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# Development of a Method of Assessment of the Problem-Solving Competency at the Technical University of Madrid*

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The competence evaluation promoted by the European High Education Area entails a very important methodological change that requires guiding support to help lecturers carry out this new and complex task. In this regard, the Technical University of Madrid (UPM, by its Spanish acronym) has financed a series of coordinated projects with the objectives of developing a model for teaching and evaluating core competencies and providing support to lecturers. This paper deals with the problem-solving competence. The first step has been to elaborate a guide for teachers to provide a homogeneous way to asses this competence. This guide considers several levels of acquisition of the competence and provides the rubrics to be applied for each one. The guide has been subsequently validated with several pilot experiences. In this paper we will explain the problem-solving assessment guide for teachers and will show the pilot experiences that have been carried out. We will finally justify the validity of the method to assess the problem-solving competence.

**Keywords:** European High Education Area; competencies assessment; problem-solving, rubrics

## 1. Introduction

### *1.1 Context of the project and purpose*

The construction of the European Higher Education Area (EHEA) has configured a new scenario in university teaching. The change proposed from the Bologna declaration is not limited to a reorganization of university studies at the new Catalogue of Degrees; it is much deeper and more significant because it implies a rupture with the traditional culture focused on the acquisition of knowledge [1].

No one doubts that university education must provide students with a fine academic background, meaning a good command of technical knowledge. However, now more than ever, it is also necessary to promote the development of general skills applicable to real-life social and work situations [2]. Therefore, one of the fundamental goals of the process of European Convergence is to guide the academic education towards the acquisition of competencies required in the professional arena [3].

Although the notion of competence has multiple definitions [3–5], there is a consensus in the pedagogical literature in which the concepts of "knowledge", "know how" and "know how to be" are integrated under this term [6]. According to Delors' report [7], when a person responds to different situations and tasks at work, he does it in a global way, using his knowledge and technical capabilities as well as his personal qualities and social attitudes.

In Spain, university studies have been designed by the Agencia Nacional de Evaluación de la Calidad y Acreditación—ANECA—(The National Agency for Quality Assessment and Accreditation of Spain) following the formulation made in "Tuning Educational Studies in Europe" [3, 8, 9]. There is a distinction between specific competencies, related to the different areas of study, and generic competencies, common to any degree and essential to prepare students for their professional and social integration.

Nowadays, generic or core competencies are gaining in importance, since they are essential skills (e.g. oral communication, synthesis, and problem-solving) that enable graduate students to deal with hurdles and challenges during their career. Enterprises and industry seek competent graduates who are able to express ideas in front of people and solve problems effectively; i.e. to confront difficult circumstances and lead changes in their professional domain. Students who have not been trained in these skills may not succeed in their future jobs [1, 2].

Following the Tuning model, the profile of graduates must respond to the needs identified and recognized by society. Therefore, each degree matches an academic-professional profile jointly defined by university and employers [3].

In order to identify the most important generic competencies for the students' education, several investigations have been made. In the international scope, apart from the Tuning project, it is also worth

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mentioning the "Alfa Tuning project for Latin America" [9] and the "Higher Education and Graduate Employment in Europe" project [11], also known as "Careers after Higher Education. A European Research Survey (CHEERS)", which has been used as a base for the "Reflex project" (Flexible Professional in the Knowledge Society) [12].Within the national scope, several academic research projects have been carried out, conducting surveys to postgraduates and professional organizations in order to design training programs to facilitate the employability of graduates [3, 13–16].

Meanwhile, in order to carry out this task, the Technical University of Madrid has funded the project "Core Competencies in Engineering. Proposal of a Model for the UPM", which is part of a greater set of Educative Innovation Projects for academic year 2010-2011 [17]. The core competencies selected for all degrees are the following: (a) team-work, (b) oral and written communication, (c) use of ICT (Information and Communications Technology), (d) respect for the environment, (e) analysis and synthesis, (f) creativity, (g) organization and planning, (h) leadership and, (i) problem-solving.

For each core competence, a working team has been set up with the aim of studying that competence and facilitating the task of teaching and assessing it. UPM's working teams have developed a scale to measure the level of competence acquisition according to the complexity of the proposed tasks. Our goal is to incorporate the most relevant aspects of each competence to all lectures and academic activities. At the end of studies, students should not only have acquired the technical knowledge but also the general skills. The methodological change in High Education is a big challenge for teachers due to several reasons. On the one hand, every course should promote the improvement of a group of competencies, consistently with the content of the course and its learning level. On the other hand, an impartial evaluation method is needed in order to ensure that students are actually acquiring these competencies [18].

This work describes the general procedure that was used and presents the model developed specifically for the problem-solving competence (PSC). The first step has been to elaborate a guide for teachers to provide a homogeneous way to asses this competence. This guide considers several levels of acquisition of the competence and provides the rubrics to be applied to each one. The guide has been subsequently validated with several pilot experiences [17, 19]. In this paper we will explain the problem-solving assessment guide for teachers, paying special attention to the level I rubrics, and will show the pilot experiences that have been carried out. We will finally justify the validity of the method to assess the PSC.

### *1.2 Problem-solving competence*

Among the different tasks of the project, our group has been responsible for working on PSC. Some definitions are needed. According to Newell and Simon [20], a problem is defined as a situation in which an individual wants to do something, but does not know the way to achieve the goal. Chi and Glaser said that it is a situation in which an individual acts with the purpose to achieve this goal using a particular strategy [21], Also, for Krulik and Rudnik a problem is a situation, quantitative or not, that requires a solution for which the individuals involved do not know obvious ways to get it [22].

Problems are situations that require individuals to respond with new behaviors. This activity is closely related to various skills such as analysis, synthesis, critical thinking, planning or creativity. Solving a problem involves tasks that require more or less complex reasoning processes and not simply a routine, associational task (as in exercise-solving) [23, 24].

Problem-solving is not new in education but it is still a scarcely implanted competence, and there is still much to be done. According to Gaulin [23] several reasons can explain the increasing emphasis on developing this competence. The first can be found in the current social-constructivist perspective of learning. It defends the importance and influence of context (learning environment) in the construction of knowledge [25]. Discussion, team work and social interaction are important factors that influence learning and problem-solving provides a good chance to work according to these ideas.

The second reason arises from the need to prepare students to live in an increasingly complex and changing world, and to face more and more difficult situations, even with technology. Problem-solving can enhance the learning of strategies and skills that enable students to autonomously deal with new situations.

The third and last reason relies on the current educational policy, which emphasizes competence training in order to ensure that students not only learn contents, but can also apply them to real situations in different contexts [24]. Learning PSC is learning to face new scenarios, where you have to think and use new strategies. Therefore, emphasizing PCS will probably make easier to the students to acquire general competencies [27]. However, it is not an easy task, since some international studies have revealed that most teachers feel unprepared to teach PSC.

The aim of this work is to promote among the students the right mental attitude that encourages them to learn, understand and apply knowledge in an autonomous manner [28, 29]. The development of this competence requires an active approach by students. The proposed problem must be appropriate to the level of the studies (but not merely exercises) [23], the wording must be motivating, not direct and provide the development of concepts [28–32]. In this regard, problems must be practical, meaningful and contextualized in the current reality of students and their future career [32]. Learning should deal with the results and analysis but, above all, with resolution procedure.

#### *1.2.1 Problem-solving procedure:*

There is not a universal strategy for teaching PSC. We have chosen the original procedure proposed by Pólya [34]. The reason is that it is a very general strategy that can be easily adapted to the usual problems of every field of knowledge. This strategy is structured in four steps [23, 34]:

1. Problem comprehension: read carefully the problem and represent it in different ways. Then, highlight significant data and unknowns.
2. Planning the solving process: It is normally the most difficult task, since relationships between data and unknowns have to be established in order to find a problem-solving plan.
3. Implementation of the plan: if the problem-solving plan is well conceived, its implementation is usually relatively easy, though some changes in the plan may be required.
4. Assessment of both, the solution and the procedure. This step is essential to improve how to learn PSC. You should critically examine and evaluate the results obtained as well as the procedure used. It is important not to let the details distract us from the general ideas.

Attending to the four-rule procedure proposed by Pólya [34],we have developed a set of generic rules to guide the students on the main aspects and the right order to be considered when solving a problem. First of all, we have elaborated a very generic procedure based on all the rules relevant to problem solving. This procedure applies tony problem, regardless of its approach or complexity. Each one of these aspects is given a score from 1 to 4 (from D to A) according to different criteria. The proposed problems differ a lot depending on the subject and the year of the studies. Thus, we have divided the PSC in four levels, each one with its proper procedure and with different rules—always based on the rules we have exposed above in this section.

In this paper we have defined the first-level problem-solving procedure which is designed to be specifically applied to first-year students of engineering degrees. This procedure enhances students' ability to deal with complex problems rather than merely exercises. The wording of each task includes more information than the strictly needed to solve the problem. Students have to choose between at least two ways to solve the problem (usually one correct and the other not). In upper university courses, the problem statements are more complex and their solution can be approached in several ways, some of which may be more efficient than the others.

Once a good problem-solving procedure is properly designed, the next step is to make students use it and to evaluate the effectiveness of the method.

#### *1.2.2 Rubric: Assessment criteria of the problem-solving competence:*

Rubrics are guidelines used to assess what grade the student earned through some fixed criteria [35–37]. Each problem is evaluated twice; lecturers and students use the same rubrics. This method helps us indifferent ways. Firstly, it makes the students more conscious of their own grade of competence command. Secondly, it allows us to compare lecturers 'evaluation, so that the general results can be better contrasted. Finally, the participation and motivation among students increase significantly when they feel involved in the task.

In the pilot studies, the PSC is analysed through six different aspects or criteria: comprehension, application of the method, justification and clarity, results, efficiency, and critical analysis. The possible punctuations to the mentioned criteria are:

A—Excellent
B—Advance
C—Acceptable
D–Unsatisfactory

Our set of assessment criteria have been summarized in Table 1.

## 2. Pilot studies

### *2.1 General data of the pilot studies and their development*

Pilot studies were conducted in four subjects of the first and second years for the degrees of Aerospace Engineering and Natural Environmental Engineering. The total number of volunteers was 146. Students who achieved an A grade in the pilot study got a raise of up to 0.5 points into their course grade mean. This means an extra 5%of the total grade. This raise descended gradually for worse grades.

Assessment criteria from table 1 were explained in

**Table 1.** Set of assessment criteria developed for the PSC [40]

| Criteria | Unsatisfactory (D or 1) | Acceptable (C or 2) | Advanced (B or 3) | Excellent (A or 4) |
|---|---|---|---|---|
| Comprehen-sion | The information of the problem is neither clearly identified nor relevant. | The relevant information (data, variables, conditions needed. . .) is identified but in a disorganized or improper way. | The relevant information of the problem is properly identified. | The student also justifies the need for and the utility of the information. |
| **Application of the method** | The method has not been applied or its application is not correct. | The method has been properly applied, but in a disorganized way and without explanation. | The method has been applied systematically, but without providing explanations. | All the steps have been explained. |
| **Justification and clarity** | There are few ore even no explanations that make it easier to read and understand the resolution of the problem. | There are some explanations but they are not well organized and have a few mistakes. | All the explanations needed are included in an organized way. | The explanations are given in a clear and rigorous way. The solution is highlighted. |
| **Results** | The results are not present, correct or they are incomplete. | The results are correct and complete with unimportant mistakes (numerical or notation). | The results are correct and complete. They are properly given (adequate notation and unities). | The results are also given clearly and rigorously. |
| **Efficiency** | The possible alternatives are not present and the procedure chosen is a bad one. | There are more than one alternative, but the chosen one is not the best. | The alternative chosen is the best one. | All the alternatives are presented and reasoned out. The choice is justified. |
| **Critical analysis** | Neither the results nor the procedure have been checked. | The results have been checked and they are coherent with the conditions of the problem but the procedure is not analyzed. | Both the results and the procedure have been checked. | The solution has been checked and contrasted. Its application is extended to other contexts and generalized. The procedure is analyzed and some improvements are proposed. |

**Table 2.** Summary of the subjects and degrees from the pilot study

| About the degrees | | | | About the students | | |
|---|---|---|---|---|---|---|
| **Academic year** | **Semester** | **Subject/ Course** | **Degree** | **Number of participants** | **Registered students** | **% participation** |
| 2010–2011 | 2nd | *Physics II* | Natural Environmental Engineering | 11 | 72 | 15.2 |
| | | *Maths II (stage 1)* | | 48 | 75 | 64.0 |
| | | *Maths II (stage 2)* | | 29 | 75 | 38.7 |
| | | *Maths II (stage 3)* | | 9 | 75 | 12.0 |
| | | *Mechanisms* | Aerospace Engineering | 23 | 150 | 15.3 |
| 2011–2012 | 1st | *Chemistry* | Natural Environmental Engineering | 25 | 99 | 25.3 |

detail to the voluntary students before beginning the pilot study. To this aim, the lecturer formulated some examples of problems to the students and explained to them possible ways to come up with suitable solutions, as well as the advantages of using these evaluation criteria. Afterwards, the lecturer proposed a problem to be handed according to the problem-solving rules.

Some general data are provided below, at Table 2. Maths II refers to the subject "Mathematics II".

### *2.2 Brief description of the pilot study topics*

Chemistry problem-solving experience was exemplified with Water Quality Global Indicators. Students had to elaborate a concept map with all the concepts involved in these indicators, and hence use them in problems with different conditions.

In Mathematics II, the pilot study was divided into three stages, with increasing levels of difficulty and number of assessed criteria. Statistics and River Hydrology also took part in the study. Firstly, a

Hydrology lecturer taught a seminar of some river flow concepts, such as return periods for some heavy diary rains and expected flow. Afterwards, Statistic lecturers were teaching ways to estimate these flows and some Stat graphics' tools. Finally, the Mathematics teacher asked the students to evaluate and justify the choice of a particular estimation method.

In Physics II, students had to calculate the calorific energy needed to increase a room's temperature and then the following descend of temperature, when the insulating material was reduced.

In Mechanisms the teacher gave the students the design of a cam-follower mechanism used to shake samples and asked them to calculate the parameters necessary for it to work properly. The students had to study the problem during that afternoon and the next day they were requested to solve it in the classroom and give the solution to the teacher.

## 3. Results

The following section shows the pilot studies results. Although PSC is studied in different knowledge fields (Physics, Math, etc.) and in different careers, the acquisition level of the competence is similar in all the subjects, so similar statistic distributions are expected to be found among these fields. Therefore, these results are not always grouped by subjects.

### *3.1 Results for each assessment criteria*

#### *3.1.1 General score distribution:*

Global results for the whole set of criteria are shown in Fig. 1, from worse to better punctuations over the abscissa axis. Student's evaluation matches to the stripy bar charts and lecturers to non-stripy ones. Notice that the ordinate axis refers to percentages (%).

The first five aspects considered follow a similar distribution, for both, students and lecturers assessments. However, students usually tend to correct themselves with slightly higher marks. This fact is also visible in Fig. 2.

The average punctuation of these first five criteria is between C (acceptable) and B (advanced). Nevertheless, comprehension and application of the method achieve a higher percentage of B's and A's (excellent). In contrast, critical analyses have always worse mark than the others; since D punctuation (unsatisfactory) is significantly higher from lecturer point of view (around 40% of students were given a D). The number of excellent grades is notably high in results, almost 30%.

#### *3.1.2 Average score and standard deviation for the whole sample:*

Global average scores and standard deviation for the whole set of assessment criteria are shown in Fig. 2. An acceptable level of each criterion is achieved when the score is equal or above 2 points; i.e. a C grade. This acceptable level is underlined by a discontinuous line on the graphics. Notice that mean scores from lecturer point of view overpass the C level in the first four levels, while in efficiency and critical analysis the score is a little bit under the acceptable level. This can be explain taking into account we are evaluating the first level of the competence –following levels of the competence will be evaluated in the last courses of the

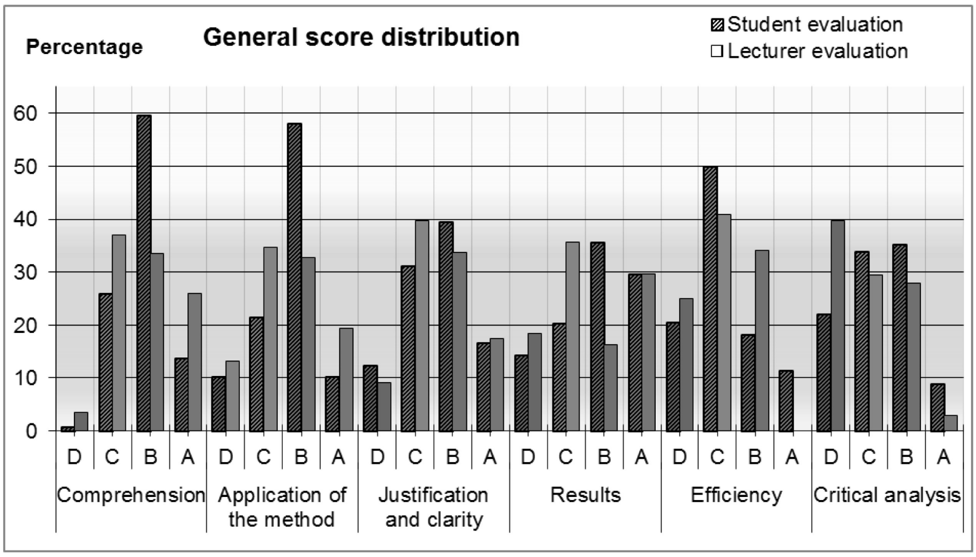



**Fig. 1.** Global score distribution from D to A for each assessment criterion. Evaluation for both students' and lecturers' point of view are shown here.

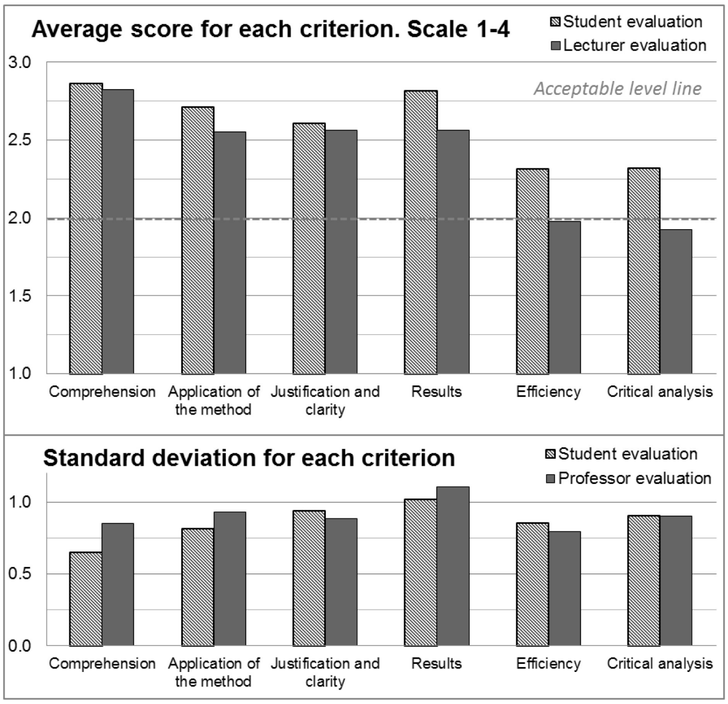



**Fig. 2.** Mean value and standard deviation for each assessment criteria. Evaluation for both students' and lecturers' point of view are shown here.

graduate and in post-graduate masters. The same students are expected to have better results in these criteria in the following levels (not yet studied) as they require more experience and maturity.

Standard deviation is normally above 0.75 but below 1.0 in most of the assessments. Data dispersion is slightly higher in evaluations of the lecturer for comprehension, application of the method and results. Critical analysis is evaluated for students with a mean value of 2.3, which differs for lecturers, who give them an average of 1.9. This is the biggest difference among students and lecturers average evaluation for the whole sample.

### *3.2 Results for each subject and assessment criteria*

Once the global results have been analyzed, Fig. 3 shows the data obtained for each pilot study. In this figure average scores are presented for each subject and assessment criteria. Note that the subject Mathematic II was divided into 3 stages and that efficiency was not evaluated in Chemistry.

Some different results can be found among the different subjects of the studies, (e.g. mean value or standard deviation ($\sigma$) of a given criterion for some subjects). The largest difference appears in the item "results". This fact can be explained because results normally depend more on the problem proposed

| Subject | Evaluator: | Comprehension | | Application of the method | | Justification and clarity | | Results | | Efficiency | | Critical analysis | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | σ | Mean | σ | Mean | σ | Mean | σ | Mean | σ | Mean | σ |
| Chemistry | Lecturer | 4.0 | 0.2 | 2.7 | 1.0 | 2.6 | 1.1 | 3.7 | 0.7 | | | 1.8 | 0.9 |
| Maths II (stage 1) | | 2.4 | 0.5 | | | | | | | | | | |
| Maths II (stage 2) | | 2.9 | 0.7 | 3.0 | 0.6 | 2.6 | 0.6 | 2.8 | 0.9 | | | | |
| Maths II (stage 3) | | 3.3 | 0.9 | 2.3 | 1.4 | 2.9 | 0.8 | 1.8 | 1.0 | 2.1 | 0.9 | 2.3 | 1.0 |
| Mechanisms | | 2.3 | 0.9 | 2.3 | 0.7 | 2.5 | 1.0 | 1.8 | 0.6 | 2.0 | 0.8 | 1.9 | 0.8 |
| Physics II | | 2.5 | 0.7 | 1.9 | 0.9 | 2.2 | 0.9 | 1.6 | 0.5 | 1.8 | 0.8 | 1.9 | 1.0 |
| Chemistry | Student | 3.1 | 0.6 | 2.9 | 0.6 | 2.3 | 0.7 | 3.2 | 0.6 | | | 2.8 | 0.7 |
| Maths II (stage 1) | | 2.7 | 0.5 | | | | | | | | | | |
| Maths II (stage 2) | | 3.1 | 0.7 | 3.1 | 0.4 | 3.1 | 0.7 | 3.6 | 0.5 | | | | |
| Maths II (stage 3) | | 3.5 | 0.8 | 2.0 | 1.2 | 2.1 | 1.4 | 3.1 | 0.8 | 3.3 | 0.9 | 2.2 | 1.5 |
| Mechanisms | | 2.6 | 0.7 | 2.6 | 0.7 | 2.7 | 1.0 | 2.0 | 0.9 | 2.0 | 0.6 | 1.9 | 0.8 |
| Physics II | | 2.5 | 0.7 | 2.1 | 1.1 | 2.3 | 1.0 | 1.5 | 0.7 | 2.3 | 0.6 | 2.3 | 0.6 |

**Fig. 3.** Mean value and standard deviation ($\sigma$) for each subject and problem-solving aspect considered. Evaluation for both students' and lecturers' point of view are shown here.

than the other items. Indeed the global standard deviation for results is relatively higher among the entire sample (Fig. 2) than the particular deviation for each subject (Fig. 3).

Efficiency and critical analysis obtain worse average punctuations compared to the rest of criteria. This statement occurs for assessments of both, students and lecturers. In contrast, comprehension is normally better evaluated, especially in Chemistry, where most of students were given a 4 (excellent). However, the majority of the subjects reaches or overpasses a mean level considered as acceptable (C) and there is not a remarkable difference in the standard deviation between the different subjects as it is expected for a cross competence as problem-solving.

### *3.3 Relation between the pilot studies and the improvement in the level of competence acquisition*

The pilot studies were designed to study the level of acquisition of the PSC by the students. Since there is no information on the level of PSC prior to the pilot study, it was not possible to measure directly its improvement. However we can compare the final results of the students that received some training in the PSC with the results of the rest of the students.

The data on Table 3 shows a positive incidence of PSC learning in the academic results of students. Nevertheless it is worth it to remark that might there be other variables (a higher interest of students participating in the study, previous academic level. . .) influencing these results.

On the other hand, the mere participation in the pilot study contributes to the global training of students. Learning core competencies (such as problem-solving) forces students to think about their own learning process which according to Zabala and Arnau [27] facilitates a deeper learning process and a reduction in the learning cost as it is shown in the metacognition theory [43]. The use of rubrics as a self-assessment method forces students to think about this process. As a consequence of this active, conscious and analytic learning process, students become aware of the PSC and are able to rationalize it.

### *3.4 Satisfaction survey*

In this type of experiences is also recommended to evaluate the satisfaction grade of both, students and lectures. Therefore, students were asked to punctuate some aspects of the pilot study and lecturers had to write down a short standard report.

#### *3.4.1 Students results*

Once the students have taken part in pilot study and received the professor's correction, they were asked to fulfill a questionnaire of satisfaction consisting in 22 questions. The number of responses was 70, which means two thirds of the volunteers (Table 4)

The questionnaire was divided into three parts. The first gathered information on the experience carried out, the second on the rubric and evaluation system, and the last one collected the overall impression of the pilot study. The obtained results are presented in Table 5.

Although some differences were found among the different subjects, students tend to punctuate most aspects in a similar way with little variation in mean values.

More than 60% of the students admitted, not only that this pilot study had been interesting to them, but also that the difficulty of the chosen problem was adequate to their own level. In addition, most of the survey respondents (over 80%) quite or totally agree on the following facts: these kinds of experiences should be voluntary and part of the final mark and the students would like to take part in similar pilot studies in other subjects. In addition, the

**Table 3.** Average mark per subject. Comparison of the results obtained by the students that participated in the pilot study and the rest of students

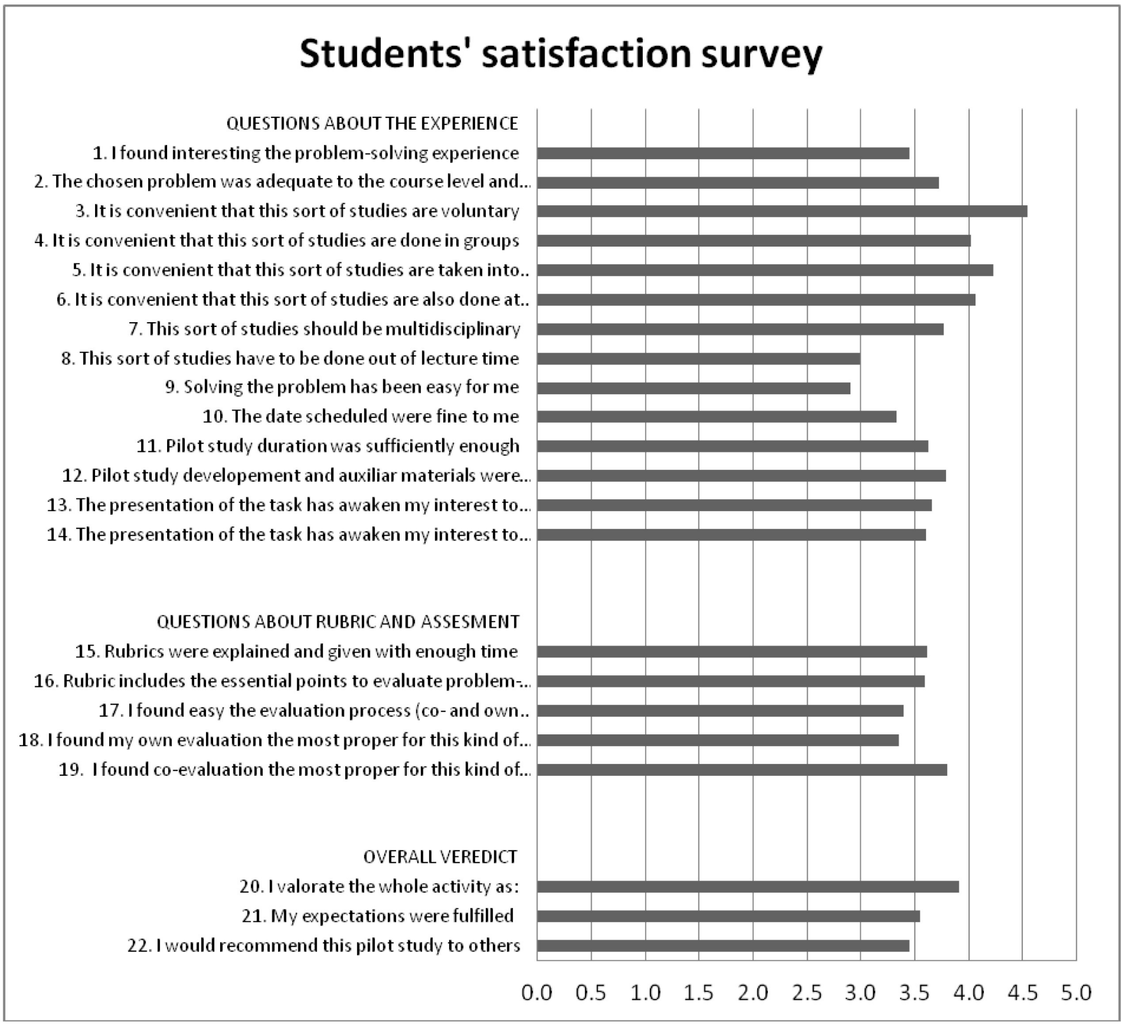
| Subject | Students that did the pilot experience | | Rest of students | | All students | |
|---|---|---|---|---|---|---|
| | No. of students | Average mark | No. of students | Average mark | No. of students | Average mark |
| Chemistry | 25 | 6.8 | 99 | 5.2 | | 5.7 |
| Physics II | 11 | 6.3 | 61 | 5.9 | | 6.0 |
| Mechanisms | 20 | 3.7 | 32 | 3.3 | 52 | 3.5 |

(*) The pilot study corresponding to Mathematics is not included due to its multidisciplinary nature and the different number of participants in each phase of the study.

**Table 4.** Summary of student's survey. Participants

| | Chemistry | Math II | Physics II | Mechanisms | Mean/total |
|---|---|---|---|---|---|
| Number of responses | 16 | 21 | 10 | 23 | 70 |
| % of responses | 64 | 44 | 91 | 96 | 65 |

**Table 5.** Questionnaire of students' satisfaction. 1: totally disagree, 2: quite disagree, 3: indifferent, 4: quite agree, 5: totally agree




majority of students also agreed that the given time had been sufficient, as well as the way of presenting the task attractive to them. On the contrary, students did not agree to attend to similar pilot studies out of the lectures time.

Regarding assessment criteria, half of respondents thought that the rubric was a proper manner of evaluating the pilot study, but a high number were indifferent to the question. Besides, only one third of the respondents had found the problem easy.

In general terms, two thirds of the respondents thought that the experience was positive or very positive, so that they would recommend other students to participate in similar pilot studies. Only ten percent of them found the whole experience negative.

### 3.4.2 *Teacher's opinion*

From teachers' point of view, the pilot study developed satisfactorily and students were especially interested in the task, because they had to solve a problem in a different context.

These kinds of experiences are to be expanded to all students in some subjects and along the semester; it is now imperative to develop cross competencies, and to be able to demonstrate that they have been practiced and evaluated in the assigned subjects.

The problem arises with the time involved in correction with rubrics, that is, by far, largest than classic numeric correction, as well as the analyses of results; this questions the viability of carrying out a large number of mandatory experiences distributed throughout the semester, especially considering the high number of students enrolled by subject.

In order to implement this assessment system to the full student's sample, a careful selection of the experiences will be required. Moreover, the rubric can be simplified, reducing the number of criteria to make the evaluation easier and quicker

Some improvements have been suggested in the survey, among which are those related to the opinion of student's score. In particular, the next two questions have been added:

- Lecturers' evaluation was fair and adequate.
- Both evaluation parts were coherent with each other.

## 4. Conclusions

We have designed a problem-solving assessment procedure and explained in detail the first level of acquisition of the competence. We have carried out four pilot studies to determine the validity of our rubric. These experiences have been used to fine-tune the procedure and we can conclude that it works and it is ready to be used as a standard assessment procedure for PSCat the UPM. The next step is to broaden our problem-solving procedures to other subjects and levels.

Although different knowledge fields were involved in this study, the skills of the students belonging to different groups are similar and the procedure and criteria used are the same, allowing us to compare the different pilot studies and generalize the results.

Based on the results of the students who have participated in the pilot studies, we can conclude that the students of the first courses at UPM have a basic knowledge of the PSC—they have obtained a good level of achievement of the first assessment criteria-. But they need to progress in the acquisition of the competence to get a good level in the last criteria, especially in the critical analysis of the problem. New pilot studies will be performed in the last courses of the career and in postgraduate studies to confirm the improvement in the students' competence.

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