Challenging Students' Responsibility:

An Engagement Methodology

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***Abstract*— In order to challenge the students' responsibility, motivation and participation in mathematics courses this paper reports an action-based research about some ways to tackle such tasks for increasing their motivation and course engagement from a "teamwork" competence. Their comments and suggestions provide strategies to improve the results obtained.**

Keywords: Competences, Formative Assessment, Rubric, Student's Opinion, PBL/EBL, Teamwork

	Students	Percentage	Mean
Don't succeed		74,92	
Electricity	7,00	2,17	3,37
Industrial Electronics	27,00	5,34	4,13
Industrial Chemistry	6,00	1,09	4,18
Mechanics	32,00	9,18	3,09
Management Informatics	20,00	7,30	3,95
Total	92		3,67

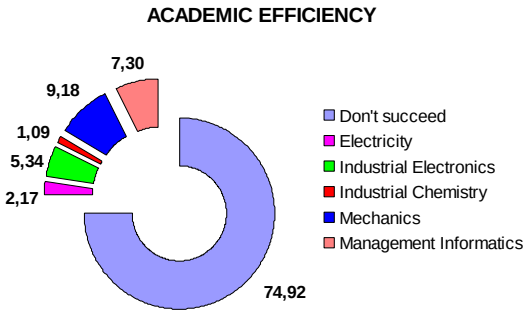
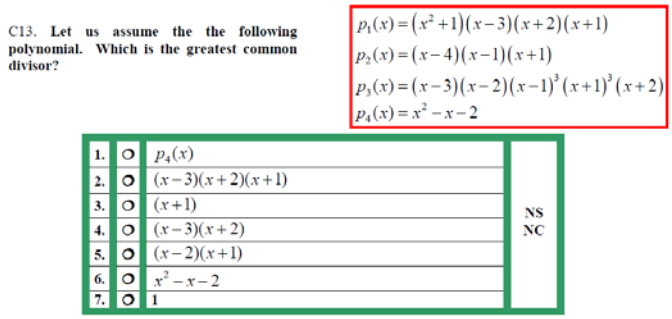


Figure 1. Outcomes of a prerrequisite validation.

I. STATE OF THE ART

On the one hand, several studies have analyzed the state of the art in the curriculum of Mathematics. On the other, it has been observed that our civilization is experiencing the "impact of a regression to the mean". Namely, the quality of the learning/teaching process (LTP) in Mathematics in students entering the university is in decline; for most students the mathematical maturity is achieved (from nursery to school) more as a product of random events outside the family environment; it should require a more rigorous mathematics education programs in compulsory and secondary school; there is a clear difference between 'mathematical thinking" and "the process of calculating"; as calculators, while excellent tools for many things, do not imply the development of resolution and reasoning strategies; … [4, 15]. For instance, when first-year students tried a mathematical prerequisite test on undergraduate contents they do not succeed (Figure 1). This study has been done at the very beginning of this course to test the mathematics mean level of 92 students entering our School. That questionnaire involves multiple-choice answer easy questions on calculus, algebra and statistics (Figure 2). Also, at the very beginning of this course a literacy study has been implemented with the students, that this year were entering the university for the first time. This short test includes numerical, schematic and written knowledge for information in prose, considered from a basic competence point of view [13]. Results have been discouraging: the mean label attained has been label one out of five (see Figure 3), although the sample studied has not been valid from a statistical consideration (the sampling error being 4.28 %). Namely, 90 % of the students do not reach level 3, which is considered the minimum desired following the international conventions.


C13. Let us assume the the following polynomial. Which is the greatest common divisor?

$p_1(x)=(x^2+1)(x-3)(x+2)(x+1)$
$p_2(x)=(x-4)(x-1)(x+1)$
$p_3(x)=(x-3)(x-2)(x-1)^3(x+1)^3(x+2)$
$p_4(x)=x^2-x-2$

1.	O	$p_4(x)$	NS NC
2.	O	$(x-3)(x+2)(x+1)$	
3.	O	$(x+1)$	
4.	O	$(x-3)(x+2)$	
5.	O	$(x-2)(x+1)$	
6.	O	x^2-x-2	
7.	O	1	

Figure 2. Example of the prerreqisite questionaire.

In addition, many students are not successful in developing their LTP. There is a misconception about the work method to be developed in university environments (especially in mathematics). Our students are generally not successfully developing appropriate skills and capabilities to achieve the strategic objectives for [10]. Furthermore, the Bologna Declaration has set the challenge to improve education, research and management schemes in the European Higher Education Area (EHEA), because in the corresponding curriculum the student is considered as an overall planning process. Consequently, they should expect rapid change (but hopefully not accelerated). The task-based LTP will become obsolete. The student, not the teacher, is the goal of the curriculum and the teacher becomes now a guide (in the sense

of an adviser to him or a coach). Finally, but equally important, the New Information and Communication Technologies suggest future changes in climate to be given to the curriculum. That is, they bring different tools to assist the teacher in the development of any LTP. Learning and mastering these tools will help the teacher to have more resources to address the aforementioned failure. The three referred causes suggest that this might be a good time for a rethinking of the basic principles that guide the LTP from a teacher's viewpoint, so that if using the experience gained so far, there is a process of self-reflection and self-criticism to analyze and correct those weaknesses and along with the strengths observed, so as to improve in the quality of the educational process. An adequate approach is provided from the research-action methodology [8].

LITERACY						
LEVEL 1			LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
0-125	126-175	176-225	226-275	276-325	326-375	376-500
N1			N2	N3	N4	N5

LEVEL	NUMBER OF PERSONS	PERCENTAGE
< LEVEL 1	0	0 %
LEVEL 1	14	66 %
LEVEL 2	5	24 %
LEVEL 3	2	10 %
LEVEL 4	0	
LEVEL 5	0	
MEAN LEVEL	LITERACY MEAN LEVEL	
	N1	

Figure 3. Results of the Literacy short test.

In the year 2010 the Bologna process (namely, EHEA) will be completed in the Spanish universities: changes in learning and teaching, in institutional and management levels. To improve the competitiveness of universities and the quality of higher education in the European Union curricula will be worked based on the professional responsibilities/academic competences, the student's active and ongoing learning, the flexibility and the internationalization of studies, the introduction of the European Credit for Transfer and Accumulation (ECTS), the alignment of curricular structures in two cycles and the people's mobility. The graduate profile will be a benchmark reference of the new curriculum, which is being designed at present in the Spanish university, because it will have to establish the core (basic) competences (standards for learning to learn and learning to know), crossed competences (learning to live together and learning to be), and specific competences (learning to do). That new curriculum will develop the spirit EHEA/ECTS: a Long-Life-Learning development profile of the student through a development of competences (i.e., skills, attitudes, aptitudes and values –the competence viewpoint).

As a consequence, changes are expected in the educational methodologies and in the assessment and accreditation processes of the syllabus [14]. Formative assessment will have to be emphasized since: it facilitates the development of self-assessment (reflection) in learning; it encourages teacher and peer dialogue around learning; it helps clarify what good performance is (goals, criteria, expected standards); it provides opportunities to close the gap between current and desired performance, it delivers high quality information to students about their learning; it encourages positive motivational beliefs and self-esteem; and, it provides information to teachers that can be used to help shape the teaching [7, 12]. This paper reports an experience where assessment is used to engage student's motivation, responsibility and participation using rubrics as valuation tools.

UNIT	ENGINEERING STATISTICAL METHODS 5 ECTS	WEIGHT (%)	
1	Introduction to Statistics	3.33	33.33
2	Descriptive Statistics	10.00	
3	The Theory of Probability	6.67	
4	Probability Models	13.33	
5	Introduction to Quality Control	6.67	45.00
6	Parameter Estimation, Hypothesis Contrast and Model Contrast	28.33	
7	Regresión and Correlation Theory	10.00	
8	A PBL Project of applied orientation	21.67	21.67

- **C1:** To determine in detail from a theoretical/numerical perspective the key elements of deductive and inferential Statistics. Based on the contents of the subject, general strategies must be significantly implemented to get involved in the resolution of engineering problems and related matters.
- **C2:** To derive and analyse the information inherent in a given statistical series (significant random sample), by means of numerical/symbolic computations. The use of some scientific software (SPSS, R, Mathematica, and / or Excel) of interest in engineering and applied sciences is needed. Simple examples are planned and solved, analyzing the error attributable to the process developed and studying the relationships with situations, in which students usually will find in engineering environments.
- **C3:** To develop statistically valid conclusions in a critical way (reasoned and justified) from the results produced, that are based on an efficient management of information acquired.
- **C4:** To cooperatively plan and develop in a coherent way a simple research paper on any contextualized chemical situation, including an oral presentation and/or written essay that describes the main steps in the implementation completed. The most relevant facts and findings must be highlighted, while verifying the management of the resources used (people, media, mathematical programs, times, concepts, ...), which the working team/group has necessitated (from a multidisciplinary perspective).
- **C5:** To acquire working strategies and mechanisms to promote the continuing need to improve a meaningful learning throughout life, worrying about the quality of the accomplishments, making particular use of computer management through ICTs, focusing on rigor, precision and excellence.

Figure 4. The syllabus: a) The main contents; b) the core competences of the syllabus.

II. PROBLEM STATEMENT

Several studies have shown that the characteristics of the classes usually rated by the students include great challenge, but full opportunity to review and improve their work before they are qualified and, therefore, to learn from their mistakes in the process [3]. One of the advantages of the formative assessment is that it does fit simpler procedures than those used in traditional exams as outlined for summative assessment. Valuation matrices (or rubrics) are scoring guides used in assessing student's performance that describe the specific characteristics of a product, project or task at various levels of performance, in order to clarify what is expected of the student's work, assess their implementation and facilitate the

feedback supply [1, 11]. Students get bored at grading [2, 16]. How can the teacher deal with this environment? This paper reflects over ways to engage (in an action-research environment) undergraduates in motivation, participation and responsibility tasks challenges, since they are not accustomed to work such competences. Besides, such values are rarely treated in the first and second courses of the any university degree. That is, it is reported how to challenge students in mathematics courses, taking into account the comments provided in the preceding section.

Each course the students must complete in cooperative groups a research about a statistical problem related to the most important descriptors and contents of the syllabus (see Competence 5 in Figure 4). Consequently, the student must deal a great deal of skills that define such team-work competence: cooperative work, communicative strategies, effective meetings, tutorial reinforcement, resource management optimization, team work (of course), facilitation and supervision, and assessment, among many others. It is a quite complex competence [6, 7, 9].

The students have been proposed to get involved in all the stages of the preparation of an assessment tool for accreditation of one of the syllabus competence (i.e., team work). Figure 4 shows the structure of the course syllabus; namely, credit weight and key competences. Such a process has included: **a)** a questionnaire to decide the evaluation criteria for formative and summative assessment that would be considered in the competence rubric; **b)** a proposal to pose the quantification of the criteria applied; **c)** the use of that tool in the formative assessment to other groups; **d)** the use of the rubric to look for evidences to be added to his/her portfolio to produce the summative self-evaluation, which is discussed with the teacher at the end of the course; **e)** to provide both qualitative and quantitative justifications and reasoning about the opinion of the results obtained ; and **f)** as a consequence, an improvement strategy has been derived to be applied next time.

This study is part of a cross-sectional study of a team of educational innovation (TEI) conducted in five degrees on the student's opinion regarding the competence of "team work." It includes public and private universities of the Basque Country land: 5 faculties, 6 degrees and 8 researchers are included. Here, the results of a statistics course (2nd year in a 3-year degree on Industrial Engineering where multiple teaching methodologies are used surrounding the PBL/EBL (Problem Based Learning / Enquire Based Learning) approach) will be presented and discussed (Figure 4 shows its main characteristics).

III. METHODOLOGY

The methodology has implied the following steps:

(1) Analysis of the evaluation indicators and assessment criteria, which must be considered in a given course.

(2) The assessment rubric has been designed and implemented.

(3) The rubric has been applied in the formative and the summative stages of the assessment. Also, it has been applied to valuate the product of each group, which has been presented at a conference poster session type.

(4) The process has been evaluated looking for the students' comments and valuation, altogether with the professor's considerations.

		IMPORTANCE		COURSE	
		Mean	St. Deviation	Mean	St. Deviation
Structure/ Estructura	Ability to plan and organize work *Capacidad de planificar y organizar el trabajo*	2,56	0,58	2,51	0,63
	Organize and prioritize tasks *Organizar y priorizar las tareas*	2,38	0,65	2,31	0,67
	Ability to engage and work together *Habilidad para implicarse y trabajar en equipo*	2,28	0,61	2,25	0,64
	Willingness to work *Disposición para el trabajo*	2,36	0,70	2,34	0,73
	Level of content acquisition and transmission to their partners *Nivel de adquisición de los contenidos y transmisión a sus compañer@s*	2,04	0,61	1,99	0,62
	Participate in various activities *Participar en las diferentes actividades*	1,96	0,68	1,94	0,71
	Study habits *Hábitos de estudio*	2,60	0,58	2,59	0,63
	Responsibility *Responsabilidad*	2,72	0,61	2,68	0,67
	Autonomous learning *Aprendizaje autónomo*	2,36	0,57	2,29	0,60
	Solutions for learning difficulties *Busca soluciones a los problemas de aprendizaje*	2,52	0,65	2,51	0,69
	Ability to adapt to new situations *Capacidad para adaptarse a nuevas situaciones*	2,32	0,56	2,20	0,63
Implementation/ Procedimiento	Attendance at meetings *Asistencia a las reuniones*	2,44	0,65	2,42	0,75
	Having clear and shared work goals *Tener claros y compartir los objetivos del trabajo*	2,44	0,58	2,33	0,68
	Development of the task *Desarrollo de la tarea*	2,20	0,58	2,07	0,62
	Meet standard/agreed norms *Cumplir las normas establecidas/pactadas*	2,40	0,76	2,38	0,84
	Contribute to the tasks assigned by the group *Contribuir en las tareas asignadas por el grupo*	2,56	0,65	2,55	0,75
	Meeting the agreed schedule of tasks *Cumplir el cronograma de tareas acordado*	2,08	0,64	2,03	0,72
	Undertake tasks / roles in terms of objectives *Asumir tareas/roles en función de los objetivos*	1,84	0,69	1,77	0,74
	Efficient management of resources using the group work *Gestión eficiente de los recursos de trabajo que usa el grupo*	2,04	0,68	1,99	0,68
	Keeping colleagues informed and share all relevant information *Mantener a los compañeros informados y compartir toda la información relevante*	2,64	0,57	2,59	0,69
	Effective meetings: capacity for organization and planning *Reuniones eficaces: capacidad de organización y planificación*	2,36	0,49	2,24	0,59
Relationships/ Relaciones	Interact positively with the rest of the group *Interrelacionarse de forma positiva con el resto del grupo*	2,56	0,77	2,51	0,79
	Communicating effectively (orally and in writing) with the other students *Comunicarse de forma efectiva (oral y por escrito) con los otros compañeros*	2,36	0,57	2,29	0,67
	Contributions made to the project and the work team *Aportaciones realizadas al proyecto y al equipo*	2,40	0,50	2,29	0,61
	Participate actively in the work of the group and make significant contributions *Participa activamente en las tareas del grupo y hace contribuciones relevantes*	2,16	0,62	2,12	0,66
	Meeting the commitments made *Responder a los compromisos adquiridos*	2,40	0,65	2,38	0,68
	Solve problems that arise *Resolver los problemas que surjan*	2,36	0,64	2,33	0,67
	Leadership and initiative *Liderazgo e iniciativa*	1,76	0,60	1,72	0,63
	Ask for ideas and opinions for the decisions and plans *Solicitar ideas y opiniones para la toma de decisiones y planes*	2,08	0,64	1,99	0,62
	Cooperation *Cooperación*	2,52	0,59	2,50	0,63
	Putting the group's goals for personal interests *Anteponer los objetivos del grupo a los intereses personales*	2,08	0,70	1,99	0,74
	Integrating those not participating *Integrar a los que no participan*	2,12	0,78	2,08	0,73
Emotions/ Emociones	Ability to express, empathize and communicate emotions *Capacidad para expresar emociones, empatía y comunicarse*	1,92	0,81	1,91	0,84
	Group dynamics *Dinámica grupal*	2,20	0,58	2,16	0,67
	Promoting healthy disagreement and debate, working consensus. Constructive criticism *Fomentar el sano desacuerdo y el debate, trabajando el consenso. Hacer crítica constructiva*	2,36	0,76	2,30	0,77
	Publicly recognize the achievements of others *Reconocer públicamente los logros de los otros*	2,08	0,81	2,00	0,84
	Rate equally the point of view and opinions from all members of the group *Valorar por igual la opinión de todos los componentes del grupo*	2,64	0,64	2,59	0,68

Evaluation/ Evaluación	Assume one's responsibility for its results Asume su responsabilidad sobre sus resultados	2,52	0,71	2,51	0,74
	Evaluate one's skills and own position in the group Evalúa sus capacidades y su propia situación en el grupo	2,16	0,62	2,07	0,68
	Co-evaluation between components on the involvement of each member Coevaluación entre los componentes respecto a la intervención de cada miembro	1,83	0,70	1,81	0,67
	Monitoring the process of group work by the faculty Supervisión del proceso del trabajo del grupo por parte del profesorado	2,20	0,82	2,17	0,83
	Assessing the group's final outcomes Valoración de la producción final del grupo	2,40	0,71	2,42	0,74
		2,29		2,24	

Figure 5. The students' decision about the assessment indicators of the team-working competence (over 4 points).

(5) An improvement planning has been retrieved as the final outcome, where corrective, preventive and/or improvement actions have been taken into account.

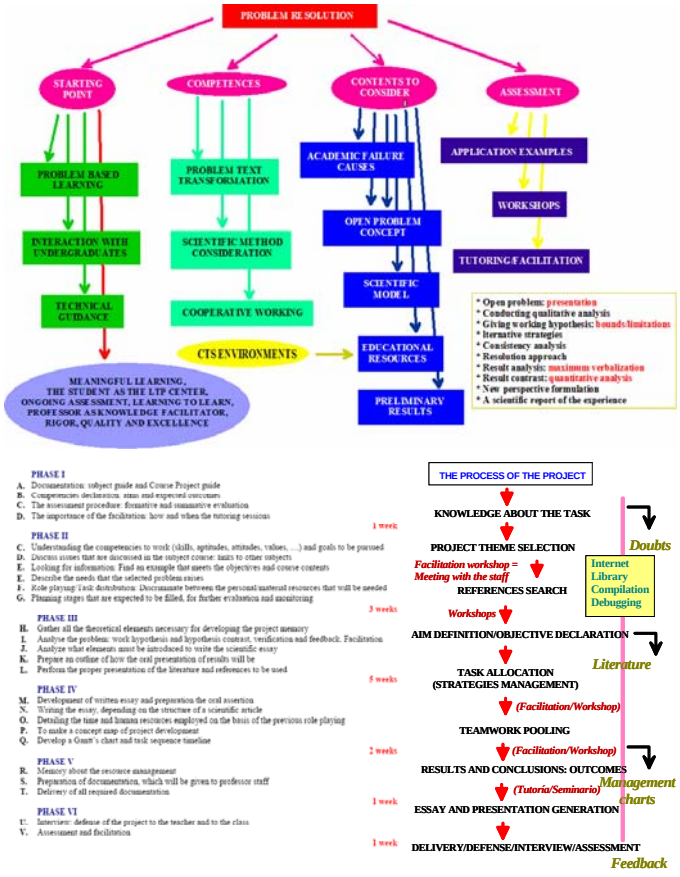


Figure 6. Problem/Project solving via a PBL/EBL approach.

The TEI has carefully considered the knowledge, abilities, skills, values, attitudes, aptitudes and virtues that can define this competence. At last, four affinity groups (evaluation criteria) with a total of 42 evaluation indicators have been produces; namely, the structure of the group (11 items), the process generated (10 items), the relations established (11 items), the appeared emotions (5 items) and the assessment itself (5 items). The students have chosen (Figure 5 shows the results of the syllabus reported in Figure 4) what items must be included in a given course (last two columns) and have decided its relative importance (first two columns) in the whole of the competence environment. Columns 1 and 3 are mean values and columns 2 and 4 are standard deviations. The mean values reported show that students think that the mean importance of this competence is 2.29 (out of 3) while the mean course is 2.24 (out of 3). In other words, the importance assumed is high and students suggest that this competence must be developed in the upper courses of the degree. To challenge this situation some explanations are necessary to engage the students, because they are accustomed to play a little role on the daily discourse of the LTP.

25 students (over 36 –that attend class regularly; i.e. 69.44 %) have answered the questionary. However, 15 students (29.41 %) did not go regularly to class: they were matriculated but they were not going to class.

Then, an analytic valuation matrix has been defined (see the Figure 14 at the end of this paper). It contains five evaluation criteria: the general situation of the (5 evaluation indicators); the procedures implied in the group development (6 items); the relationships between the group members (4 items); the treatment of the emotions that have appeared (3 items), and the assessment process (4 items). Three competence levels have been only established: "quite competent" (2 marks), "only acceptable" (1 mark) and "does not fulfil" (the task or so must be redone again). Each student has applied this tool regularly as formative assessment to decide where the group does not fulfil the necessary requirements to be competent as team work or where the group must improve its development to play the role of a real group. However, each student has token this rubric into account to analyse his/her contribution to the general development of the group itself or to analyse how the group was helping him to grow up as a person. These reflections are evidences for the portfolio that can be used to explore the performance of the student's evolution over the subject competences. As it has been mentioned, at the beginning of the course the evaluation criteria are discussed with the students and some consensus is reached. Then, each team evaluates its work which is discussed with the professor in an interview (inner evaluation) and the remaining teams do evaluate the oral presentation, which must be given (outer evaluation) in the general context of a PBL/EBL approach (Figure 6). Otherwise, the student has an opportunity to fix the minimum quality of the production result the group will have to develop, and, at the same time, there exists a non-explicit level to show the group where the excellence level is located.

It has been noticed that the team work competence must be approached quite differently at first courses or in the last ones during the implementation of the PBL/EBL methodology. Because of that, facilitation and supervision are peremptory [6]. When developing a PBL/EBL Project course great care must be devoted to the tutoring task, above all in the first courses (namely, this is the case where strengthening work in basic sciences is called for [7]); namely, focusing on improving the student's communication [9]. In this sense, facilitation must develop daily reflection: pre-session (to present a focus concerning group dynamics so that facilitative questions should be used to start reflection), ordinary supervision session (with timeouts to discuss focus and to play diverse roles) and post-session (to facilitate reflections on the focus). Furthermore,

facilitation implies tutoring and supervision (sometimes, even control) to respond to student's problems in terms of meta-skills [5, 7] (see Figure 7). Several dimensions are taken into account: the intellectual dimension, the personal dimension, the social dimension, the practical dimension (with several viewpoints: providing support, encouraging independence, developing the interpersonal) and assessing research (formative assessment, creativity and originality, reliability and validity) [9, 16].

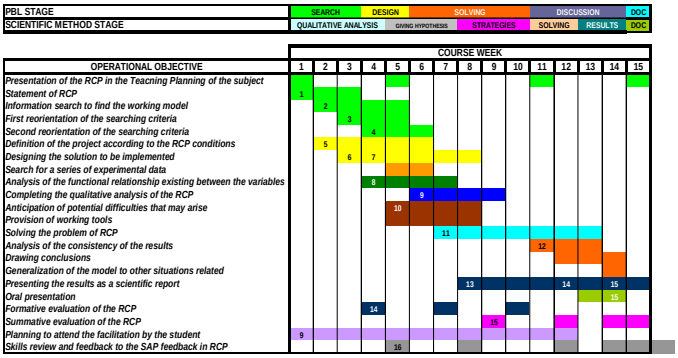


Figure 7. A Gantt's diagram of the Course Project timing.

However, the teacher's role must also be considered from a leadership point of view: from hierarchy / autocratic / consultative to autonomy / functional / contractual via cooperation / negotiation / consultative. This implies that the student/teacher relationships ought to include six dimensions: the planning dimension (goal-oriented, aims, ends and means), the meaning dimension (cognitive understanding of experience), the confronting dimension (raising awareness to individual and group resistance), the feeling dimension (addressing emotional competence and incompetence), the structuring dimension (methodology of structuring experiences) and the valuing dimension (creating a support climate that celebrates individuals) [6, 12].

This research is action-oriented (see Figure 10); so, a Deming's wheel (a Plan-Do-Act-Check cycle) must be reconsidered once an again. That is, the design and the implementation being developed mechanisms and tools to look for information about the results and about the address of the research must be considered. In order to know the students' opinion a half-opened questionnaire has been given to the students (Figure 8). The following topics are considered to attain the student's point of view on the approach, development, evaluation and analysis of the team work competence. Specifically, the elements taken into consideration cover the information supplied, the initial training, the degree of initial expectation with respect to the competence itself, the degree reached in its development, the development of the teaching methodology applied, the facilitation/supervision/tutoring set up and the assessment considered.

Remembering, the result of this teaching task is to produce a scientific essay in a cooperative environment (Figures 6 and 7). So, the own subject questions the student about the contribution of this competence (see Figure 9) related to all the another competences, because its weight is 21.67 % (Figure 4). Students also write some comments in the portfolio about their viewpoints on this approach, which are given in the interview at the end of the course when they explain the evidences carried out in their portfolios.

IV. RESULT DISCUSSION

Formally, these results demonstrate the need and urgency that the students show to introduce (early) this competence in their studies (Figure 5). Students are quite surprised by what they have been presented with this methodology. All the students that have answered the questionnaires were involved in this approach, but since they were not all of the students of this subject results are not conclusive. However, this sample includes the 84.45 % of the students who went to class.

Applying this strategy, all the existing groups have succeed in their marks because they have fix beforehand a reference level to surpass in the assessment rubric (it has been degree 1 in the evaluation indicators –see the rubric at the end of the paper). Table I provides high positive answer percentages to the questions of Figure 8. In particular the most voted evaluation indicator is "21 - Evaluation modes" and the most negative "17 - Conflict resolution" in the rubric applied, because students didn't well understand it –they added in the comments at the end of the questionnaire. There is great agreement with this methodology (87.65 %) but feedback has produced interesting ways to deep in (see this section below).

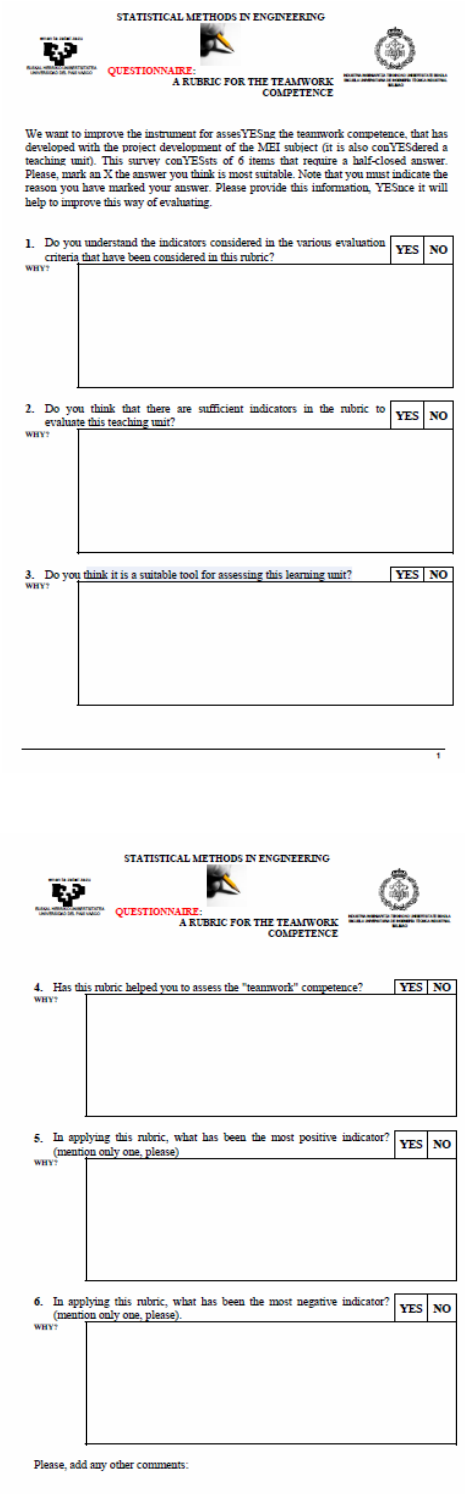
TABLE I. RESULTS OF THE STUDENT'S OPINION QUESTIONNAIRE

ITEM	EXPLAINATION	Percentage	¿WHICH?
1	The assessment criteria understanding	95,13	
2	The assessment criteria sufficiency	98,83	
3	Evaluation tool adequacy	82,03	
4	The rubric has been useful	82,36	
5	The evaluation indicator most voted	91,23	21,00
6	The evaluation indicator most negative	65,23	17,00
	Mean value	**87,65**	

Table II summarizes the overall performance mean rates of this research, which the students have directly answered for. All responses ranged from zero to ten points. The general opinion about the methodology deployed is good (7.2 points), and students like the syllabus (7.6 points), but improvements can be carried out. The competences and objectives of the course are well understood (8.1 points); however, the competence here researched has dealt with difficulties (6.5 points) because the way has been worked out is a bit difficult to be followed (the students have said). Moreover, the motivation rate is good (7.8 points) but the participation index provided has been excellent (9.1 points), but problems have arise because of the responsibility indicator is not so good (7.3 points). The students demand a lot of help and care (though they are in first courses) –self-sufficiency index is 6.2 points, while they have considered an excellent level of facilitation (8.9 points), too.

The methodology implemented in Section III provides a protocol to be applied to engage students in the LTP of the

syllabus, where a practical learning is set down. But this strategy implies to look after alliances with students analyzing very carefully those synergies that usually appear in class. Results are quite good (mean values of Tables I and II) and they invite to use the PBL approach. However, these results can be improved, and the students can help in such a task. The comments provided but students have declared and pointed:



STATISTICAL METHODS IN ENGINEERING

QUESTIONNAIRE:
A RUBRIC FOR THE TEAMWORK COMPETENCE

We want to improve the instrument for assesYESing the teamwork competence, that has developed with the project development of the MEI subject (it is also conYESdered a teaching unit). This survey conYESsts of 6 items that require a half-closed answer. Please, mark an X the answer you think is most suitable. Note that you must indicate the reason you have marked your answer. Please provide this information, YESince it will help to improve this way of evaluating.

1. Do you understand the indicators considered in the various evaluation criteria that have been considered in this rubric? YES NO
WHY?

2. Do you think that there are sufficient indicators in the rubric to evaluate this teaching unit? YES NO
WHY?

3. Do you think it is a suitable tool for assessing this learning unit? YES NO
WHY?

STATISTICAL METHODS IN ENGINEERING

QUESTIONNAIRE:
A RUBRIC FOR THE TEAMWORK COMPETENCE

4. Has this rubric helped you to assess the "teamwork" competence? YES NO
WHY?

5. In applying this rubric, what has been the most positive indicator? (mention only one, please) YES NO
WHY?

6. In applying this rubric, what has been the most negative indicator? (mention only one, please). YES NO
WHY?

Please, add any other comments:

Figure 8. A questionnaire about the student's viewpoint.

(1) as **strengths**: the novelty of the methodology, the variety of teaching methodologies involved, the facilitation provided and the student's implication, and

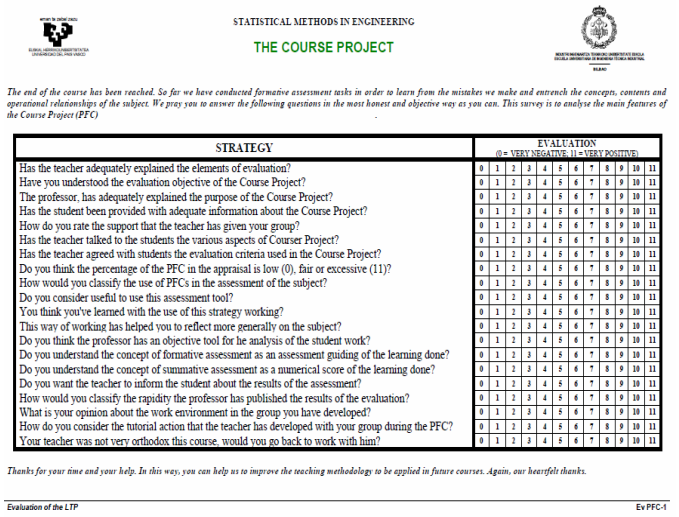
(2) as **weaknesses** of this implementation: the hardness test, the existence of a lot information, a lot of work to be made by the student (specially that one off-class) and the peer to peer coevaluation.

The students themselves suggest some activities to cope for an **improvement planning**, as feedback:

(1) As **improvement actions** they propose: to reduce the quantity of information and to apply other forms to challenge them.

(2) As **corrective actions**, they proposed deep in the explanation of the student's responsibility and what the student is assumed to produce as final outcomes, or to provide specific examples of similar results or portfolios.

(3) As **preventive actions**, they press to give greater freedom and to use specific examples of the syllabus instead of being them themselves to look for them. They are also concerned that this way of working implies great job, in exchange for a far more profitable, but in the long term.



STATISTICAL METHODS IN ENGINEERING

THE COURSE PROJECT

The end of the course has been reached. So far we have conducted formative assessment tasks in order to learn from the mistakes we make and entrench the concepts, contents and operational relationships of the subject. We pray you to answer the following questions in the most honest and objective way as you can. This survey is to analyse the main features of the Course Project (PFC)

STRATEGY	EVALUATION (0 = VERY NEGATIVE; 11 = VERY POSITIVE)
Has the teacher adequately explained the elements of evaluation?	0 1 2 3 4 5 6 7 8 9 10 11
Have you understood the evaluation objective of the Course Project?	0 1 2 3 4 5 6 7 8 9 10 11
The professor, has adequately explained the purpose of the Course Project?	0 1 2 3 4 5 6 7 8 9 10 11
Has the student been provided with adequate information about the Course Project?	0 1 2 3 4 5 6 7 8 9 10 11
How do you rate the support that the teacher has given your group?	0 1 2 3 4 5 6 7 8 9 10 11
Has the teacher talked to the students the various aspects of Courser Project?	0 1 2 3 4 5 6 7 8 9 10 11
Has the teacher agreed with students the evaluation criteria used in the Course Project?	0 1 2 3 4 5 6 7 8 9 10 11
Do you think the percentage of the PFC in the appraisal is low (0), fair or excessive (11)?	0 1 2 3 4 5 6 7 8 9 10 11
How would you classify the use of PFCs in the assessment of the subject?	0 1 2 3 4 5 6 7 8 9 10 11
Do you consider useful to use this assessment tool?	0 1 2 3 4 5 6 7 8 9 10 11
You think you've learned with the use of this strategy working?	0 1 2 3 4 5 6 7 8 9 10 11
This way of working has helped you to reflect more generally on the subject?	0 1 2 3 4 5 6 7 8 9 10 11
Do you think the professor has an objective tool for he analysis of the student work?	0 1 2 3 4 5 6 7 8 9 10 11
Do you understand the concept of formative assessment as an assessment guiding of the learning done?	0 1 2 3 4 5 6 7 8 9 10 11
Do you understand the concept of summative assessment as a numerical score of the learning done?	0 1 2 3 4 5 6 7 8 9 10 11
Do you want the teacher to inform the student about the results of the assessment?	0 1 2 3 4 5 6 7 8 9 10 11
How would you classify the rapidity the professor has published the results of the evaluation?	0 1 2 3 4 5 6 7 8 9 10 11
What is your opinion about the work environment in the group you have developed?	0 1 2 3 4 5 6 7 8 9 10 11
How do you consider the tutorial action that the teacher has developed with your group during the PFC?	0 1 2 3 4 5 6 7 8 9 10 11
Your teacher was not very orthodox this course, would you go back to work with him?	0 1 2 3 4 5 6 7 8 9 10 11

Thanks for your time and your help. In this way, you can help us to improve the teaching methodology to be applied in future courses. Again, our heartfelt thanks.

Evaluation of the LTP Ev PFC-1

Figure 9. Student's opinion about the LTP process in the curriculum.

(2) as **weaknesses** of this implementation: the hardness test, the existence of a lot information, a lot of work to be made by the student (specially that one off-class) and the peer to peer coevaluation.

The students themselves suggest some activities to cope for an **improvement planning**, as feedback:

(1) As **improvement actions** they propose: to reduce the quantity of information and to apply other forms to challenge them.

(2) As **corrective actions**, they proposed deep in the explanation of the student's responsibility and what the student is assumed to produce as final outcomes, or to provide specific examples of similar results or portfolios.

(3) As **preventive actions**, they press to give greater freedom and to use specific examples of the syllabus instead of being them themselves to look for them. They are also concerned that this way of working implies great job, in exchange for a far more profitable, but in the long term.

TABLE II. PERFORMANCE MEAN RATES

PERFORMANCE RATE	VALUE
Your opinion bout this teaching methodology	7,2
Understanding of the syllabus competences/objectives	8,1
The development of the group in the "team-work" competence	6,5
The facilitation/supervision/tutoring provided	8,9
Motivation level	7,8
Participation level	9,1
Responsibility level	7,3
Self-sufficiency level	6,2
In general, a mean mark for the whole LTP of the syllabus	7,6

V. CONCLUSIONS

This paper reports an engaging experience based on the methodology and the evaluation in Statistics teaching: students' involvement in building and implementing competence assessment models as a valid learning engagement alternative where the relevance of the assessment criteria is established by the students. The importance of process action research in teaching environments becomes increasingly important to improve the LTP (see Figure 10): students develop a project in groups by applying PBL/EBL techniques where the facilitation tools are essential (see Figure 11). This is one of the main cornstones

Figure 10. The process oriented research.

The student's opinion is analyzed over a given competence (team work), using such a synergy to promote students' motivation, accountability and participation via challenges. The student has been invited to take part in the design, implementation and discussion of the assessment instrument of that competence through the generation and consideration of valuation matrices. The performance indicators to be considered have been agreed, and a protocol has been established to give students the understanding throughout their formative evaluation process. The competence has been developed in diverse scenarios: the one considered in this paper deals with a Statistics syllabus through course short projects, worked from the perspective of an active learning methodology such as PBL/EBL.

ACTIVITY TO ASSESS		COMPETENCE	APTITUDE FOCUSED	QUESTION TO POSE/ APPROACH COVERED
Looking for the best information in an optimum way	FA	C4	The individualization of the LTP: task assignment	References looked up and constructed used Time used to do the seeking
Definition of the open problem based on the given standards	AA	C4	Student's proactive participation and implication	Rigour and precision of the approach proposed The way in which is declared the future implementation of the Course Project Adequate justification of the choice posed
Role playing in the team/group	FA	C5	Contribution to the cooperative spirit of the team/group	Reasoning about the given role playing proposal in the group How the group worktable has been accomplished? Has the group productivity been followed? How? Which tools have been employed?
Forecasting of the difficulties which could come up/arise	FA	C5	Qualitative analysis of the solution found out	How can be interpreted the resolution of any linear system equation in an approximate manner? Can be a qualitative analysis of the problem made?
Look for values to settle the numeric problem down	FA	C4	Coordination and linking with other subjects of the degree	How the chosen data can be disposed in order to apply the algebraic theory of the syllabus?
Resolution approach and formulation	FA	C5	Task arrangement	Which methodology type is applied? How the work is distributed among the group members? Is there any concept map about the implementation developed? A Gannt's diagram about times and role playing has been presented?
Result contrast related to the planned outcomes	AA	C4	Coherence between the obtained results and the theory applied	The results looked for have been attained? The values obtained, can be justified?
Analysis of the difficulties that have been encountered	FA	C4	Interesting contributions	How have been solved the encountered difficulties? How the resources used have been managed? A problematic situation will be suggested (it will be a direct consequence of the project his/her group has worked
Implementation computational costs	FA	C5	Result contrast	How the used method cost has been measured? Is there any cost study?
Teamwork applied methods	AA	C5	Self-assessment skills	Quality of the self-assessment report presented Which values are pointed out by his/her group-mates?
Scientific report of the project experience	AA	C4	Helping the use of an appropriate structure for the project approach of the group	How is used the mathematical language and the formal relations? How is it reasoned?
Oral presentation of the report	AA	C5	Coherence of the defence presented	Reasoned justification of the report presentation carried out
Last interview for assessment	FA	C5	Use of the procedural knowledge related to the subject	How does the student answer the questions that have been posed?
Attitude in the facilitation and tutoring times	FA	C4	A more emphatic relationship between undergraduates/students and the teaching staff	Is there a positive attitude in the group structure running? The group, does it appear open-minded, active, productive, efficient, effective, …? A given student, which is the position that shows in the presence of his/her group-mates?

Figure 11. Some questions that are posed to students along the help/tutoring sessions (**FA** means formative assessment; **AA** stands for additive assessment).

A survey has been designed to analyze the student's perceptions regarding the approach, development, assessment and competence analysis from the students' viewpoint. The items considered take into account aspects such as: the information provided, the training involved, the initial level of expectation with respect to the competence, the degree of development reached, the development of the teaching

methodology applied, the tutorial action (in the sense of facilitation) applied and the global assessment deployed. The results of this survey are presented in this work to help refocus the teaching methodology with which that competence will be worked in the future.

coached	Step 1	What do we understand about ...? **Clarification of terms** Building a common understanding	class
	Step 2	What are the questions, problems, fields of problem? (Hypothesis?) Which problems have to be tackled first to find a solution? **Definition, Analysis, Weighting of the problems** Naming and organising the problems systematically, extracting the most important	
	Step 3	What do we already know about ...? **Connecting with previous knowledge**	
	Step 4	What knowledge do we miss? **Gap Analysis** Finding knowledge deficits	
	Step 5	**Specifying the learning targets, deriving the work packages and distributing them among students**	
not coached	Step 6	**Carrying out the work packages**	self-study
		Knowledge exchange, Synthesis	class
		Developing a solution, writing the paper	
coached	Step 7	**Discussion of the solution and the its approach with an expert**	class

Figure 12. The PBL approach working concept).

What about student's and teacher's effort? In short, it is different because this implementation is part of a broader strategy to engage students through motivation and participation, while making them see the need to involve themselves in a responsible manner. The subject of the paper lies in the learning engagement domain as student-driven assessment model, taking into account the student's participation/cooperative effort in an assessment set-up as teaching alternative. The results support this work methodology; they highlight the importance of a proper facilitation and supervision to the student progress adequately (see Figure 12) in order to determine the concept structure and the relationships of the involved mathematical units (see Figure 13).

ACKNOWLEDGMENTS

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CODE POC	TASK TO IMPLEMENT	ACTIVITIES TO DEVELOP	OUTCOME TO MEASURE/OBJECTIVE	ESTIMATED TIME (hours) CLASSROOM	ESTIMATED TIME (hours) NON-ATTENDANCE	DIFFICULTIES ENCOUNTERED
1	- Presentation of the subject Teaching Planning STP - Explanation of the teaching method that is the base of the Course Project - Text of Course Project as an open problem *This task is reminded from time to time to ensure that students are aware of what it really means*	- Statement of competencies involved in the Course Project - Using simple examples for explanation - Definition of objectives - Influence on the assessment	- Specific questions specific in tutoring/facilitation sessions and/or classroom - Use a daily log as a register diary	0.25		- The student feels that the documentation (delivered on the first day of class) is excessive - The subject guide may be useful to overcome this difficulty, if provided that it is very well designed
2	Finding information in books, magazines, specialised articles, reports, encyclopaedias and /or the Internet, asking to other teachers based on the descriptors of the subject, given the first day of class	The student looked for information on the sources suggested	- The student will deliver the **statement of the problem**, that will work, as openly as possible - **List of** used **references** given by the method of Harvard (examples are given in the STP) - At a later stage, the student will give a complete Problem Resolution (PR) approach, using the modelling suggested when the solution implementation be done		0.50	- It is normal for the pupil to be disoriented as he is not accustomed to working under the scientific method - Student makes reports handwritten - It is not anything to be delivered as early
3	New reformulation of the search criteria	Very specific descriptors are provided to generate an appropriate search: dynamic system, linear system, linear approach, controllability, robustness, resonant systems, ...		0.17	0.50	- At this stage any student needs facilitation to be addressed in the right direction - Real-time corrective feedback must be done often, either because students react in a way not intended, either because the expected progress does not materialize in the expected steps/phases
4	New reformulation of the search criteria	The student is told about the most productive topics of the subject			0.25	
5	Open formulation of the problem, to be solved according to the PR methodology, clearly incorporating the relationships linking the proposal with other subjects of the Degree	The student will have to develop the theory underlying the model presented, linking mathematics and that interest area	- The proposed statement should make clear **the relationship between contents and descriptors** in the subject - **Analysis of the model**: the theory must be described succinctly and directly		2.00	- The student usually shows difficulties when verbalizing his/her work experience - The difficulties that can lead the future development of the project ought to be written
6	Design of way the implementation of the solution will be addressed	- Problem analysis - Analysis tools that can be used - Locate resources that will be needed	- **List of variables** involved - The student will prepare a **concept map**, organigram or similar, where a **working and calculation strategy** will be provided, reasoning about its key points	0.50	1.00	- The student does not have a clear idea of the tools to work as a top-down/bottom-up design - The student does not adequately link to the key concepts of the subject with the experience in the Course Project: the concept maps of the thematic units of the course must be continuously be recalled
7	Remember the theoretical concepts involved	Summary of the descriptors most needed to develop the Course Project	**Concept map of the contents covered**	0.17	0.50	The student must be drawn to study daily
8	Deduction of the working model from the graphical representation	Analyze whether the problem is discrete or continuous, clarifying what the variables are and the relationship between them	- **Deduction of the theoretical model** - **Justified and reasoned statement of the working hypotheses**, to implement the resolution of the problem		0.50	- Difficulties in discriminating the data and results - The variables are not discussed in the right way - No way are correct Descriptors and keywords are not correctly expressed
9	Refinement of the qualitative analysis	Giving an overview of the whole approach to see if mistakes take place	**Justified listing of the mistakes appearing**		0.50	The student does devote no time to review and reflect
10	Analysis of the weaknesses of the approach by the teacher	Monitoring, normally permitted, the student		0.50		The facilitation session must be compulsory; otherwise, the student does not come voluntarily
11	Implementation the solution by solving systems of linear equations in the sense of least squares	Calculate the parameters involved in the model of the Course Project	**Coherence of the results obtained**	0.17	1.50	The student often uses only pencil and paper, not making use of ICT to enhance their overall productivity
12	Deduction of conclusions	Answer in a way justified the questions raised in the Course Project discussion	Results are correct and explanations are well justified		0.50	There are numbers, no units are provided, and typically the results obtained are not discussed
13	Oral presentation and/or written report for the Course Project	Perform a PowerPoint presentation that summarizes all the essentials of Course Project outcomes	**Quality of the report/presentation** following the criteria reported in the valuation rubrics at the beginning of the course		1.00	- There is not too much interest to generate a document with enough presence to the university level - There is no autonomy when generating the report of the Course Project
14	Evolution of the student's evolution and progress in mastering the techniques involved in the Course Project	Interview (3 sessions of 10 minutes) with the teacher of the course on an individual basis and with other group members	Daily records	0.50		It is quite difficult to verbalize feelings and emotions in front of a teacher, and more if other students are there, albeit in a small group
15	Final evaluation of the work done with the Course Project	Personal interview Team interview Analysis of team data and student's data	Summative assessment of the Course Project with the student's follow-up, and the opinion of each group member	0.25		Initially, the student is reluctant to assess their colleagues, provided that there is no group mentality
16	Following the REDER philosophy the learning-teaching process of the Course Project is reviewed on an ongoing basis, which has the corresponding control mechanisms	Quality of the Course Project report Oral presentation of the Course Project Student's self-evaluation	Lejk's method to **evaluate the team guided work**, that has done the Course Project			Students need to comment the assessment results to them as immediate or mediate feedback

Figure 13. Flow diagram of the Course Project implementation (formative and additive assessment in blue colour).

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VALUATION MATRIX / RUBRIC: TEAMWORK 1/2

		COMPETENT (5 MARKS) *It has been fully met*	ACCEPTABLE (3 MARKS) *Some mistakes are evident*	DOES NOT MEET (0 MARKS) *It must be again redone*	Q
General level of the team/group	*Organization and presentation*	The report is bound and formatted: there is an index, it is well structured, indexed and paged, there are references and appendices. The important thing is the main area, the accessory is led to the annexes. The construction, syntax and spelling of the sentences is correct. The explanations are clear. The title of the report is very suitable	The memory is not well structured, but contains all the required sections. Lack of clarity in the explanations provided. There are spelling errors. Much explanation is not given. The title of the report is adequate	The report is not formatted, there is no index, poorly structured and is not paged, no reference. Misspellings abound. It is not clear. No resources are used well. The title is not suggestive	
	Contents development	It makes use of all contents and descriptions of the subject, relating them adequately	These findings indicate that some content does not appear, or the explanations are limited	The contents presented are inadequate. There are only relations	
	Argumentation and justification	The results and accompanying comments are justified, using the theoretical concepts and practical convenient descriptors	There are results and / or comments that are not justified or not based on the concepts and theoretical and practical descriptors	No reasoning is provided	
	Coherence	There is consistency between what the group has worked and the presentation conducted. It is noted that there has been a cooperative work. All the deadlines have been respected	Not all the members have managed to cover the understanding of the entire project. The group's work has been collaborative. Sometimes times have not been observed	Each member is responsible only for their share. The work has been individualistic, or only one component has worked	
	Objectives of the Course Project	The report submitted meets the all the requirements of a project	The report submitted meets the some of the requirements of a project	The documentation submitted does not represent at all a research report	
Procedures in preparing the project report	*Class attendance*	There was a total attendance of all members at every meeting	Any member has not attended any meeting. Few meetings held	There has been little meetings. It has produced an individualistic work	
	Compliance with rules	The group has met the standards that have been established. The workflow has been dynamic	The group has worked in a dynamic but in a somewhat anarchic	Rules have not been respected	
	Selecting the item submitted	The group's mission is very much in line with the selection of the work submitted. And it has a large component of elements of the subject with proper justification	The group's mission is in line with the work presented. Yet covering most elements of the subject, are well justified	The issue presented was to get by	
	Resource planning	There has been adequate foresight and planning of resources and time, and carried out according to the objectives set	Resource planning has existed, but were not always met expectations	There is no planning activity	
	Group consciousness	Group members were informed of the progress of others. There has been rotating roles. The methodology was designed in accordance with the objectives designed. Were achieved initial results expected	Group members were informed of the progress of others. There has been rotating roles. The initial results have not been reached	The group has been a complete chaos	
	Effective meetings	There have been all calls, records and evaluations of all sessions. The group's work plan has been presented and justified	There have been some calls, some records and / or evaluations of the sessions. The group's work plan has been presented and justified	No calls, no records, no evaluations of the sessions. There has been no work plan	

VALUATION MATRIX / RUBRIC: TEAMWORK 2/2

		COMPETENTE (2 PUNTOS) *Se ha alcanzado completamente*	ACEPTABLE (1 PUNTO) *Se aprecian algunos fallos*	NO CUMPLE (0 PUNTOS) *Se ha de realizar de nuevo*	PUNTOS (1)
Relationships in the group	*Work cycle in the group*	Group consciousness has been developing the qualities of the group beyond a PDCA cycle (plan-do-check-act). The cooperation has been evident. Resources have been shared	The group has worked as a PDCA cycle. It has always cooperated. Resources have been shared	It has not been reached a PDCA methodology. The cooperation has been conspicuous by their absence. There are no shared resources	
	Communication in the group	Communication within the group has been completed in the records, and is reflected the evaluation report of the group. No member of the group has given any objections over the project development	Communication within the group has failed at times, but it is also unclear in the report submitted	People have not behaved as a group	
	Leadership	There has been a person that stands out above all others. It is equally valued the contribution of the group members	It was necessary that a person in the group moved to the other so that the work was carried to fruition. Sometimes, the contributions made have not been equally valued	A person has clearly dominated over other people in the group. The other members were subject to the decisions of that person	
	Autonomy	The teacher only replied to questions made by the group	Special sessions have been required with teachers for the project to move forward	The group has completely disengaged from the process of tutoring, ...	
Emotion treatment	*Integrating the differences*	Nobody has outperformed all others, trying to involve colleagues, when necessary. It has fostered healthy disagreement and debate, working consensus. Constructive criticism has carried out	There have been problems that are resolved in a process of communication within the group. There has been disagreement and debate in a healthy manner. Sometimes, they have not produced well tolerated criticism	The friction between people have been constant. Not rated opinion of the members. The disagreement has been constant.	
	Conflict resolution	There have been no conflict because team members were very clear that what mattered was the person to achieve the objectives of the group	There have been conflicts, because no team members were very clear that what mattered was the person to achieve the objectives of the group. It was necessary to apply decision-making techniques to make some decisions	Conflicts have been continuous	
	Recognising the individuals	When it has been necessary the merit of individuals has praised. There are recorded in the reports of the group. This fact has been made public in the usual dynamic class	Only the teacher has stressed this fact in front of the class (as large group)	There have been no such indications	
Evaluation	*Transmission of knowledge*	The group has shown that there has been learning from each other	The group has not demonstrated that there was learning from one another	The group has not demonstrated that some members have helped others	
	Obtained outcomes	The objectives achieved are in line with the initial objectives. The reasoning is well structured	There have not provided all the original aims. There are errors in the reasoning	The results achieved are far from the objectives. There is no reasoning	
	Evaluation modes	The group has carried out formative and summative assessment. In addition, its members have been involved in evaluating	The group has not performed work for formative or summative evaluation. In addition, its members have not fully involved in the evaluation	They have not been involved in evaluating	
	Self-evaluation report	The group has performed a very detailed report, and all its members have participated	The evaluation report is vitiated by the no participation of its members	There has been no self-evaluation report	

Figure 14. An analytic rubric for assessing the team work competence.