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Integrating Generic Competencies into Engineering Curricula*

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The new degrees in Spanish universities generated as a result of the Bologna process, stress a new dimension: the generic competencies to be acquired by university students (leadership, problem solving, respect for the environment, etc.). At Universidad Politécnica de Madrid a teaching model was defined for two degrees: Graduate in Computer Engineering and Graduate in Software Engineering. Such model incorporates the training, development and assessment of generic competencies planned in these curricula. The aim of this paper is to describe how this model was implemented in both degrees. The model has three components. The first refers to a set of seven activities for introducing mechanisms for training, development and assessment of generic competencies. The second component aims to coordinate actions that implement the competencies across courses (in space and time). The third component consists of a series of activities to perform quality control. The implementation of generic competencies was carried out in first year courses (first and second semesters), together with the planning for second year courses (third and fourth semesters). We managed to involve a high percentage of first-year courses (80%) and the contacts that have been initiated suggest a high percentage in the second year as well.

Keywords: generic competencies; teaching and assessment; curricula; coordination

1. Introduction

One of the guidelines set by the convergence process towards the European Higher Education Area (EHEA) refers to the need to develop generic competencies (skills) of our students. In the Spanish national context, the legal framework is given by RD 1393/2007 [1], which indicates the competencies each graduate should acquire, and Universidad Politécnica de Madrid (UPM) establishes a set of generic competencies common to all degrees taught at this university [2]. However, the approaches undertaken so far are ineffective or very difficult to implement. As far as generic competencies are concerned, the teaching guides of every course simply specify a set of generic competencies without any specific training plan or assessment.

Based on an initial exploration of the current situation, we can say that this is the general situation among the Spanish universities involved in the Bologna process. However, we can cite some experiences that have worked with greater rigor in the introduction of generic competencies in the curriculum. For example in [3], where the most demanded skills for computer science graduated are analyzed. Some skills issues are detailed and some possible tools are introduced to assess them. Sánchez makes a proposal [4] on working and assessing generic competencies in the courses of a degree, and advocates for distributing generic competencies among subjects, including activities that enable students to improve a certain competence. Rue [5] agrees with this approach, stressing the need to root the development of skills in the context in which it takes place, thus strength and degree of relevance are increased. On the other hand, Sicilia [6] proposes to design tasks in courses taking as a reference activities in the professional world.

In [7] the authors describe a tool (CUSP) for globally managing competencies and their location in the curriculum, but they do not indicate how those skills are developed and assessed in daily academic work. The study in [8] implies the need for a stakeholder-responsibility approach in prescribing a comprehensive normative solution to the employability of graduates. In addition, it also postulates that the culture of learning and gaining varied skills in different spheres of life need to be inculcated amongst students from early years. In [9] Male asserts that "Based on a literature review, this paper recommends that engineering educators should help their students to develop competencies that are often called "generic competencies", by focussing on "generic engineering competencies" which encompass technical and non-technical competencies required across all disciplines of engineering." Finally, in [10] the authors explain in which courses should competencies be achieved, and to what degree. Besides, they specify the "learning outcomes" relating them to generic competencies that should be worked out according to these goals. Throughout the study, students are required to take what they call co-curriculum activities: sports, cultural, "uniform", discussions, martial arts, etc.

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They speak of the need for evaluation, but do not say how to do it.

This paper aims to take a step in the organization of competencies within a curriculum and facilitate their introduction into the syllabus of the courses. The goal is to implement a process within the degrees of Graduate in Computer Engineering and Graduate in Software Engineering at the School of Computing Science at Universidad Politécnica de Madrid (SCS-UPM) that allows the teaching, development and assessment of generic competencies planned in these curricula. On the one hand, the relevance of this study is based on the innovation of this approach in the context of the Spanish implementation of EHEA, since no similar studies or experiences have been documented. On the other hand, the relevance is based on extending the implemented model, allowing to apply the same procedures in other contexts and degrees, not only in the field of engineering and architecture, but in other fields of knowledge as social sciences or humanities.

This paper is organized as follows: Section 2 describes the implemented process and the participants who took part in it. Section 3 presents the main results of this experience and discusses the main difficulties encountered and the actions used to overcome them. Finally, section 4 sums up, in summary, the main conclusions of this study.

2. Method

To develop this work we started from a previous study conducted by the CALEE group [11], which proposes a generic model for training, development and assessment of generic competencies in undergraduate degrees. Applying this model we obtained a selection and organization of competencies based on criteria of completeness and complexity thereof. By completeness we mean that this model ensures the assessment of all the competencies described in the legal framework. Complexity means that competencies are ordered in levels of increasing complexity, starting from the simplest ones, so that each competence can give support to competencies in higher levels of hierarchy. The competencies are distributed over semesters (Table 1).

The competencies listed in Table 1 are assigned a value in brackets that indicates the number of times that this competence is dealt with. The degree consists of 8 semesters but the eighth semester is devoted to optional courses and therefore, we do not include last semester in the plan, in order to ensure that every student has worked on each competence at least once.

2.1 Participants

For the effective implementation of the plan, several meetings were held with the organizations involved and the coordinators (the teachers responsible for coordinating all groups in the same course) of the first year courses that were to participate. A Generic Competencies Monitoring Committee (GCMC) was formed, whose mission is to globally coordinate the implementation of the process. A coordinator and a specific Competence Committee were appointed for each single competence. Every Competence Committee is constituted by the coordinators of the courses associated with that competence, although it is open to any teacher giving these courses. Also, a website was developed using Moodle in order to share material and ideas among the members of the committees.

After reporting the implementation process to the

Table 1. Assignment of competencies to semesters

1st semester	Written Communication (I). Basic documents	Problem Solving (I). Guided problems	Analysis and Synthesis (I)	Social and Environmental Responsibility (I)
2nd semester	Organization and Planning (I)	Problem Solving (II). Guided problems	Oral Communication (I)	Basic Critical Thinking (I)
3rd semester	Organization and Planning (II)	Autonomous Learning (I)	Written Communication (II)	
4th semester	Team Working (I)	Motivation for Continuous Improvement (I)	Analysis y Synthesis (II)	
5th semester	Written Communication (III). Scientific and technical documents	Problem Solving (III). Ill-structured problems solved in groups	Team Working (II)	Autonomous Learning (II)
6th semester	Leadership (I)	Creativity (I)	Critical Thinking (II). Scientific and technical documents	Motivation for Continuous Improvement (II)
7th semester	Oral Communication (II)	Oral and Written Communication in English		

School Board in July 2012 and obtaining its approval, we proceeded to inform in detail to the Heads of Department. Then the plan was explained to all the coordinators of the freshmen courses of both degrees. This meeting ended by presenting a first proposal for competencies-courses allocation. To develop this proposal, members of the GCMC reviewed the educational guides of every single course in each degree (which contain all relevant information about the course: its syllabus, the competencies, teaching methodology, assessment methods, etc.). For each course, the competencies, together with the methodologies and assessment systems of the course were analyzed. Once this analysis was completed, we made a final matching, associating one single competence (among those in Table 1) to each course. Finally, from the resulting set of subjects, three of the coordinators decided not to participate in the process since this first year the process is not mandatory. The Social, Ethics, Professional and Legal Issues course has, exceptionally, assigned two competencies, on request of faculty members teaching the course. The matching of competencies with courses is shown in Table 2.

Tables 3 and 4 show the total number of students involved in the implementation process in each engineering degree.

In regards to the teachers, the process achieved a participation of 48 teachers from the total of 78 who offer teaching in both semesters of both degrees. This first time, participation was voluntary. Teachers were motivated by talks in which it was explained that this process would be required in the short term. The director of ANECA (National Agency for Quality Assessment and Accreditation of Spain) was invited in order to highlight the importance of the development and evaluation of competencies. We developed guides and abundant material for teachers to introduce competencies in their subjects. We also organized training courses on these competencies. Participating teachers received advice throughout the whole process.

Table 2. Matching competencies-courses in the first two semesters

Generic Competencies	Computer Engineering	Software Engineering
Problem Solving	Algebra (AL, 2nd semester)	Algebra (AL, 1st semester) Object Oriented Programming (OOP, 2nd semester)
Critical Thinking	Social, Ethics, Professional and Legal Issues (LI, 1st semester)	Social, Ethics, Professional and Legal Issues (LI, 2nd semester)
Oral Communication	Computer Technology (CT, 2nd semester)	Introduction to Economics and Business Management (BM, 1st semester)
Written Communication	Computer Structure (CE, 2nd semester)	Introduction to Economics and Business Management (BM, 1st semester) Computer Structure (EC, 2nd semester)
Analysis and Synthesis	Mathematical Analysis (MA, 1st semester)	Mathematical Analysis (MA, 2nd semester)
Social and Environmental Responsibility	Social, Ethics, Professional and Legal Issues (LI, 1st semester)	Social, Ethics, Professional and Legal Issues (LI, 2nd semester)

Table 3. Students who have participated in the implementation process in Computer Engineering Degree

Subject	MA	LI	AL	CE	CT
Number of students (male/female)	204	141	180	157	191
Number of men	176	122	156	134	165
Number of women	28	19	24	23	26
Minimum age (number of students)	19 (54)	19 (32)	19 (50)	19 (45)	19 (42)
Maximum age (number of students)	44 (1)	44 (1)	44 (1)	40 (1)	47 (1)
Mode (number of students)	20 (59)	20 (48)	20 (53)	20 (49)	20 (61)

Table 4. Students who have participated in the implementation process in Software Engineering Degree

Subject	AL	BM	LI	MA	CE	OOP
Number of students (male/female)	229	244	115	256	200	185
Number of men	201	215	19	223	173	160
Number of women	28	29	19	36	27	25
Minimum age (number of students)	19 (61)	19 (61)	19 (57)	19 (55)	19 (56)	19 (57)
Maximum age (number of students)	56 (1)	36 (1)	43 (1)	56 (1)	42 (1)	44 (1)
Mode (number of students)	19 (61)	19 (61)	19 (57)	19 (55)	19 (56)	19 (57)

Table 5. Schedule of workshops for training in Oral and Written Communication Competencies

Workshops planning		
January 30th	10:00–11:00	Written communication. Guidelines for writing an scientific document
	11:00–13:30	Team work: write down an essay on a subject proposed by the teacher
	13:30–14:30	Analysis and assessment of the writings made
February 1st	09:00–10:00	Techniques for public speaking
	10:00–11:30	Team work: preparation of the public presentation
	11:30–13:30	Presentations in public (5 minutes per group). Analysis and assessment of presentations

2.2 Implementation process

The implementation plan was developed over nine meetings of the GCMC, and was approved by the School Board in July 2012. During the academic year 2012/13, the GCMC met about ten times, dealing with issues such as the revitalization of the competence committees, the development of materials to support teachers, or the design of a skills training plan for teachers. Throughout this first year and a half, the GCMC has generated several documents: 1) Base Document for presentation and justification of the plan; 2) a guide for every competence which includes the definition of the competence, teacher support material, a rubric for assessment and examples of activities for acquiring the competence; and 3) competence reports, which are filled in by the end of the course. Furthermore, the development of a plan for quality control of the implementation process is its first stages.

The process began to be implemented in its three dimensions (training, development, and assessment) in the academic year 2012/13. Coordination meetings were held by each competence committee in order to reach agreements concerning training and assessment strategies and the adequacy of the activities proposed by the courses to ensure that the students acquire the competencies. The committees also reviewed the rubrics, discussed which indicators might be measured with each activity, and what is the maximum level of acquisition that can be achieved by students. These competence committees met fourteen times in all.

2.2.1 Training

The training plan began in September 2012. The only competencies which were not planned to be covered by any regular course are Oral and Written Communication. In order to cover these two competencies, every freshman of either degree were offered the opportunity of attending two workshops, one on Oral Communication and one on Written Communication, taught by the Institute of Education Sciences of UPM, the first week of the academic year. Each workshop lasted 2 hours and was attended by around 100 students from each degree in September of last year. For students who did not attend in September, a second chance was offered on January 30th (Written Communication) and February 1st (Oral Communication). This second time only around 20 students attended. Table 5 displays the topics covered in these workshops. Regarding the remaining competencies (Problem Solving, Social and Environmental Responsibility, Critical Thinking, Analysis and Synthesis), teachers train students within their subjects. Since teachers also need to be trained, two workshops on Organization and Planning and Problem Solving were offered to teachers on July 1st and 2nd 2013. This is part of a more general training plan for teachers, organized over the next three years, for all generic competencies we wish students to acquire.

2.2.2 Development activities

The introduction of competencies is done through activities that are carried out within the teaching program of the subjects. The goal is to integrate smoothly the development of the competence in the teaching programming of the courses. To achieve this, each competence guide includes one or more activity models that foster its development and assessment. These models of activities are offered for incorporation to the courses. They may in time choose to incorporate new activities always following the models proposed, or indeed adapt some already foreseen activities to certain models of activity proposed to them.

For each competence, the models of activities are graduated according to different levels of complexity. In some cases, activities combine two generic competencies, if they are closely related. In addition to the models of activities described, each competence guide provides some examples of specific activities carried out in the courses. These examples serve as a reference for future academic courses in order to design new activities. The goal is to continue enriching the set of examples of activities to be implemented. During the academic year 2012/2013 we completed the competence guides of: Analysis and Synthesis, Written Communication, Oral Communication, Critical Thinking, Social and Environmental Responsibility and Problem Solving. For the next academic year 2013/2014, moreover, we expect to complete two new guides: Autonomous Learning and Organization and Planning.

As an example, we describe below the two types of activity proposed for the competence Analysis and Synthesis:

1. A moderately complex text is handed out to students, for instance some book sections that provide new concepts. Students should fill out a questionnaire in which they have to reflect several aspects of the text: main idea, supporting details, relevant information, arguments used by the authors, usefulness of new concepts, conclusions, etc. The class discusses these issues in the text, seeking a satisfactory solution of the activity. A peer to peer assessment is then carried out by the students on the redistributed questionnaires.
2. A technical text of greater complexity is provided, such as an article or a more complex book section, which provides new knowledge on the agenda of the subject. The student must write a summary of around 300 words and a concept map. In the classroom the issues that should be covered by the abstract are discussed and peer to peer assessment is undertaken by students. In the case of an article, the teachers might compare the abstracts submitted by students with the original abstract of the article.

An appropriate combination would consist of performing an activity of type 1, as a first step, and then performing at least two of type 2. This competence can be coordinated with Written or Oral Communication Competence.

We list below, very briefly, some of the activities undertaken in some of the courses during the academic year 2012–2013:

- Algebra (Problem solving): Students must follow the basic steps for solving a problem in order to sort out an activity in an individual test. The assessment, using the rubric, takes into account the process followed and the arguments presented by the student.
- Social, Ethics, Professional and Legal Issues (Critical Thinking and Social and Environmental Responsibility): The development of the competence takes place in discussions and debates held in class. Subsequently, the competence is assessed on some homework on Electronic Commerce, which is valued at 10% of the final grade. At the beginning of this homework, teachers explain the fundamentals of the competence and hand out the rubric that will be used to assess it.
- Computer Structure (Written Communication): Students solve four laboratory activities related to analysis and design of digital circuits. Besides solving the exercise, students have to write a report explaining the reasons for the proposed solution.
- Object Oriented Programming (Problem Solving): Teachers propose an ill-structured programming problem. Students have several weeks to plan and develop a solution. The first step to be addressed by students is a clear definition of the problem. They then explain some alternatives and argue the selected option. Students should seek information not provided in the presentation of the problem. This activity uses 5 out of 7 indicators of the rubric.

2.2.3 Assessment strategies

In most cases, the competence assessment and the development activities go together. It is thus possible to assess the competence integrated into the technical training that the student is acquiring. The evaluation can be performed in different ways: using tests ([12, 14]), solving specific exercises ([13, 15]) and, in many cases, through rubrics. The latter case requires the prior preparation of these rubrics, common to the whole degree, so that each competence is evaluated using the same rubric in all courses that are matched with it.

In some courses in the first years of the degree, the activities proposed will not be complex enough to use the full rubric. Therefore, some courses have chosen not to use part of the rubric; and they do this in two ways:

- Not all the indicators of the rubric are covered, i.e., we consider that in the scheduled activity students do not use or develop these indicators.
- In some of the indicators there is a cap on the level achieved, i.e., it is considered that the activity is not complex enough for the student to demonstrate the highest level of achievement in that indicator.

For instance, the rubric used to assess Problem Solving Competence has 7 indicators with 4 possible values (Annex A). These indicators are: problem identification, gathering relevant information, strategy used for resolution, quality of the selected solution, results, conclusions, and use of resources. The Algebra course, for instance, does not cover indicators 2) and 7), and the top level for indicators 3) and 4) is 3, not 4, the maximum.

2.2.4 Software tools

Finally we note that this process is supported by various software tools. The UPM has a website [16] dedicated to generic competencies to support the work of teachers. In the context of the SCS-UPM we have developed a tool for teachers to enter grades on generic skills [17] (authorization is required in order to gain access; teachers can ask any of the authors for authorization). The research group CALEE has also developed a website [18] (authorization is required in order to gain access; teachers can ask any of the authors for authorization) that allows students to undertake automated tests on generic competencies. In addition, the working group has set up a collaborative tool whereby participants can share teaching materials and experiences [19].

3. Results

In both degrees and both semesters, 80% of the courses were involved in this process. Regarding the participation of teachers, not all of them have joined the first year plan. Consequently, the competence Organization and Planning has not been assigned to any of the courses. In addition, there are courses in which not all groups have worked on the assigned competencies. However, the model ensures that every freshman has worked every competence at least once. The faculty and students who took part in the process appreciated the approach adopted for the incorporation of competencies in the curriculum (integrated approach), in the sense that the competencies form part of the mandatory activities of the course, have a weight in the course and, in turn, are used to obtain information about the level achieved in the competence. This model is considered appropriate since students are motivated by the short-term rating on the subject, and on the other hand the information gathered about the level of competence acquisition allows us to observe the improvement of the student throughout the degree. Nevertheless, some courses did not pay the same attention to this additional task of introducing the rates regarding the generic competencies, consequently, to date, we only have the ratings of two subjects of the first semester. Therefore we will have to wait for the rest of the subjects to introduce their ratings in order to evaluate them. However, one of the aforementioned subjects, Mathematical Analysis, which evaluated the competence Analysis and Synthesis in Computer Engineering has found an interesting correlation. Table 6 indicates the qualifications obtained in one of the activities (homework) during the academic years 2011/12 and 2012/13.

We highlight that during the year 2012/13 both the percentage of students who have handed the homework in and the percentage of homework that passed were higher than the previous year. The marks obtained in the homework seemed significantly better. In order to check this, an analysis of variance was conducted to see if the difference was statistically significant. The p-value obtained was $p = 0.0246$ which means that we can reject, with a confidence level of 95%, the hypothesis of equal means. That is, we can assert that this year students have improved the outcome in this activity. We might also suppose that the improvement in results is due to the academic level of students in both courses. However, if we take a look at the last column (No. of students passing the subject) we observe that it is not so, the number of passes is slightly better during 2011/12. We can conclude that, with due caution, training in the competence Analysis and Synthesis improves students' math skills.

Finally, it should be noted that a problem has been detected in the rubrics used to evaluate the competencies of Oral and Written Communication. Both rubrics contain indicators which are divided into aspects. According to teachers who have used them, assigning ratings to each aspect is too tedious a task for the little information provided. They feel it would be better to specify the indicators with the same level of detail but assigning an overall rating to the indicators instead to each aspect.

4. Conclusions

A process to introduce generic competencies progressively into the curriculum has been successfully implemented, ensuring the training and assessment of all students in all the competencies planned in the curriculum.

The main conclusion from this experience is that using the method proposed by the CALEE group, coordinating mechanisms and providing enough support material for courses, we achieved the introduction of training, development and assessment of generic competencies in the curriculum.

However, we found some significant difficulties. First of all, some courses decided to participate rather hesitantly when they had to change their teaching plans. This difficulty can be overcome by gradually introducing competencies in the courses and increasing their confidence through the support

Table 6. Comparison of homework in Mathematical Analysis. Academic years 2011/12 and 2012/13

Year	No. of Students (July)	No. of Students handing the homework in	Average mark of homework	Standard Deviation Marks	No. of Home work obtaining a mark ≥ 5	No. of students passing the subject
2011–12	148	89	5.82	2.25	59 (66.29%)	53 (35.81%)
2012–13	141	107	6.45	1.61	95 (88.78%)	51 (36.17%)

material that is provided. Furthermore, in some cases there was an initial position of rejection. In this regard, experience has shown that this initial position changes over time.

As we have shown, the model demonstrates several advantages: (1) it is flexible, since it allows the incorporation and management of any generic competence according to each university's objectives, (2) it is comprehensive, since the training, development and assessment of competencies are integrated into the working of each course (integrated approach), (3) it is economical, as there is no need for different activities within the courses, although the tasks to be performed may be more complex or at least require a different approach when being designing.

Despite these benefits, the implementation of the model has met some resistance among teachers. This reluctance to join the process has several aspects. We want to highlight the lack of information and training received by teachers in this field, which somewhat limits the "possible enthusiasm" for the new activities. To this we must add that the training processes require time and dedication to topics that are not considered important, relevant or even necessary by all teachers. On the other hand, no clear guidelines are provided by the Chancellor, such as the obligation to implement this type of process or at least, bonuses for those who do it. Besides there is no clear policy on how the rates obtained from the competence assessment are integrated into overall marking. Despite these difficulties, we have observed a decrease in the reluctance of teachers to get involved in the process. This is, undoubtedly, because there is more information and training on the subject. The forecasts of the incorporation of new teachers for the first four semesters are optimistic.

Limitations of the study presented here refer to two aspects. First it is necessary to complete the process for at least one cohort of students. This means deploying the process in all subjects of both degrees. Second, it is necessary to validate the proposed process in other engineering degrees in the first instance, and then apply the model to degrees from other branches of knowledge.

In the short term, over the next three years, we will extend the model described to the other semesters (from third to seventh) of the degree of Computer Engineering and Software Engineering, and of course, on the Final Project. In the medium term we will try to export this model to other disciplines within the branch of knowledge of engineering and architecture both within the UPM and other universities. In the long term the model should be validated by applying it to degrees of the other four branches of knowledge: Arts and Humanities, Science, Health Sciences and Law and Social Sciences.

On the other hand, it is necessary to improve the rubrics developed and to design other assessment strategies that may be more appropriate than rubrics for certain courses. For instance, we can additionally use psychometric tests as described in [20] or observation protocols on the group work in order to assess teamwork.

As far as students are concerned, at the end of the academic year 2013–2014 students shall complete a satisfaction survey about the proposed competence model. This survey was not being asked to carry out in the first year of implementation, since the process was a pilot project. These surveys will continue going on a regular basis to provide feedback with a view to quality control of the entire process. We shall thus be able to improve the activities defined in the implementation process. The same feedback procedure shall be applied to the teachers involved.

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Appendix A. Rubric used to assess problem solving competence

Criteria	Unsatisfactory: 1	Acceptable: 2	Good: 3	Exemplary: 4
1. Identifying problem:				
Reading and understanding the text: identifying data, relevant facts, assumptions, unknowns ...	Ignores fundamental aspects, showing that the problem has not been understood: does not identify all the relevant information (unknowns, data, facts, opinions ...).	Demonstrates understanding of much of the problem, but some aspects are unclear or insufficient: identifies relevant information (data, unknowns, conditions, opinions, facts) but in a disorganized, incomplete or inaccurate manner.	Demonstrates understanding of the problem: identifying all the relevant information in an organized manner using appropriate language or notation.	Clearly demonstrates full understanding of the problem: gathers all the relevant information in an organized and rigorous manner, justifying their necessity or utility; identifies secondary issues or topics implicitly contained in the problem. Should the problem so require collection of additional relevant information.
2. Gathering:				
Should the problem so requires, collection of additional relevant information.	Has not looked for information or the information gathered is clearly insufficient or irrelevant.	Seeks information, but the information gathered is incomplete or superficial.	The information gathered is appropriate for solving the problem.	The information gathered to solve the problem is relevant and complete, comes from reliable sources and is properly referenced.
3. Strategy:				
Selection of an abstract model in which the? relationship between data and unknowns is represented.	Does not choose a suitable model, does not represent the relationship between data and unknowns or makes serious mistakes in expressing the relationship.	Chooses a suitable model but makes some mistakes on the relationship between data and unknowns, or the relationship is unclear or incomplete. Things must be assumed that are not explicitly expressed.	Selects a suitable model and represents the relationship between data and unknowns in a correct and complete fashion.	Selects a suitable model and argues the choice in detail. Represents on it, correctly, completely and clearly, the relationship between data and unknowns.
Selection and reasoned application of a method	Does not choose a suitable method or does not apply it correctly, or makes several errors.	Chooses an appropriate method but makes some mistakes or the argument is weak: there are gaps or logical order is not correct.	Chooses a suitable method, applies it in a correct, complete and logically ordered way, but does not argue all the steps.	Chooses an appropriate method, applies it correctly and the presentation of the argument is complete and logically ordered. The analysis facilitates decision-making.
If the complexity of the problem requires it, break down of the problem into simpler sub problems.	Fails to break down a complex problem into manageable parts.	Divides a complex problem into parts but does not solve all of them or does not link them properly.	Breaks down a complex problem into manageable parts that are properly linked.	Brilliantly recognizes the parts of a complex problem and their relationships. Has an integrated view.

4. Efficiency:				
Choosing the most efficient method, should there be more than one option.	Does not consider alternatives or chooses an inefficient option.	Directly selects the most efficient option, but implements it poorly or shows more than one alternative but fails to study strengths and weaknesses.	Chooses the most efficient option and runs it correctly, or describes several alternatives and sufficiently compares their strengths and weaknesses.	Immediately chooses the most efficient option and executes it correctly. Describes, compares and evaluates alternative modes in a complete fashion.
5. Results:				
Obtaining results.	Does not present results or they are totally or partially incorrect, with serious errors (notation, number, ...)	The results presented are correct and complete, with slight errors (numeric, notation ...)	The results are correct and complete but they are not presented in a concise way or certain points are imprecise.	The results are correct, they come naturally from the proceedings and are presented, clearly and concisely, as a final conclusion of the problem.
6. Conclusions:				
Reflection and conclusions.	Obtains inconsistent results and does not reflect on the matter. Does not review the results and the procedure.	Checks the results and contrasts their consistency with the conditions of the problem, but expresses the conclusions in an incomplete manner or with some mistakes.	Checks and interprets the results contrasting their consistency with the conditions of the problem. Draws correct and complete conclusions.	Besides checking and interpreting the results, draws conclusions which allow to generalize the problem or its solution, or to particularize it in cases of special interest. Analyzes the process and suggests possible improvements.
7. Technology:				
Use of resources	Does not make use of the technologies required or uses them inappropriately.	Uses technology, but this does not help in obtaining a solution.	Integrates the use of technology appropriately in search of the solution.	Integrates the use of technology appropriately in search of a solution, demonstrating a command that allows him to reach the solution in a remarkably efficient way.

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