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Educational Activities for Acquiring Skills in the EEES adapted Degrees

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Abstract
The main objective of this paper is to describe the performance of a serial of training activities focused on the acquisition of skills by different groups of undergraduate students related to science as a branch of knowledge. Specifically, we used those activities where students receive knowledge, such as theoretical classes (T), computational (PC) and laboratory (PL) sessions, exercises (P), ECTS tutorials and bachelor thesis (TFG). Among the different activities, it must also be highlighted the undergraduate dissertation. The activities were conducted in different courses of the Chemistry degree of the University of Extremadura, in order to obtain information from the different competences that appear in the verification report of this title. Finally, the students filled out a survey giving their opinion about the skills acquired in each of the activities.
The results of the experience is that students achieve most of the skills considered in the title. Likewise, the results from the activities considered show that not all skills are achieved and other activities should be considered to cover those deficiencies. The activity that most contributes to the acquisition of transversal competences are laboratory practices, while for specific skills, the activities developed with large group of students (T and P) are the most significant. TFG is the activity that best covers most of competences, especially Basic and General.

Keywords
Teaching Methodologies; Innovation in Education, Applied Sciences. Education Competences, Formative Activities.

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1. Introduction

Adaptation to European Higher Education Area (EEES) has led to the Spanish universities the need for more comprehensive training that includes, in addition to the specific competences of each degree, basic, general and transversal competences. Thus, the memories of the new curricula verified by the Agencia Nacional de Evaluación de la Calidad y Acreditación (ANECA) incorporate a detailed compendium of the competences of the professional profile of each qualification, understanding that are key to enhancing employability.

The current design of the curriculum requires that learning are oriented to the acquisition of skills by students, teachers must assess the degree of achieving them. Therefore, in this new context, the challenge is to design a program of training activities and planned experiences specifically to support the student to achieve particular learning outcomes and, in turn, develop a framework to assess the different skills the student has to acquire.

Regarding the design of training activities to achieve the acquisition of the competences of a degree, it requires the use of different teaching methods and evaluation criteria adapted to each type of activity. The importance of this study is even greater if we consider the insufficient previous evidence linking the full acquisition of skills, the training activities, and methodologies to achieve with the evaluation of learning results. Consequently, the fundamental objective of this work is to check to what extent the training activities employed have achieved the acquisition of skills, and to what extent an application of training activities can improve the acquisition of skills.

2. Competences/Skills

Degree in Chemistry at the University of Extremadura (BOE 05/01/2010 and 08/03/2010) stated in his Verification report the competences given in Table 1, which can be grouped into four main groups: Basic (CB), General (CG), Transversal (CT), and Specific (EC) skills.

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Only 12 of the 35 specific skills listed in the degree report have been considered, particularly those related with the disciplines considered in the conducted surveys.

Table 1. UEx Chemistry Degree Competences.

Basic Competences	
CB1	Demonstrate knowledge and understanding
CB2	Knowing how to apply their knowledge to their work
CB3	Having the ability to gather and interpret data
CB4	Communicate information and solutions
CB5	Have developed learning skills
General Competences	
CG1	Students engage in learning tasks
CG2	Students must develop an interest in learning
CG3	Students acquire knowledge and practical skills
CG4	Students develop skills/abilities
Transversal Competences	
CT1	Ability to use the method of induction, analysis and synthesis, organization and planning, work in an international context, both oral and written expression, critical thinking, problem solving, decision making and teamwork
CT2	Ability to communicate knowledge and conclusions
CT3	Ability to learn new techniques and knowledge
CT4	Development of personal learning abilities and to acquire skills in interpersonal relationships
CT5	Show sensitivity to environmental issues
CT6	Recognition of diversity and multiculturalism
CT7	Commitment to respect human rights
CT8	Motivation for quality

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CT9	Knowledge of a foreign language (preferably English)
CT10	Use of ICT
CT11	Manage technical or professional projects
Specific Competences	
CE1 (*)	Gain knowledge of chemical terminology, nomenclature, conventions and units
CE2	Interpret the atomic structure and the quantum chemistry principles
CE3	Relate the variation of the characteristic properties of chemical elements according to the periodic table
CE4 (*)	Identify the characteristics of the different states of matter and the theories used to describe them
CE5 (*)	Distinguish the main types of chemical reaction. Principles of thermodynamics, kinetics and electrochemistry
CE6	Identify chemical elements and their compounds, understanding the synthesis, structure and properties of the compounds
CE7	Analyze the radiation-matter interaction. Understanding the principles of spectroscopy
CE8	Differentiate principles and procedures for the determination, identification and characterization of chemical elements and compounds
CE9	Assimilating the relationship between macroscopic properties and properties of individual atoms and molecules
CE10	Distinguish and apply the methods of structural determination
CE11	Identify and develop unit operations of Chemical Engineering
CE12	Perform mathematical processing of data from chemical processes and quality management in laboratories
CE13	Recognize the structure and reactivity of the main classes of biomolecules and the chemistry of the main biological processes
CE14	Differentiate materials and deduce their properties
CE15 (*)	Demonstrate knowledge and understanding of essential facts, concepts, principles and theories related to the areas of Chemistry
CE16 (*)	Solving qualitative and quantitative problems
CE17	Recognition and analysis of new problems and plan strategies for their solution
CE18 (*)	Ability to function safely in a chemical laboratory
CE19 (*)	Evaluation, interpretation and synthesis of data and chemical information. Collection, processing and treatment of chemical data using computational techniques
CE20	Execution of laboratory procedures involved in synthesis and analytical works, involving organic and inorganic systems

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CE21 (*)	Interpretation of data derived from observations and measurements in the laboratory
CE22	Capacity to carry out projects in the chemical industry
CE23	Knowledge of a foreign language (preferably English)
CE24 (*)	Using the most appropriate ICT in each situation
CE25 (*)	Recognition and measurement of chemical processes in daily life
CE26 (*)	Understanding of qualitative and quantitative aspects of chemical problems
CE27 (*)	Understanding the relationship between Chemistry with other disciplines
CE28	Demonstrate have reached an adequate understanding of the different physical phenomena
CE29	Have current knowledge in some aspects of Physics
CE30	Ability to identify the essential elements of a complex physical situation
CE31	Having a good knowledge and mastery of mathematical and numerical methods most commonly used in Physics
CE32	Problem solving in Physics
CE33	Knowledge and understanding of Mathematics
CE34	Solve problems and basic exercises of Mathematics
CE35	Read and understand mathematical textbooks

(Marked with asterisks those competences studied in the surveys)

3. Work methodology

The data used in this study were collected from surveys filled by students from different courses of the Degree in Chemistry, covering various subjects with different training activities: theoretical (T) and problem (P) classes, laboratory (PL) and computer (PC) practices, tutorials (ECTS), and Bachelor thesis (TFG). Specifically, the surveyed subjects were: **Aggregation states of the matter and chemical kinetics** in the second year of the degree (including activities of T, P, PC, and ECTS types); **Classical methods of quantitative analysis** also in the second year course (with activities such PL); **Chemistry III** in the first year (only with PL type activities), and the Bachelor thesis, considering only in this case those students who submitted their thesis during the course 2014/2015. We pay special attention to the latter group of students as many of the skills listed in the Chemistry Verification Report are collected in this activity.

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Almost a total of 100 surveys were collected. Different surveys were completed according with the type of learning activity. Thus, surveys about theoretical and problem classes were conducted during the **Aggregation states** subject; ECTS surveys were performed in **Chemical Kinetics** tutorial activities. The information related with computer practices were obtained in the **Simulations of the liquid state** activity, on the other hand, laboratory survey was done during the **Electrochemistry and chemical analysis** laboratory hours. Finally, **Bachelor thesis** information was collected from surveys filled by students of different areas of Chemistry.

We will consider in the analysis that a competence is *"achieved"* when the percentage from the survey exceeds 50% and it is *"adequately achieved"* when it does a percentage above 75%. In the same way a percentage less than 25% can be considered that the competence were *"not achieved"*.

4. Result analysis

4.1 Basic competences

Figure 1 shows the percentage of basic skills acquired from different training activities. It can be seen that in general, these skills were well acquired in the learning activities carried out in a large group of students (namely, T and P activities) and in practical laboratory sessions (PL), but they were not achieved in the computer sessions and in ECTS tutorials.

It can be seen that CB1 competence, related to *knowledge and understanding*, reached the maximum rate possible of acquisition with theoretical lessons. By other hand, CB2 competence (*knowing how to apply knowledge to work*) was achieved in the greatest rate with laboratory activities, and CB3 one (*having ability to gather and interpret data*) with in the elaboration of the Bachelor thesis.

The CB5 competence (*have developed learning skills*) appears as the most successful on all training activities, the sum of the percentages is the highest and has the narrowest range between 45-80%.

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It is also worthy to note that CB3 (*have the ability to gather and interpret data*) and CB4 competences (*communicate information and solutions*) are acquired during the performance of the Bachelor thesis rather than with the traditional activities of lectures and problems.

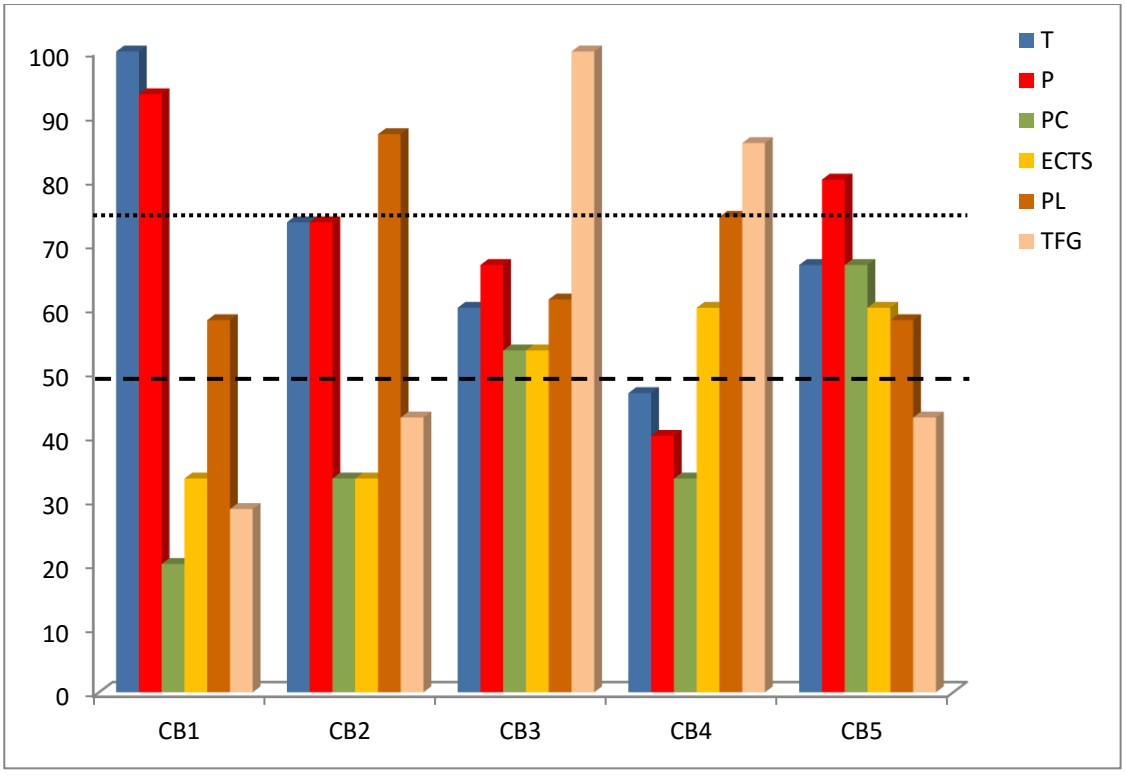

Figure 1. Percentage of Basic skills acquired in each activity

Finally, we will mention that there is always some activity that makes that all the basic competences reach the qualification of *"adequately achieved"*, as seen in Figure 1, there is at least one activity for each competence that exceed the dotted line.

4.2 General competences

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The acquisition of general skills in Chemistry degree has been analyzed in a similar way that the basic ones, showing the results in Figure 2.

It can be appreciated for the CG1 (*engage in learning tasks*), CG2 (*interest in learning*), and CG3 (*acquisition knowledge and practical skills*), that the activities with a large group students (T and P) are responsible for reaching a percentage that qualifies as *"adequately achieved"*.

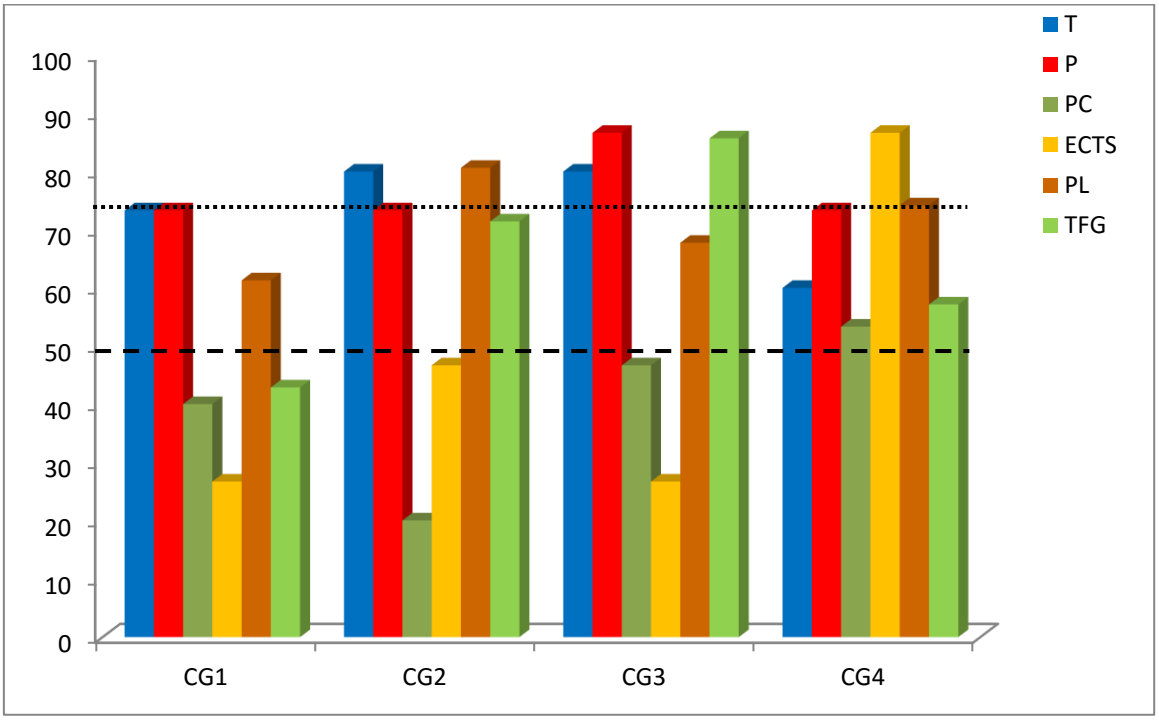

Figure 2. Percentage of General skills acquired in each activity

The CG4 competence (*development of skills/abilities*) is the largest overall percentage; in fact, it is the only one that reaches more than 50% in all activities (beyond the dashed line of the graph), and the only one in which ECTS tutorials acquires a significant value (greater than 80%).

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In general, students consider that general skills are acquired very well with the theoretical lectures and problems sessions, and with laboratory practices, although to a lesser extent in this case.

4.3. Transversal competences

Figure 3 shows the results obtained for the transversal competences of the chemical degree. The activity that most contributes to the acquisition of these skills are laboratory practices, particularly in the CT1 (*using the method of induction, analysis and synthesis, organization and planning, work in an international context, speaking and writing properly, critical thinking, problem solving, decision making and teamwork*) and CT8 ones (*ability to learn new skills and knowledge*), whose percentages exceed the value of 75%, considering them as *"adequately achieved"*.

Note that there are specific activities for the acquisition of certain transversal competences. Namely, computer activities (PC) contribute to the highest percentage (80%) in the CT10 skill (*use of ICT*). In the same way, ECTS tutorials contribute to the CT2 competence (*communication knowledge and conclusions*).

The highest percentage is reached in CT3 competence (*learn new techniques and knowledge*) with theoretical classes reaching a value of almost 90%. However there are skills that barely reach a 25% of acquisition with all training activities, such as CT6 (*recognition of diversity and multiculturalism*), or as in the case of the CT7 (*commitment to respect human rights*) where most activities do not allow to obtain this competence, which will require other activities for their achievement.

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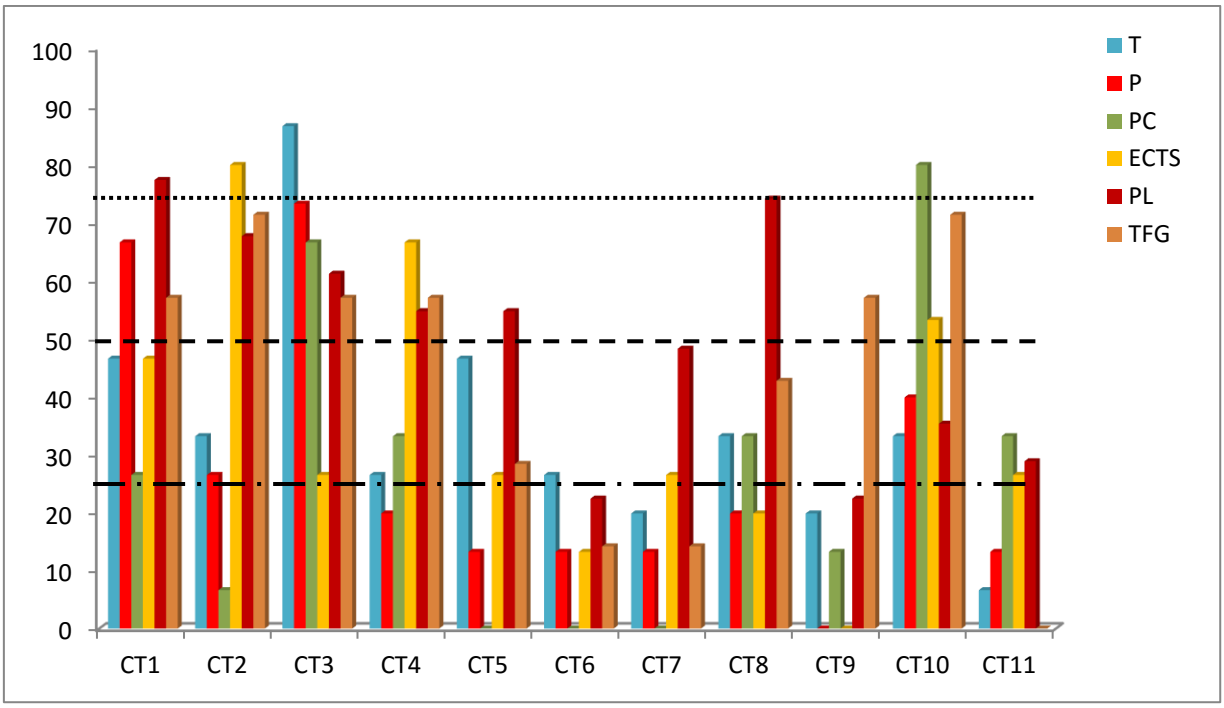

Figure 3. Percentage of Transversal skills acquired in each activity

4.4 Specific competences

In Figure 4, the results of specific skills related to the subjects of Aggregation States of Matter, Kinetics, Chemical Analysis and General Chemistry are displayed.

Theoretical activities contribute, in the opinion of students, with a 100% in the achievement of CE1 competence (*gain knowledge of chemical terminology, nomenclature, conventions and units*). This kind of activities also contribute over 90% in the CE4 (*characteristics of the different states of matter and the theories used to describe them*) and CE5 skills (*principles of thermodynamics, kinetics and electrochemistry*). This same observation could apply for these three competences using sessions of seminars/problem though with lower percentages.

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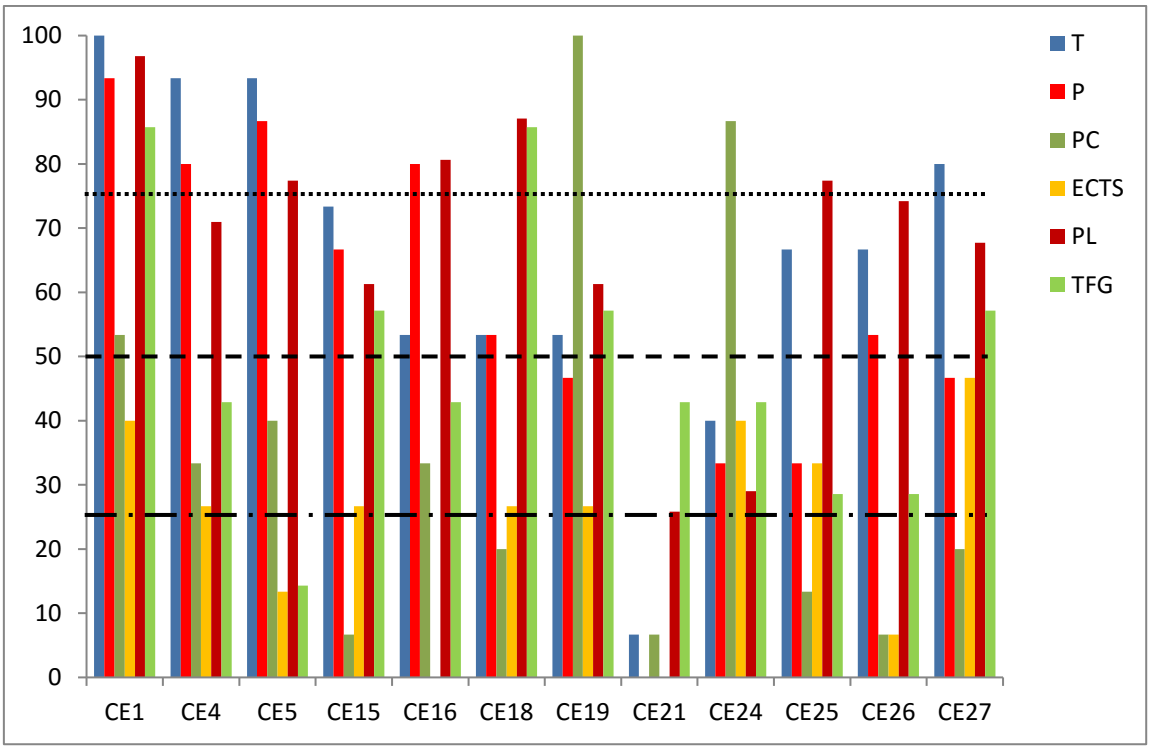

Figure 4. Percentage of Specific skills acquired in each activity

Highlight the good response provided by laboratory practices in much of the skills, the results of the computational practices in CE19 (*collection, processing and treatment of chemical data using computational techniques*) and CE24 skills (*use of ICT*), and the Bachelor thesis in CE1 (*knowledge of chemical terminology, nomenclature, conventions and units*) and CE18 ones (*ability to function safely in a chemical laboratory*).

In general, we can say that with theoretical sessions 75% of specific skills are acquired, a 66% is achieved with problem activities, a 66% with laboratories, a 16% with computing sessions 16%, and Bachelor thesis about a 41%. It can be said again that ECTS tutorials contribute very little to the acquisition of such skills.

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4.5 Bachelor thesis activity

The Bachelor thesis is a degree final work (TFG) and covers very well the CB3 (*gather and interpret data*), CB4 (*transmit information and solutions*), CG3 (*possess knowledge and practical skills*), CE1 (*gain knowledge of chemical terminology, nomenclature, conventions and units*) and EC19 competences (*evaluate, interpret, synthesize, obtain, process and treat chemical data*).

It shows a surprisingly low percentage of acquisition of the CB1 skill related to the acquisition of knowledge, and of the CE5 competence on solving qualitative and quantitative problems. On the contrary, the results of CT6 and CT7 competences (related to environmental issues, diversity and multiculturalism) can be expected because the work cannot have cover this subject.

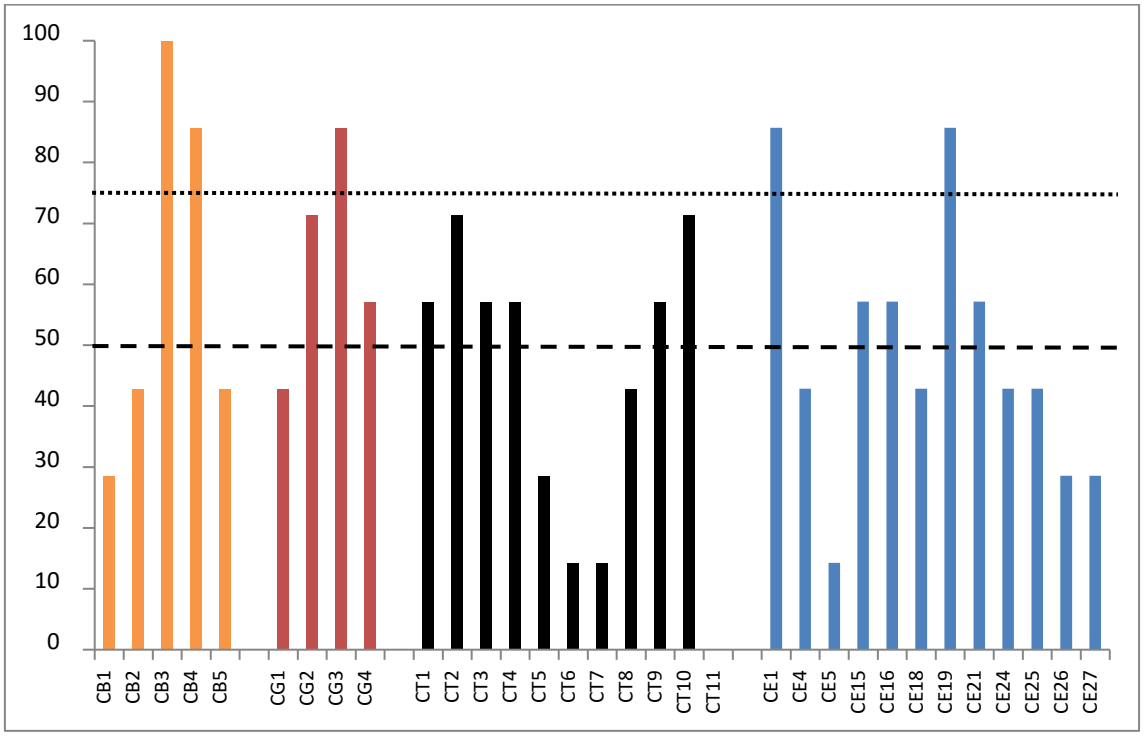

Figure 5. Percentage of competences acquired in TFG

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TFG is able to achieve most of the competences, 16 of the 32 competences analyzed exceeds the minimum value of 50% to acquire the skill in this activity. Moreover, according to the data collected, there is a competition (CT11) related to the management of technical/professional projects that is not acquired in TFG, perhaps because it is not a topic offered in the Degree in Chemistry.

5. Conclusions

In general, we can say that the activities undertaken by students throughout the Degree in Chemistry allow obtaining, in greater or lesser extent, the skills set out in the Chemistry Verification Report.

1. There is always some activity, which makes the Basic competences to reach the qualification *"adequately achieved"*.
2. The General skills are acquired very well with the theory and problem sessions, and with laboratory practices, although to a lesser extent.
3. The activity that most contributes to the acquisition of Transversal competences are laboratory practices, while for Specific skills, the activities developed with large group of students (T and P) are the most significant.
4. TFG is the activity that best covers most of competences, especially Basic and General.
5. The least appropriate activity for the acquisition of skills are the ECTS tutorials.
6. Finally, CT6 (*recognition of diversity and multiculturalism*), CT7 (*respect for human rights*), and EC11 skills (*technical project management/professional*) are poorly acquired with the activities performed.

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