 4th year IDP. It can be seen that in this case both elements have the same weight, indicating that achieving good technical deliverables as a team is as important as the path taken to accomplish the task.

The use and development of competencies have been so far evaluated for the 1st year students by applying the procedure sketched in Figure 4.3. This procedure is largely inspired on the findings of self directed behavioral change research [30]. In essence, it states that the more the students control their change process, from the initial goal setting stage to the point where the progress toward the goal is evaluated, the higher the likelihood that they will eventually take on personal responsibility and voluntary commitment to change and to achieve their change goals. Again, it has to be emphasized that self efficacy or the beliefs in one's capabilities to organize and execute courses of action required to manage prospective situations, is key to developing self regulatory strategies, motivation and achievement in the academic setting [6]. Therefore, the IDP provides a convenient social environment to learn and develop competencies.

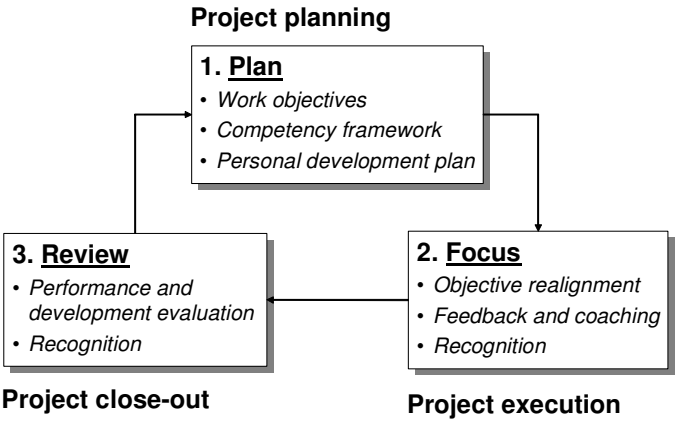

Figure 4.3. Evaluation procedure for the use and development of competencies in the integrated design projects

During the planning phase of the project, team leaders facilitate the assignment of work objectives to team members and help them to understand the competencies that will support the achievement of the work objectives. In doing so, team leaders make use of a competency form, in the format of a 10+ pages long questionnaire available upon request from the authors, that collects definitions and behavioral indicators clustered in different levels of competency mastery for all the competencies described in Table 4.3. This competency form is largely based on generic competency dictionaries such as that proposed by Spencer and Spencer [34]. Students are trained to use the competency form and the overall assessment process right at the beginning of the integrated project. This competency form constitutes a conceptual framework for students to analyze their behaviors and become aware of the deviations that may exist between one's current level of competency and the desired level. Finally, the competency form facilitates the provision of feedback and recognition by team managers, team members, and professors during the execution of the project.

During the closeout of the project, each team member holds a meeting with the team leader to reach a consensus on competency evaluation (development and use). Team members - 1st year students - bring to this meeting a self assessment based on the competency form. This self assessment constitutes the basis for discussion with the team leader who, in turn, uses all data on team members recorded during the planning and execution phases of the project. In this meeting, the team leader and the team member work to reach consensus on the self assessment, i.e. on the actual level of competency achieved. They also discuss the developmental goals that are reasonable to consider for the next stage of studies. If consensus is not reached, a professor of the PDP course (sponsor) mediates the search for a compromise.

4.4 Deployment and Preliminary Evaluation of the Model

The ETSEQ had to undergo the concentric transformation waves shown in Figure 4.2. An organizational change initiative like this one poses a colossal challenge that requires a large amount of effort and long term planning. In addition, if this change has to be implemented at a research oriented university, where the recognition and reward processes are not fully aligned to foster improvements in teaching, the endeavor becomes even more challenging [35]. Ultimately, the whole university system should also undergo the above mentioned transformation waves. In spite of these unfavorable conditions, the ETSEQ has smoothly progressed along individual and organizational transformation waves over the past ten years. Figure 1.5 highlights the milestones of the competency based education model implementation process at the ETSEQ. Overall, there are two key success enablers that have driven, facilitated and sustained such a change.

The first key enabler being the strong determination and leadership of a group of professors, circa 25% of the total faculty, actively involved in promoting effective teaching methodologies [9]. The second key success enabler being the ETSEQ/Dow Chemical Company partnership that was established in 1997. As a result of this partnership the Dow Chemical Company has provided professional change management consultants and methodologies to facilitate the organizational change needed at the ETSEQ to deploy effectively the competency based educational model. A series of workshops were organized in order to create a common vision for the ETSEQ, develop key elements to reach that vision, establish change readiness, and develop change leadership. Most of the ETSEQ professors and staff participated in these workshops and realized how much of a change the competency based education model would mean to the current way of teaching. The Dow Chemical Company has also provided expertise on team management and team development, and has facilitated the access to several learning resources. For example, the ETSEQ obtained from the Dow Chemical Company licensing use of Enhancing Team Performance® workshop materials [32] and other support for external interventions (extra-curriculum activities).

The IDP and the rest of project based cooperative learning approaches were institutionalized by the ETSEQ dean following the approval by the governing council at the end of the 2000/01 academic year. The deployment of the approach over the first 4 years of the ChE program has just been completed in this year 2005 due to resistances to change encountered at the 2nd year of the program. The approach followed to overcome this difficulty has been to involve professors into the new system rather than impose the new system on them. As a result, there is an expectation that transformation undergone by the ETSEQ, which follows the model in Figure 4.2, will be more enduring than if started as an institutional initiative. The current approach of client oriented, breakthrough changes is more likely to generate commitment and a sense of ownership among faculty, students and staff.

The backbone of the model in terms of the project oriented cooperative learning approach (central right column in Figure 4.1) is currently (year 2005) in place and

operational. The deployment of external training interventions (left column in Figure 4.1) is complete in 1st year and is at the field testing stage in 2nd, 3rd and 4th years. The workshop Enhancing Team Performance©, that has been adopted to train both students and professors, has enhanced the overall acceptance of the educational model. It also accelerates the formation of teams and the perception by students that working in teams is of advantage in engineering practice. Breaking this barrier or cultural shift from individual to teamwork has in turn facilitated the social modeling of knowledge and competencies that are inherent in the proposed model.

Global Empowerment is the only external intervention that is currently pending. According to Figure 4.1 and Table 4.2, this intervention, which is planned for the last year of studies and has a workshop format, should enable pre graduating students to implement, evaluate and improve continuously the management system of an organization. To reinforce the following two competencies, Organizational Development and Performance and Organizational Leadership (see Table 4.3 and the two outer circles in Figure 4.2), Global Empowerment should encompass in the workshop allocated (see Table 4.4), several mini projects carried out by teams of 5th year students to self assess the organization. These mini projects should be designed so that they can be carried out in close collaboration with the 4th year students acting as leaders and facilitators of IDP. Also, they should emerge from within the EFQM's cyclic RADAR methodology [36], which involves the phases of Results, Approach, Development, Assessment and Review, shown in Figure 4.4.

At the core and sustaining the RADAR cycle are the needs to INTEGRATE all enabling agents (leadership and processes affecting people, policies and strategies, alliances and resources) and operational processes, and to MEASURE all results. The enabling agents are well taken into account by the model itself and by the partnership with the Dow Chemical Company. The components of RADAR that are totally or partially missing currently are those related to MEASURE (perception measures and indicators), both in the assessment and review, and in the results step of Figure 4.4.

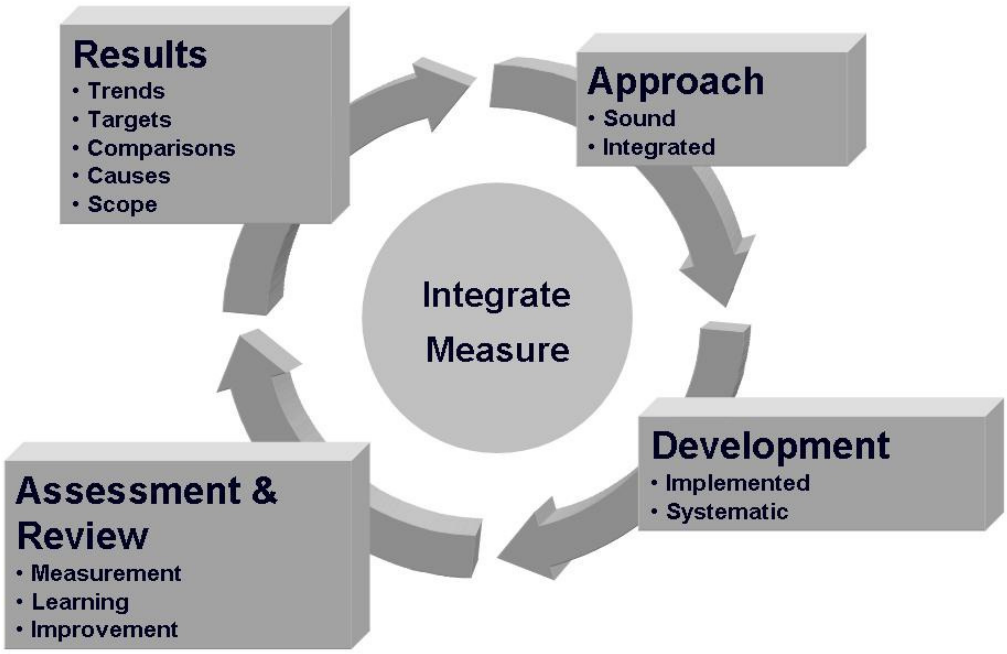

Figure 4.4. The self assessment RADAR cycle of the European Foundation for Quality Management

The assessment and review together with the analysis of results of the competency based educational model that 5th year students will carry out, should close their own learning process loop and contribute to the institutional transformation wave of Figure 4.2, which is a key area of improvement at the ETSEQ itself. Many procedures have been developed and documented throughout the years and the educational model has been continuously improved. However, there is not an accepted process management system along with associated process indicators in place. Such a system be used to assess comprehensively and quantitatively the model and, ultimately, identify, prioritize, plan and implement improvements. Probably, it is necessary that the ETSEQ goes first through this institutional transformation wave, facilitated by the ABET and other regional and national accreditation processes, before the self assessment related competencies can be developed by senior students. The successful implementation of the last intervention on empowerment is a key factor for the ongoing completion of the last two steps Assessment & Review and Results of the RADAR cycle (Figure 4.4) and for the continuous improvement of the current educational model.

The fact that most measures of the assessment currently available are of a qualitative nature does not impede to clearly perceive that classes are overwhelmingly attended, that drop out has decreased to background noise levels, that more professors act as facilitators in the classroom, and that teaching methods are more active and student centered every day. Since the proposed educational system is client oriented, it is worth stating the opinion of our industrial partner. The

Dow Chemical Company has felt the positive impact of the competency based educational model of the ETSEQ when selecting chemical engineering students for internships or graduates for new jobs. The first indicator that shows positive tendency is the number of 5th year students who carry out their industrial internship at Dow Chemical Ibérica. Placements of ETSEQ students as a percentage of total student internships has increased tenfold, from 5-7% in the late 90's to a current average of 50%. The Dow tutors highlight the fact that ETSEQ students are not only technically well prepared, but also are highly valued for their ability to overcome difficulties by searching effectively alternative solutions with initiative and teamwork. Another indicator that reinforces this positive trend is the percentage of ETSEQ chemical engineers hired annually by the Dow, which has increased by a factor of nearly three over the same period. It should be noted that the Dow follows a competency based interview scheme for recruiting purposes. The scorings of ETSEQ chemical engineers showed that:

- they possess the technical knowledge required for the job
- they are open to new challenges
- they are willing to stretch goals through effective communication, teamwork and joint development

These preliminary but qualitatively conclusive results (evidence) show that the competency model works and that it has the desired effects on student education. These trends are an encouraging early sign that the four hypotheses stated in subsection 4.2.1 are consistent with the scope of the current endeavor. It remains to measure how much this effect is tangible in every competency and to define improvement actions. In doing so, each competency will be divided into measurable components or characteristics. For example, client orientation can be broken down and measured as:

- gives a quick and adequate response to (responds to demands, questions, complaints and requests made by) clients
- shares information (keeps communication open) with clients
- finds solutions to and reaches consensus about (commits to solving) client's problems
- involves others (works) to improve service
- adds value (economical, environmental, health and safety, etc.) to clients beyond expectations

The process of defining indicators for every competency is the next step in the assessment and review step that 5th year students will carry out according to the RADAR methodology depicted in Figure 4.4.

4.5 Final Remarks

The initiative of a team of professors committed to active teaching methodologies, together with the pressures from ABET and other European accreditation boards, led to the adoption of a competency based educational model at the ETSEQ. To support the change from a conventional educational organization to a competency based system with empowered students, a partnership with Dow Chemical Ibérica was

established. This partnership facilitated the implementation of a project based cooperative learning structure and the weakening of resistances opposing change. Key for the success of the implementation has been the adequate selection of ten competencies (client orientation, versatility, entrepreneurship and innovation, systemic thinking, responsible and active learners, facilitative leadership, teamwork and cooperation, human interaction, organizational development and performance, and organizational leadership), the implementation of a team organization coherent with the model, from leader centered to a self directed empowered teams, and the delivery of appropriate external training interventions, designed to foster the development of the above competencies. Preliminary results show that students have developed technical and social competence to the point of being offered significantly more internships and permanent positions by the partner chemical manufacturer.

It should be noted that this chapter presents the final educational model proposed for competency development at the ETSEQ. The material presented, which is the main contribution of the thesis, will be published as such in the International Journal of Engineering Education (see Appendix D). Since the current work started from the successful IDP models developed at the ETSEQ depicted in Figure 1.4 and the partnership with the Dow Chemical Company back in 1997, many variations of the IDP model had the opportunity to be tested on a restrictive, unofficial basis. The impact of official adoption by the ETSEQ of the IDP in 2000/01 has permitted to recover some of the past experiences very recently, like the adoption of the 1st and 4th year model in the second year of the ChE program. This is the reason why the current model of Figure 4.1 already reflects this and other currently underway realizations. The surveys presented and discussed in Chapter 3 reflect the state of the IDP system prior to implementing or in the initial stages of testing any of the key elements of the current competency based educational model. This gap has been inevitable given the personal situation of the author of this work as well as the idiosyncrasy of the Catalan University System.

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Table 4.1. Team organizations of Figure 4.1 defined according to responsibilities and activities of members

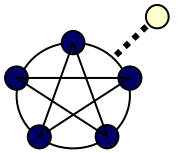
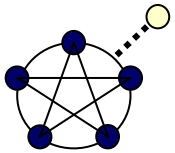
Responsibility of Activities Leader Shared between Leader & TM (not necessarily 50/50/) Shared between Instructor & TM (not necessarily 50/50/) Team Members (TM) **Activities**	**Leader directed**	**Leader centred**	**Shared leadership**	 **Self-managed**	 **Self-directed**
1.- Formulate team objectives (project scope)					
2.- Identify learning issues and apply learning processes					
3.- Establish team norms					
4.- Communicate with project clients					
5.- Communicate with project sponsors					
6.- Provide feedback to team members					
7.- Manage conflicts					
8.- Manage decision making process					
9.- Design and apply a balance of consequences system					
10.- Define and improve teamwork procedures					
11.- Determine the required reviews and approvals					
12.- Manage project's risks					
13.- Schedule project's activities and create a project budget					
14.- Establish quality standards for activities					
15.- Assign activities to team members					
16.- Monitor project progress					
17.- Integrate new team members					
18.- Assess individual performance and competency development					
19.- Evaluate team performance					

Table 4.2. External interventions supporting the educational model and the competency structure

Interventions	Description
Enhancing Team Performance® (**ETP**)	Modular workshop [Fundamentals; Common Purpose; Team Capabilities; Change; Norms; Communication/Conflict; Recognition/Reward; Operating Procedures; New Member Integration; Evaluation]
Cultural Diversity	Workshop based on the resource *Managing Across Cultures®* by Trompenaars, Hampton-Turner, 2000, to develop concepts of culture and relate cultural patterns with behaviours and actions (in collaboration with Dow)
Organizational Development	Modular workshop jointly designed with Dow to build the foundation for core values and to enhance competencies like client orientation and system thinking [organisational design; strategy development & implementation; business processes]
Facilitative Leadership	The learning resource selected is *Human Interaction®* developed and sponsored by Witt & Partner. It deals with the complexity of resolving conflicts and leading teams without exercising managerial power
Global Empowerment	Based on Dow's *Global Empowerment Assessment Workshop* to help tracking the progress of team organizational stages toward empowerment, to ensure that team members and leaders display appropriate behaviours, and to become aware of the processes and methods available to develop, implement, evaluate and improve continuously the management system of any organisation

Table 4.3. Operational definitions of the ten competencies selected according to the concentric structure of Figure 4.2

Client Orientation	The ability to identify and listen actively to clients, to anticipate and identify what clients need and value, and to seize opportunities in a responsive manner
Versatility	The ability to be open to changes and new information. To adapt behaviour and work methods in response to new information, changing conditions, or unexpected obstacles. To deal effectively with pressure; maintain focus and intensity; remain optimistic and persistent even under adversity. To be resilient and capable of dealing with disappointments and setbacks
Entrepreneurship & Innovation	The capability to identify and solve problems with creativity, to have bias for action, and take appropriate risks. The confidence to try something different without being afraid of making mistakes. The determination and ability to challenge the status quo with new and valuable ideas and to apply existing ones in new and improved ways
System Thinking	The ability to deliver technical capability based on a vision of the big picture and managing any individual or collective endeavor according to a holistic model. The capacity to recognize patterns and complete the big picture from partial information
Responsible & Active Learners	Takes responsibility for own learning and development by acquiring and refining of technical and professional skills needed in job related areas. Obtains developmental opportunities proactively. Applies knowledge and information gained as appropriate
Facilitative Leadership	The ability to help other people improve performance, promote an environment that fosters the development of others, influence and guide others toward identifying and achieving objectives, provide purpose and direction, and motivate and enthuse others
Teamwork & Cooperation	The capability to contribute to effective team output by cooperation, participation and a commitment to share vision and goals, and to achieve interdependence with personal accountability
Human Interaction	The ability to communicate effectively in interpersonal and group situations, whether through written or oral means
Organizational Development & Performance	Contributes effectively to increasing organisational performance by the knowledge of relevant management methodologies and their implementation
Organisational Leadership	Establishes directions, objectives and resource requirements required to respond to organisational needs and opportunities. Thinks strategically about longer term needs and the capabilities required to address these needs

Table 4.4. List of compulsory and elective courses, and external interventions supporting the educational model and the competency structure

Year	Course	Semester	Hrs	Type
1	Enhancing Team Performance© (ETP) modules: *Fundamentals*, *Change*, *Team Operating Procedures*, *New Member Integration*, *Recognition/Reward*	1	15	External compulsory
2	ETP modules: *Common Purpose*, *Team Norms*	1	6	External compulsory
	Communication Techniques for Chemical Engineers	1	30	ChE elective
	Cultural Diversity	2	15	External compulsory
3	ETP modules: *Communication/Conflict*, *Team Capabilities*, *Evaluation*	1	9	External compulsory
	Organizational Development	1	20	External compulsory
4	*Project Management*	Yearly	60	ChE compulsory
	Project Management in Practice	Yearly	120	ChE compulsory
	ETP complete suite of modules	1	30	ChE elective
	Facilitative Leadership	1	10	External compulsory
5	*Empowerment Journey*	1	30	External compulsory

Table 4.5. Example of the assessment process of the integrated project related activities at the first year of ChE studies

Assessed Element	Who is assessed?	What is assessed?	Weight (%)	Who assesses?	How to assess?
WHAT? (Final results)	Team	Final report	25	1st year project co-ordinators	According to acceptance criteria
		Poster	25	1st year professors (Clients)	According to acceptance criteria
		Learning of instructional objectives		1st year professors (Clients)	Each client asks questions about the content of the project to a member of the team chosen at random. The score is the same for all team members
HOW? (Processes to achieve final results)	Individual	Development and use of competencies	50	1st year students	1st year students carry out a self assessment by using a competency form designed specifically for this purpose from the dictionary of Spencer and Spencer [34]. Once completed, 1st year students meet with their team leaders to discuss results. They clarify and reach consensus. If consensus be reached, differences are recorded and a professor of the Project Management in Practice course (sponsor of the project) mediates to reach a final compromise

Chapter 5

Concluding Remarks and Recommendations

5.1 Conclusions

The aim of this chapter is to provide overall conclusions, as well improvement suggestions intended to guide further research and, more importantly, enhance the implementation of activities at the ETSEQ. The concluding and final remarks given in subsections 3.4 and 4.5 will not be repeated here, but rather summarized or restated within wider context. The framework presented in the next subsection is a build up of the ETSEQ vision and provides all the necessary components to improve the competency based educational model currently developed.

The hypothesis of achieving enhanced technical knowledge through the application of social competencies has been documented and evaluated for validity. Current results provide evidence that the new competency based model of engineering education outperforms conventional approaches and is sustainable. Over a decade of research on the model initiated back in 1994 by some visionary professors [1,2] has provided tangible data to support the original hypothesis [3] (see Appendix A). It is a valid statement to confirm the sustainability of improvements [4,5], based on the long running nature of the project. The model's uniqueness is characterized by reconciliation of the classical dilemma of conveying necessary technical knowledge and adding supplementary social competencies. Typically, these two components are perceived as being mutually exclusive.

This research puts forward an assumption that not only reconciliation is possible, but also that there is additional productivity gain in enhancing technical competence through application of social competencies. The enhancement is particularly effective when it comes to long lasting sustainable results. Traditionally, students are exposed to a predetermined fixed amount of technical content, which for the sake of this discussion may be characterized as 100%. Unfortunately this amount of technical information can not be retained and overtime drops to numbers as low as 10%. If to the contrary, social competency building is integrated, the amount of technical knowledge may only be 80%, however has a much higher retention rate, typically circa 50% [6]. The supplementary information retention rate is considerable and has to be portrayed against the additional advantage of possessing superior social competencies, which complement superb technical knowledge retention. Preliminary observations clearly indicate that this new type of engineering students have an easy entry into today's highly competitive labor market, as they outperform graduates from other more conventional schools.

This research suggests full adoption of the social integration model by other schools, which would provide more talent to the job market, in addition to accelerating the necessary culture change in an academic organization, which is traditionally change adverse. To enhance the functionality of the social integration model, improvement suggestions are proposed in the following.

5.2 Recommendations for Future Research

Some additional recommendations for future research are presented here, which are complementary to those already obtainable in Chapter 4 [7]. All along the length of this thesis work some individual recommendations were highlighted and it is now imperative to structure these recommendations in a manner which would allow future research to be performed in a more effective and efficient way. The best method of structuring recommendations is by using the Change Management framework developed by the Dow Chemical Company and which is presented here in section 2.4 (see Figure 2.2) [8]. In the following subsections, various components of this framework are discussed with specific reference to future improvements for this type of research.

5.2.1 Articulate Vision

The vision of the school (see subsection 2.4.1) has been defined, but has not yet been clearly communicated and/or reiterated. Every major change is initiated by putting forward a compelling case for change, which is communicated to the organization in a very aggressive way. Very often the importance of vision communication is underestimated [9] and consequently the organization does not perceive the need for change. In this particular case, it were the professors, above all, who left the seminars with the impression that a transition to a more team based organization is more of an option as opposed to a clear mandate.

To improve the ETSEQ performance and the performance of respective management and government bodies, it should be clear that the change is a must and that there would be negative consequences [10] in case professors fail to adopt a different way of teaching and organizing education. In addition, it is proposed that at the beginning of each academic year all professors and faculty staff should be brought together for a one day learning event, at which point the vision would be revised, learning from past academic years reviewed and actions for improvement identified.

5.2.2 Establish Change Readiness

It can be concluded that at the beginning of the project, readiness for change was only established to a moderate degree. One way to institute change readiness is to construct a more upfront communication and dialogue within the school and the students. In addition, one could consider conducting simple change readiness surveys [11], which would help diagnosing the perception of change in the organization. These surveys should be normally run on a six month basis to track relative progress.

As shown in Figure 5.1, there is a generic pattern, which is followed by individuals on the path to change [12]. It is of critical importance that the individuals affected by change move fast through the negative predisposition to change journey, as commitment to implement change only occurs when the individual is in the stage of testing.

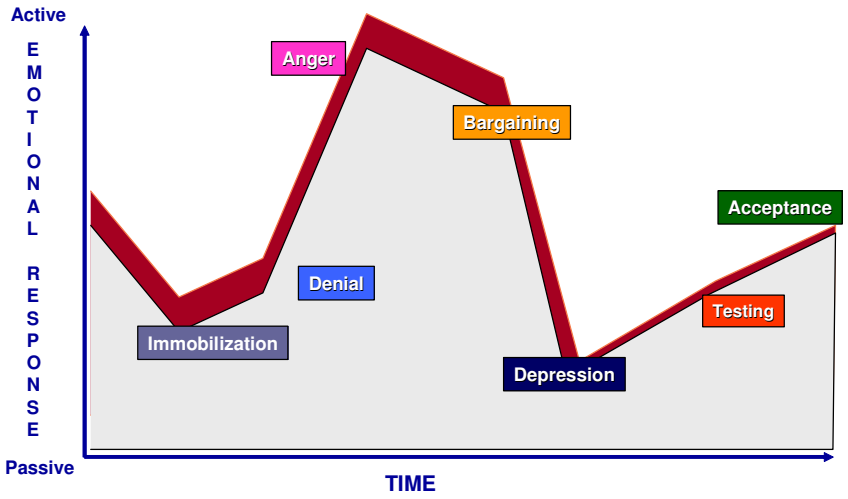


Figure 5.1. Illustration of negative predisposition to change

Only at the testing stage does the individual's energy focuses on the task. Prior to that, when going through the change, the energy is focused on emotional survival. That is the reason why in general productivity and morale will typically drop or at least stagnate when going through major change, irrespective of the nature of the organization. Figure 5.2 illustrates the distribution of energy during change.

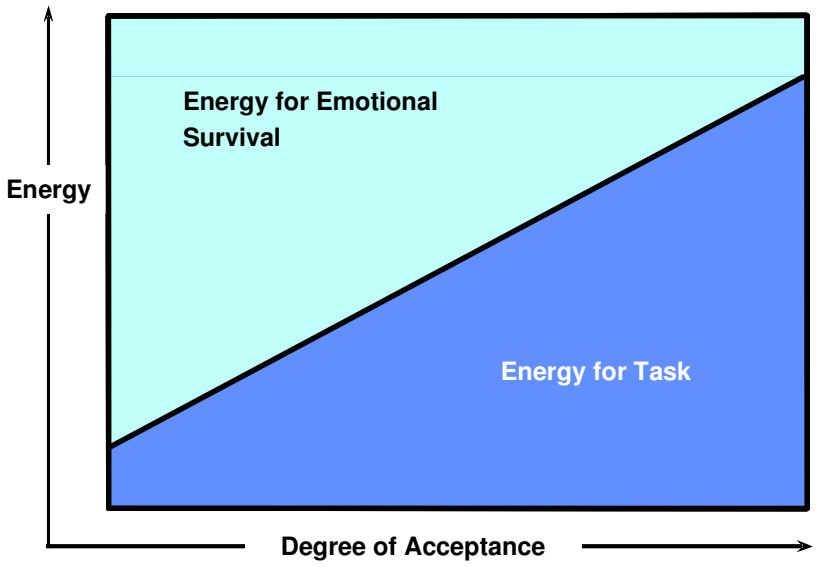


Figure 5.2. Distribution of energy during change

5.2.3 Develop Change Leadership

This is probably one of the areas where this research project needs the largest improvement, if it has to be sustainable in the long term. Building the necessary capacity to lead the school through this particular change and future transformations is crucial for success. While some education took place at the beginning of this project, it became evident that it was not sufficient to make individuals capable of driving change. It is therefore proposed that all professors, if possible, should go through an educational step, at which point they would build and enhance their competencies on how to lead change. Because of the fruitful collaboration and partnership between the ETSEQ and The Dow Chemical Company, one could think of running a two day seminar called “Implementing Change Effectively” [8] for professors and faculty to build the competencies needed. That would in turn enhance the resilience of the school as such - a strategic asset in a growing competitive environment for attracting talented students and competent professors and researchers. This is the key objective of the ETSEQ. Within the school setting, professors act as role models and their behavior shapes that of team managers and their students. So, in case a professor is a luke warm supporter of the new educational model, he/she will project that same perspective on to the students. In fact, implanting ambiguity in the school will ultimately lead to some form of civil war, as supporters of project methodology will fight resisters [13]. That takes away precious energy needed for task completion and absorbs the energy needed for emotional survival as previously illustrated in this chapter.

5.2.4 Build and Develop a Project Team to Manage New Model

When managing change on a large scale it is imperative to have a mechanism in place, which will manage implementation. In present research, this role was assigned to a project team. However, the team charter was not clearly spelled out and the roles and responsibilities not clearly allocated. This represents yet another major area for improvement, as building and maintaining a project team infrastructure is one of the success ingredients. A typical project team for the school could be formed by two professors (one of which is project leader), five students (all from different integrated projects) and two staff members (PAS). Such a composition represents a cross section of the organization and therefore should integrate the needs and concerns of all different stakeholders.

Typically, a project team should receive sound education consisting of change management and team dynamic skills. Again, from a practical point of view, the proposal calls for that same change management seminar, as proposed for the professors [8], an introduction to group dynamics “Introduction to Teams and Groups©” [14], followed by the full series of models from “Enhancing Team Performance©” [15] over time. As the integrated project methodology along with the social competency building takes momentum at the ETSEQ, one should think of rotating project team members at the beginning of each academic year. In order to guarantee continuity, it is recommended that about 4 project team members, including the leader should stay the same while the others rotate. That way an additional benefit would be obtained in form of creating multipliers at university. The project team itself would be supported by various sub teams/networks, composed of different representatives from integrated projects

and faculty. While the project team should focus on implementation and management of milestones, the respective sub teams would provide content information for the different sub streams of the project. The template proposed in Figure 5.3 for management infrastructure calls for 4 sub streams: empowerment, communication, competency building, and culture. These components are directly derived from the vision and represent the major building blocks to work with.

The project team itself is typically connected to a sponsorship team, which provides the appropriate guidance, mission statement, resources, and balance of consequences. Sponsorship team members are generally selected from the highest level in the organization. In this case, members should be the ETSEQ director, the chairs of the departments involved, and the appropriate university vice president, with representatives of government and other faculties to allow leveraging within University Rovira i Virgili and other universities.

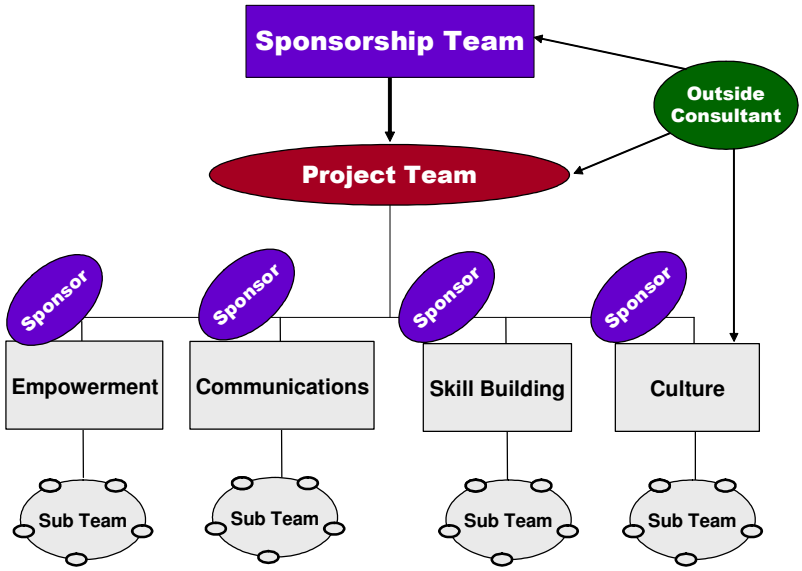


Figure 5.3. Project management infrastructure

5.2.5 Identify and Manage Expectations of Stakeholders

The prime stakeholders of this research are the various constituencies of the university. Provided that recommendations made so far in this chapter are all followed, this particular topic would be addressed practically. One could think of some other stakeholders outside of the university, in particular governmental agencies like the Ministry of Education of Catalunia, chemical manufacturers, and other universities/faculties who might be interested in learning from this project. Typical tools to track the positioning and relative movement of stakeholders are surveys, interviews, and focus groups. In this particular case, it is proposed to simply communicate more effectively with the various stakeholders, but other than that no additional measures are currently needed.

5.2.6 Design and Execute Communication Strategies

It is a today's societal paradox that despite all the information floating around, communication suffers rather often than not. It is quite a challenge to select appropriate information out of the wealth of knowledge available and appropriately communicate it to the recipients. That is the reason why one of the sub streams of the project team is communication. The task here would be to do a better job in selecting message, messenger, and media [16]. As efforts have been made throughout this research to keep the various stakeholders informed, it is recognized that additional structured efforts are needed to communicate appropriately. Given the assumption that the project team and the leadership would have received appropriate change management education, this area for improvement could be considered covered.

5.2.7 Design Jobs

As the subject of this research is an academic organization rather than a business organization, it would be more appropriate to call this area "design roles". This signifies that roles and functionalities are different before and after vision implementation. For example, before the vision implementation takes place, professors could be perceived as some form of hierarchy with the students behaving like subordinates and reporting to the professors.

The new competency based educational model is a client and service one, whereby professors represent service providers to the clients, equals students, to perform optimally. That calls for a change of roles and functionality towards a facilitation scheme, which leads towards implementation. Again, the project team with the mandate of defining empowerment would be responsible to put forward role descriptions for the new model and consequently an implementation scenario of how current incumbents would shift towards the new role descriptions and perform according to these expectations.

5.2.8 Develop Performance Measures

While a vision statement and a qualitative description of its components are available, there is a lack of quantitative performance indicators at the ETSEQ. Additionally, each objective should have a timeline and defined quantities for improvement. For example, in the chemical engineering department vision, the empowerment principles are put forward as follows: empowerment principles are applied by students, faculty members, and PAS. Effort has to be invested in order to translate these principles into compelling objectives. That should include an operational definition of what empowerment principles mean, a deadline to complete the implementation of these principles, and finally an objective way on how to measure progress. In the absence of well defined performance measures no real progress is possible [17]. Even worse, the progress made becomes the subject of interpretations and this, in turn, can ultimately fuel the 'civil war' between supporters and resistors of the change, as mentioned in subsection 5.2.3. Creative communication is required when dealing with performance measures and agreeing upon corrective measures.

When setting up the measures in more detail for the organization, a number of principles and considerations have to be adhered to. First, there has to be a hierarchy of measures [18]. The following Figure 5.4 captures the concept of this hierarchy.

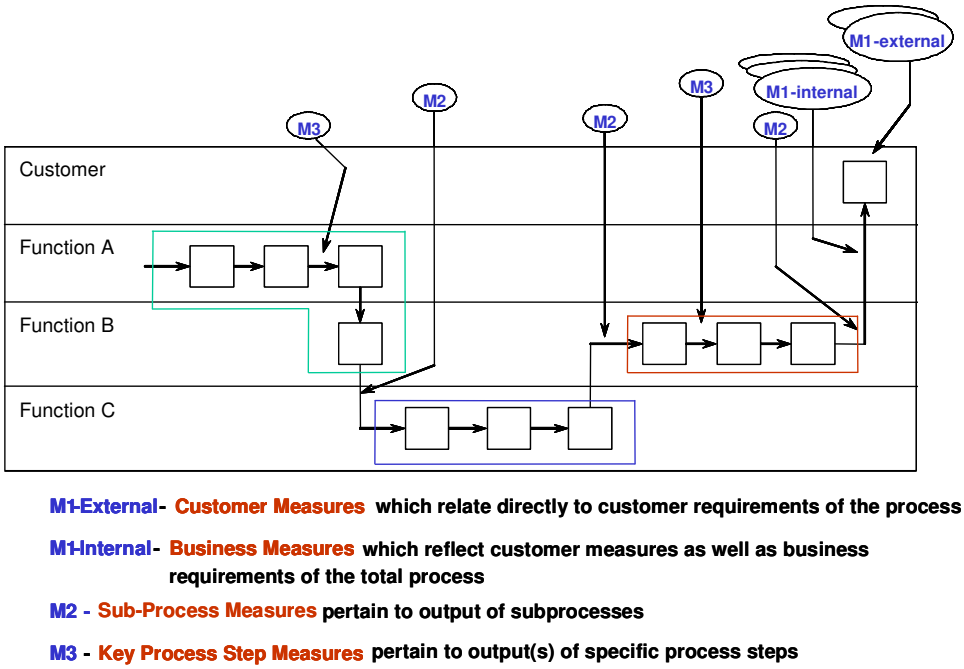


Figure 5.4. Hierarchy of measures

While this concept is primarily applied in the business world, it is nonetheless generically applicable and would serve the ETSEQ very well. In more practical terms, customer measures would be, for example, survey indicators which give supporting evidence that “we will be a center of reference in the field of Chemical Engineering in Europe with a priority hold into the Mediterranean area”. Or in other words, there have to be measures (like a survey on the attractiveness of the school in Tarragona or its perceived value by students, professors and researchers), which indicate the progress towards the accomplishment of the vision. Next internal measures should be defined, like ratings, grades, drop-out rates, etc., per faculty to reflect a unit performance. Finally, measures could be introduced on the next level below where you could compare and analyze classes within an academic year. This would be followed by student performance data.

Once the hierarchy of measures or indicators has been established, a good performance tracking mechanism has to be put in place. Typically, a grid of measures or dashboard would be used in industry. Such a grid reflects the organizational alignment, needed to show the correlation between efforts and results. In order to engage the organization, these measures are normally discussed and reviewed with the members of the organization. This allows for the teams and individuals at a working level to clearly see their contributions and impact of their activities. In more practical terms, the sponsorship team would propose the critical customer and external measures. The project team in turn would then propose the organizational measures (one level below) and, together with the sub teams, draft team and individual indicators. This way there is clear alignment between the hierarchy of measures and the change management

infrastructure, as illustrated earlier in this chapter. Figure 5.5 provides an example on how such a performance grid could be established at the ETSEQ.

Organizational Level	Cost	Satisfaction	Time	Volume	Defect
Client	University budget	Industry response	Time span between application and job offer	Number of students applying	Post evaluation of engineer hires
Organization	Department budget	Perception survey of university	Deviation from min. possible study period	Drop out rate	Professor & student feedback
Team	Cost of integrated project	Comparative survey of different faculties teams	Completion of integrated project	Number of active teams	Marks for integrated project
Individual	Cost per student	Student survey	Time required to study	Number of students participating in projects	Student marks

Figure 5.5. Performance grid for the ETSEQ

As indicated in chapter 4, one could think about additional measures to prove the hypothesis that social competencies enhance technical learning, as well as give evidence on the improvement results obtained by the social competency building. For example, it is industry standard to assess the level of empowerment. Likewise, an empowerment assessment could be applied to the teams working on integrated project during the final stages of education (4^{th} and 5^{th} years) [19]. This empowerment assessment will be beneficial, since it would facilitate the identification of future improvement opportunities and consequently allow for higher levels of empowerment. This measure would fit well in the category of team level of the performance grid. The collective view on the empowerment assessments for all teams working on integrated project would represent a measure for the organizational level. Parallel to these empowerment assessments the diagnosis tool provided by the vendor of “Enhancing Team Performance©” could also be used to validate the results of the empowerment assessment. When it comes to organizational level and customer level the EFQM model [20] and its subsequent assessment would represent another measure. While this evaluation requires competencies and effort, it provides an excellent organizational diagnosis. In addition, it would be useful to compare it with assessment already conducted at the ETSEQ back in 1998 [21].

5.2.9 Develop Competencies

Besides Develop Change Leadership this is probably the second biggest area of improvement. In subsection 5.2.3 the education of professors was discussed in detail. In this particular subsection emphasis is put on education of the remaining stakeholder, which is crucial in order to make the changes sustainable. Figure 5.6 shows the correlation between the level of competencies and empowerment. Research supports unanimously this correlation, whereby the competency

building has to be initiated first before the behavior changes become visible [22, 23].

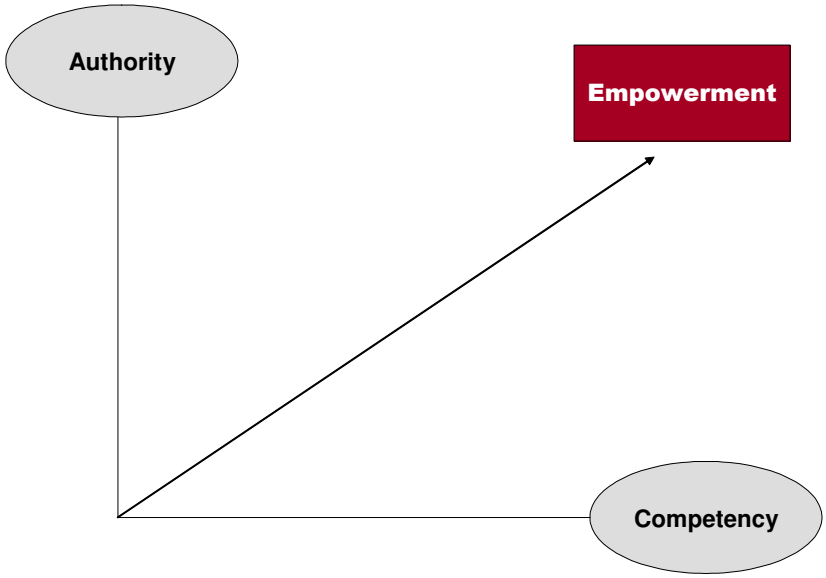


Figure 5.6. Relationship between competency and empowerment

While Figure 5.6 represents the conceptual correlation, it is worth to have a further look into the competency building process. It is important to notice that in order to accomplish the vision of a technical and social competent engineer, a large part of the education has to be focused on developing methods and social competencies. Figure 5.7, which is an upgrade of Figure 2.1, reveals the education that would enable students to become “global engineers”.

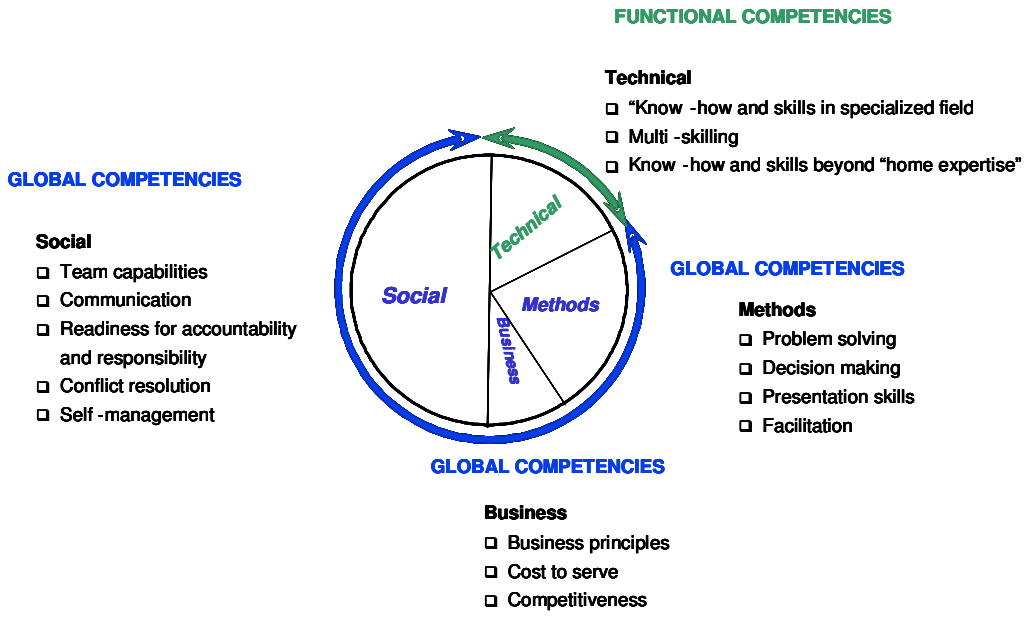


Figure 5.7. Components of competency building for a global engineer

Based on the above arguments social competencies are critical, as they allow better learning and consequently increase the ability to absorb and retain

technical competencies and knowledge. All the survey feedback obtained from students (team managers and team members), which has been reported in chapter 3, calls for more ongoing education. They are clearly demanding continuous support and coaching in order to make the learning and the behavior changes sustainable. Based on that feedback, the interventions given in Figure 4.1 and Table 4.2 as part of the proposed educational model could be complemented with other interventions in form of short courses and seminars to further enhance teamwork capability. A brief description of some of these complementary training alternatives is given below. Appendix E also includes a more detailed description of some of these proposed interventions.

One of the challenges when starting re-skilling of an organization is to find a learning resource which, while being sophisticated enough to cover the concepts and implementation, is also simple and compelling enough to be understood by the total population affected. Even though "Enhancing Team Performance©" is a great learning resource, it takes considerable effort to educate the whole organization. In addition it is a modular process and thus requires some time to convey the learning. As an improvement for future resources, it is proposed to have an alternative base education in form of "Introduction to Teams and Groups©" [14]. This is a course of approximately 6 hours, which conveys all the basic principles of teams and groups. It also allows immediate application of the learning as it contains exercises, tools and surveys, which are carried out during the course. This learning resource has been developed by The Dow Chemical Company under the leadership of the author of this research. It is proposed that the entire school population is educated with this material. This would build an appropriate foundation on which the external and more complete intervention "Enhancing Team Performance©" could be built. As "Introduction to Teams and Groups©" is only a 6 hour course, large amounts of participants could be taken through it in a relatively short period of time. This course was successfully prototyped at the ETSEQ as part of the courses for Multi-Disciplinary Seminars.

Another improvement opportunity is the provision of on-going coaching and consulting. Research unanimously supports the need for this component of learning [24-26]. It is common that groups and organizations after having received education, struggle with implementation. That is why it is crucial to have coaches and consultants available for help to overcome all kinds of barriers during implementation. The surveys feedback regarding improvement opportunities is clearly pointing in this direction. It is proposed that professors, team leaders and knowledge managers undergo a seminar on coaching. Because of the relationship with The Dow Chemical Company, it is possible to come to an agreement with the company Development Dimensions International Inc. (DDI). This relationship could be shaped in similar form to the partnership with The TRACOM Group for "Enhancing Team Performance©". The vendor DDI has a great learning resource on the market in form of the product "Enhancing Coach Performance©" [27]. Similar to "Enhancing Team Performance©", it is designed in modular form and helps coaches to fulfill their role and consequently support team performance. Under the assumption that the target population is educated in this way, it is to be expected that the implementation of the new educational model is considerably enhanced. Preliminary discussions between the author of this research and DDI have already taken place, so that "Enhancing Coach Performance©" education could start relatively soon.

In addition to the coaching support described above, it is proposed to have an external consultant available on a periodic basis. This individual would provide the coaching of the coaches in all aspects of leadership, change management and group dynamics. It is also critical that the consultant delivers the necessary tough messages to the senior level of the school and university. The advantage of being an outsider is providing a fresh pair of eyes, as well as being impartial and bringing a component of objectiveness and mediation to the party. It is proposed to set up an official agreement between this consultant and the university, so both parties could agree on their expectations. Besides consulting, this person is also to stimulate dynamics between the various constituencies of the project infrastructure.

5.2.10 Align Culture, Structure and Rewards

As discussed earlier in this research work, implementation of the educational model along with building social competencies represents a significant culture change. This philosophy is dominated by two schools of thought. One states that tools and techniques should be used to initiate the necessary culture change. The other favors the concept of “change the culture indirectly by changing the way you do things” [28]. The author of this research is a disciple of the latter school of thought. Therefore it is not recommended to introduce additional activities, but rather rigorously implement the other recommendations. As these recommendations originate at the top of the organization, a significant behavior change of professors would in turn drive significant behavior change of team managers, resulting in behavior change across the university.

When it comes to structural changes, there is no apparent need to change anything in the organizational structure or set up of the university or school. Typically when large scale reengineering projects are executed, a change in organizational structure is involved. Nonetheless, it is believed that the educational model can be successfully implemented even within the current organizational set up. This judgment is of critical importance due to the fact that structural changes in an academic organization require time consuming state approval procedure, which would slow down the speed of change. Hence it is desirable to implement the changes within the current structural set up.

Rewards represents most likely the third biggest area of emphasis. It is an accepted principle in behavioral science [24] that the reward of the desired behavior has a dramatic impact on changing behavior. The change of behavior in an academic organization is particularly complex, as there is very little direct, immediate and personal incentive to change. This assumption applies to the students and professors alike. In case of students it is not immediately obvious why they should change their behavioral pattern, when it is a valid option to maintain the status quo. Only the success of the integrated project could serve as a first tangible incentive towards improved team dynamics and consequently, more productive team behavior. Therefore, it is highly recommended that the integrated project marks should carry more weight when allocated against the total subject composition. This would not only elevate the image of the integrated project, but would also make the behavior change more desirable.

In case of professors the situation is ever more complex. The latter are by definition “funcionarios”, thus their recognition structure is rigid and state determined. A reward for this target group would have to appeal primarily to their intrinsic motivation [29]. This could take the form of student/dean feedback and personal growth and development. Preliminary attempts to initiate the student feedback to professors have been undertaken, however not in any structured form. Therefore, additional work is necessary to design – for the student and professor use – a transparent recognition scheme, which clearly links desired behavior changes and reward.

5.2.11 Develop Human Resource Policies

When business organizations undergo massive changes, they develop a high activity level at aligning and designing human resource policies. With the assumption that a reengineering effort will dramatically impact employee and career development, a revisit of human resource policies is necessary. In case of academic organization one has to look into this arena as well. Potential improvement opportunities lie in the answers to the following questions:

- How do you assign topics to professors?
- Do you introduce rotational assignments?
- Do you require social competency building and personal development for professors as condition for employment?
- Do you make participation in development activities a mandatory requirement for university members?

These and other questions should trigger a university revisit of human resource policies. A cohesive system of employee development and reward policies should be designed in conjunction with the findings of the previous Align Culture, Structure and Rewards sub chapter.

Further research and effort in the reward policy area is needed to complete the support system for the implementation.

5.2.12 Implement Change/Measure Results/Reward Teams and Individuals/Maintain and Improve

The prime objective of this section is to implement the vision and the objectives and to assure sustainability. If all along the change process the suggestions for improvement would have been implemented, it is fair to assume that by now the change is systemic and sustainable. This also implies the engagement of the total organization affected and an intense dialogue and communication throughout the implementation process. Therefore, the task at hand calls for implementation discipline with performance tracking, analyzing deviations, capturing learning and continuous improvement program. Ideally, there is an infrastructure in place to perform these tasks. This infrastructure could be represented in form of the project team, as proposed in subsection 5.2.4, or any variation of that proposal. It is mandatory that performance tracking is an integral part of the duties of university management, so that response to any deviation occurs in a timely fashion. Based on current experience, when change management is adopted, performance tracking becomes an integral part of operating. Gradually the

management of these changes has to become a daily activity and no longer carry the notion of being on top of the normal work flow.

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Design and Implementation of a Competency – Based Educational Model in an Academic Organization

by

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Tarragona, juliol de 2005

Dedication

This Thesis is dedicated to my father

Erwin Witt
1929 – 2001

Declaration

I herewith declare that this thesis work was designed and executed by myself with the help of the individuals mentioned in the acknowledgements. The research work has been presented as it appreared and the data reflects reality. No distortion of any data or outcome took place. Wherever other sources of research and intellegence were used or referenced, they have been marked as such.

Hans-Joerg Witt
July 2005

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It is impossible to list all the individuals who have contributed to this work. I would like to express my gratitude and thankfullness to all of those.

I take a deliberate and subjective choice by particularly referencing a number of people which have been key to the completion of this project. First, to my two mentors and sponsors: Professor Francesc Giralt and Doctor Steve Constantin. From the School of Chemical Engineering (ETSEQ) I owe thanks to Professor Joan Ramon Alabart, Professor Azael Fabregat, Professor Joan Herrero, Professor Robert manuel Gilabert, and to the staff of the ETSEQ. Also it would have not been possible to create this work without the editorial and logistic support from Laura Abraham and Tatiana Winter.

Executive Summary

This research project deals with the design and evaluation of social competency building in an academic organization. This topic is especially relevant, as the workforce of the future must posses a very different competency-set contrary to the past generations. In an ever changing environment the academic organizations must provide the human resources capable of managing current and future challenges.

The hypothesis of this research proposes social competency building as an enabler to improving technical capabilities. As the curricula in academic organizations are already exhausted, if not overloaded, innovative ways have to be found in order to enhance the technical knowledge through social skills. By means of integrated project work, empowered teams and social interventions, higher levels of performance can be obtained. A survey process was developed to validate the hypothesis and to obtain data to support the development of a new model for engineering education. As a result, a new competency-based educational model was designed and partially implemented at the ETSEQ with a clear client orientation profile. To facilitate the implementation of the model a partnership between the ETSEQ and Dow Chemical Ibérica was established with the purpose of providing support to the change process that the new model implied and expertise and educational materials to facilitate the development of key competencies starting from client orientation.

After nearly a decade of intense research it can be concluded that the hypothesis stands the test. Already the application of selected team work competencies shows considerable tangible improvement compared to traditional ways of engineering education. The implementation of the proposed improvements would lead to greater productivity gains and ultimately represent a step forward towards the human resource needs of today's and tomorrow's manufacturing work environment.

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