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Reptes de futur en l'ensenyament superior: Docència i investigació per a aconseguir l'excel·lència acadèmica

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Assessment of Competences in the Physical Chemistry Area: Use of the Department Teaching Portfolio

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ABSTRACT

Competences have become a standard learning outcome in present university education within the European Higher Education Area (EHEA). In this regard, updated tools for their assessment have turned out essential in this new teaching-learning paradigm. Among them, one of the most promising tools is the "learner´s portfolio", which is based on the gathering and evaluation of a range of evidences from the student, which provides a wider and more realistic view of his/her competence acquisition. Its appropriate use as a formative (continuous) assessment instrument allows a deeper appraisal of student´s learning, provided it does not end up as another summative (final) evaluation tool. In this contribution we propose the use of the portfolio as a unifying assessment tool within a university department (Physical Chemistry), exemplifying how the portfolio could yield both personalized student reports and averaged area reports on competence acquisition. A proposed stepwise protocol is given to organize the individual competence reports and estimate the global competence level following a bottom-up approach (i.e. ranging from the class group, subject, grade, and academic course).

Keywords: Physical Chemistry; Competences; Portfolio; Department; Assessment.

1. INTRODUCTION

The incorporation of Spain into the European Higher Education Area (EHEA) has changed the structure of the Spanish higher education studies through a new teaching-learning model that is centered on knowledge mobilization (concepts and skills) in different changing contexts, i.e. competences (Barnett, 2001). Within this new framework, the evaluation of competences in a more genuine way must be implemented (Monereo, 2009) in accordance with present scientific grade requirements and OECD recommendations, i.e. competence acquisition, life-long learning and a proper employment process are aligned with an ever changing society (OCDE, 2008). In this context, the *student´s portfolio* arises as a tool for assessing competences in a more realistic way (Monereo, 2009)

Portfolios show student´s performance evolution (Barberà, 1998) through the gathering of a range of evidences (e.g. team works, exercises, exams, projects, presentations, etc.) that ideally show a continuous evolution of student´s competences. It fosters student´s autonomous work (Bia, 2005; Vercher and Pérez, 2004) and involvement on his/her own learning process (Barberà, 1998; Bia, 2005). This set of evidences inform the students about their personal process in terms of obtained learning outcomes, eventually inducing a self-regulation process for performance excellence. In addition, it also allows the teachers to improve their activity. Portfolios can be framed at different levels (Jariot Garcia and Rifà Valls, 2011), i.e. a particular subject or course (*teaching-learning portfolio*), a grade or postgraduate studies (*academic portfolio*) or a wider progression timeline (*development portfolio*).

The portfolio is a kind of formative evaluation tool. This type of assessment is at the core of the Bologna Process as it conceives the evaluation as a joined (interdependent) part of the teaching-learning process that guides, provides help and traces student´s learning (Álvarez Teruel and Vega Morales, 2010). In general, a true formative evaluation has a set of elements (Figure 1):

1. Initial assessment: sets the "starting point" of the teaching-learning process. It normally uses objective data taken from different sources, such as previous teachers, student´s files and tests or questionnaires answered by students themselves. It is rather simple, but nonetheless it is not very used.
2. Continuous assessment: focuses on the didactic process of teaching-learning, as it provides "clues" for a constant improvement of student´s competence acquisition, on

the basis of known (given or agreed) evaluation criteria (i.e. learning outcomes), as well as objective and subjective observations (i.e. learning evidences).

3. Final assessment: sets the "arrival point" of the teaching-learning process. From a classic perspective, it yields a final mark; from a formative point of view, it should also give a detailed overview (brief summary) of the achievements and evolution of student´s competences. It is based on formal evidences, such as (mid-term, final) tests/exams and other weighted elements from previous phases.
4. Self-assessment: transverse phase that spreads over continuous and final assessment phases. It constitutes the true final step on the teaching-learning process, as it allows students (on an individual or peer-type basis) to participate in the assessment process, internalize quality criteria for excellence, and to practice generic competences such as the reflective thinking on their own work ("learn to learn").

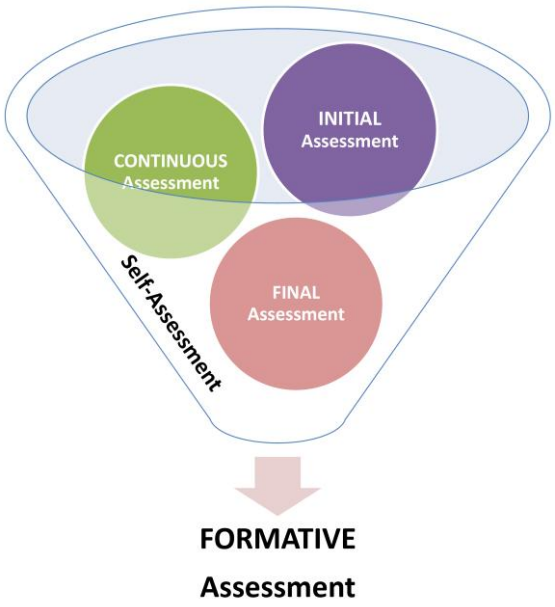

Figure 1. Formative evaluation phases and their relationship. Adapted from Álvarez Teruel and Vega Morales, 2010.

In the particular case of Physical Chemistry, we have recently proposed a new evaluation model with the learning portfolio as working tool (Monllor-Satoca et al., 2012). Each student is continuously assessed, not only from a grading perspective, but also from a formative point of view, i.e. with an explicit indication of the level achieved for each

competence. The level is chosen on the basis of the Spanish National Institute for Qualification (INCUAL), which states that a professional qualification is *"a set of professional competences with a sound meaning in the employment […]"*, and *"a person is qualified when during his/her working performance obtains the expected results by means of the appropriate resources and quality level"* (Arbizu Echávarri and Arias Fernández, 2006). In this sense, qualification is certified through 5 competency levels, being 1 the lowest and 5 the highest. At the end of the assessment, an individual competence report is generated where each student is given his/her competency levels, complementing the final (summative) grade.

In this work, we extend this recent proposal for specific Physical Chemistry subjects (Monllor-Satoca et al., 2012) to the whole area, as a way to provide a more comprehensive and holistic view of competence acquisition in terms of an *Area Portfolio* within a university grade (Grade of Chemistry; Facultad de Ciencias, 2009). This new portfolio concept represents a multi-level and coordinated assessment procedure (i.e., ranging from the class group to the grade and/or academic course) that provides useful information for both students and teachers. It would also be useful for prospective employers as well as for the fulfillment of requirements for accessing postgraduate education (Figure 2).

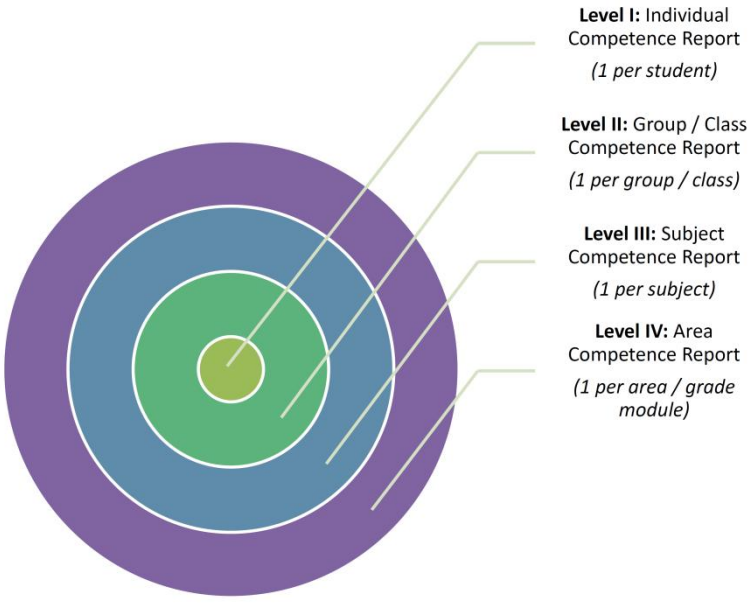

Figure 2. Multi-level competence reports in a portfolio-based assessment, ranging from individual reports (Level I) to the whole area report (Level IV) in a particular grade.

2. DEVELOPMENT OF THE RAISED QUESTION

The aim of this work is two-fold: on the one hand, to propose a portfolio-based assessment within the Physical Chemistry area subjects that reflects the competences acquisition on the basis of a previous proposal (Monllor-Satoca et al., 2012), and on the other, to bring a stepwise protocol to estimate the global competence levels in terms of class group, subject, grade and academic course. The competence reports would be based on a pre-assigned five acquisition level (1 being the lowest and 5 the highest) inspired on the Spanish National Institute of Qualifications (INCUAL). These reports would allow a transversal evaluation of competences from the Physical Chemistry area (subjects) in the Grade of Chemistry (Facultad de Ciencias, 2009).

To implement the proposal, we should first define the different levels of the competence reports, following a bottom-up approach (Figures 2 and 3): individual reports (level I), class / group reports (level II), subject reports (level III) and area reports (level IV). Each level has a set of features that define both the contents and stages at which each report should be prepared:

1. Level I (Individual): requires all students´ teaching portfolios, obtained during the course with a detailed assessment of all the subject competences (Annexes 1 and 2). These reports are prepared during and at the end of the course, and constitute the basis for elaborating further level reports. They should also be used at the beginning of a subsequent course/subject. In terms of formative assessment, this level corresponds both to the initial and self-assessment phases.
2. Level II (Class / Group): requires the competence averages taken from the students´ reports (level I). It is prepared during and at the end of the course, and corresponds to the continuous phase of the formative assessment.
3. Level III (Subject, Annex 3): requires the competences weighted averages of each class / group reports (level II). All averages should take into account the credits of each subject. It is prepared at the end of the course, and together with level II report belongs to the continuous phase of the formative assessment.
4. Level IV (Area, Annex 4): requires the competences weighted averages of each area subject (level III). Although it could be prepared at the end of the course, it is advisable to prepare it at the beginning of a new course once the department teaching

scheme (POD, "*Plan de Organización Docente*") is agreed as a starting point for teachers. Corresponds to the final phase of the formative assessment.

Competences averages could be taken as the median among all levels instead of the arithmetic average, as the latter does not reflect the formative character of the tool but turns the report into another summative instrument. The proposed multi-level protocol requires to allocate some additional teaching resources to be implemented, mainly the use of teaching assistants in some assessment stages (Monllor-Satoca et al., 2012), as well as an electronic platform and/or software to prepare the reports and properly inform students of their competence acquisition evolution.

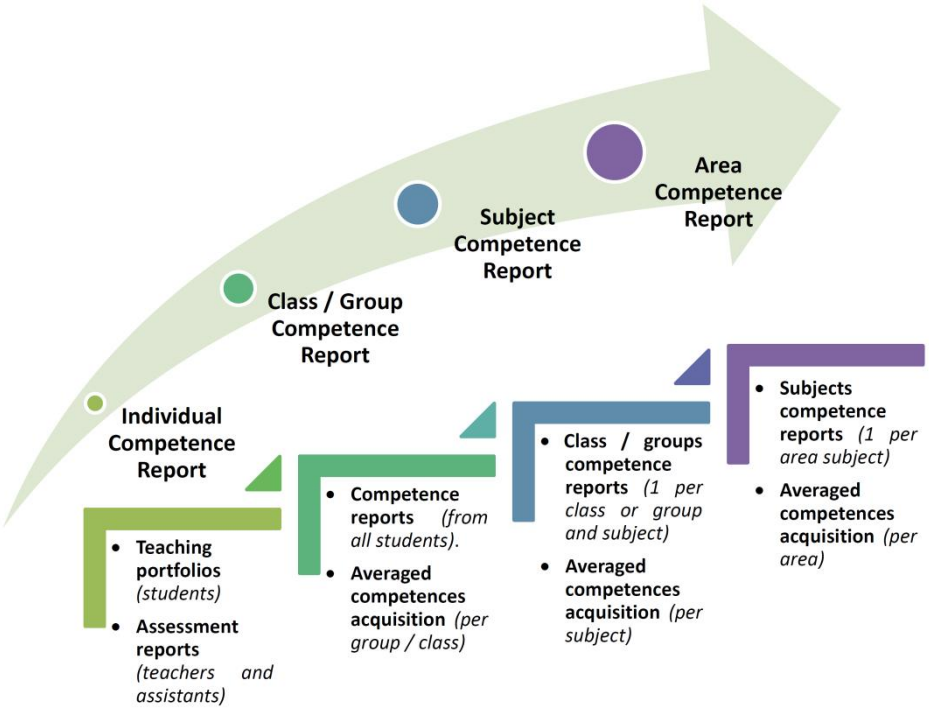

Figure 3. Types of competence reports and the elements required for preparing them. Each "level" feeds from previous ones.

This assessment procedure has some advantages, including:

- Competences are assessed in terms of pre-fixed and known quality standards (formative) and not with a unique grading mark (summative), which is a more realistic approach within the new EHEA framework.

- Multi-level comparison allows for both a continuous and final competence track within a (single) knowledge area, bringing an excellent decision-taking tool for continuous improvement of the teaching-learning process.
- Reports are scalable to larger levels, including other modules, departments, grade, faculties and knowledge areas.
- Quality standards could be externally set and informed for admission in postgraduate studies or to employers on the basis of particular competence levels, beyond grading marks.

On the contrary, as disadvantages the proposal includes:

- It requires the coordination of many area teachers. In some particular cases, it is not possible or causes rejection. To overcome such a limitation, the department teaching organization scheme (POD) should be revised accordingly.
- The assessment methodology requires a normalization process among teachers, so that all gathered information is relevant and significant for the final report. This process requires a lot of effort and preparation time for settling common evaluation criteria.
- The time for obtaining a final competency report might be perceived as too long in comparison with the grading process, which could discourage department teachers. To get over this, a new teaching-learning culture based on excellence should be sought at all (administration) levels.
- Reports can be misused as comparison tools between courses, subjects or departments within a particular grade, which could be misinterpreted as a ranking system among a single area department, or even beyond. Emphasis should be taken on encouraging its use only as a tool for internal continuous improvement, instead.

3. CONCLUSIONS

Competences assessment through teaching portfolios is revisited as a multi-level tool that yields different reports gathering the acquisition level (from 1 to 5, where 1 is the lowest level) for each competency. Reports reach different scopes, range from the individual (level I), to the class / group (level II), subject (level III) and knowledge area (level IV); each report level averages competences from previous levels. All reports can be envisaged as part of a formative assessment process, including an initial (level I), continuous (levels II and III) and

final phase (level IV). The proposed scheme can be exported to larger scenarios, including other areas / departments, the whole grade and/or faculty. Reports can be used both as an improvement tool for students and teachers, emphasizing which competences seem more difficult to acquire and should be revised in forthcoming courses. In addition, reports perfectly complement classical grading marks and can be used as quality indicators for prospective postgraduate studies entrance or graduate employment. However, its full implementation requires a set of changes on the department teaching scheme, including a larger coordination among teachers, as well as the help of teaching assistants and a unified electronic platform for preparing and delivering the reports.

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ANNEX 1. PHYSICAL CHEMISTRY COMPETENCES IN THE GRADE OF CHEMISTRY

Degree generic competences (GC)

GC01: To develop analytical, synthetic and critical reasoning capacities.
GC02: To be able to manage/direct in an efficient and effective way, showing entrepreneurship, initiative, creativity, organization, planning, control, decision making and negotiation skills.
GC03: To solve problems in an effective way.
GC04: To show teamwork ability.
GC05: To commit oneself with the ethics and social responsibility as both a citizen and a professional.
GC06: To learn independently.
GC07: To show the ability to adapt to new situations.
GC08: To acquire a permanent concern with the environmental quality and working risks prevention.
GC09: To be able to convey information, ideas, problems and solutions to both a specialized and non-specialized audience.

Universidad de Alicante generic competences (GCUA)

GCUA01: To understand scientific information written in English.
GCUA02: To express in both oral and written contexts using any of the official languages in Comunidad Valenciana.
GCUA03: To have ICT (Information and Communication Technologies) knowledge related with the study area.
GCUA04: To acquire or possess the basic ICT skills and properly manage the obtained information.

Knowledge specific competences (SC)

SC01: To acquire foundations of chemical terminology, nomenclature, conventions and units.
SC03: To identify the properties of different states of matter and the theories to describe them.
SC04: To know the main types or chemical reactions and their principal properties.
SC06: To know the main principles and chemical applications of thermodynamics.
SC07: To know the chemical kinetics laws and their applications, including catalysis and reaction mechanisms.
SC11: To know the electrochemistry principles and their applications.
SC13: To know the principles of quantum mechanics and their application to the description of the structure and properties of atoms and molecules.
SC14: To acquire the basis of the radiation-matter interaction, spectroscopy principles and the main techniques of structural investigation.
SC18: To correlate macroscopic properties with those of their constituent individual atoms and molecules, including macromolecules (natural and synthetic), polymers, colloids and other materials.

Skillfulness specific competences (SC)

SC24: To show understanding of the essential facts, concepts, principles and theories related with the different Chemistry areas.
SC25: To solve qualitative and quantitative problems according to previously developed models.
SC26: To recognize and analyze new problems and plan strategies to solve them.
SC27: To interpret, evaluate and condense chemical data and information.
SC28: To recognize and implement good scientific measurement and experimentation practices.
SC29: To process and compute data related with chemical information.
SC30: To handle reactants, instruments and devices used in Chemistry sciences.
SC32: To use standard chemical instrumentation to identify, quantify, separate and determine chemical structures.
SC33: To monitor by means of observation and measurement of chemical properties, events or changes, compiling the suitable information.
SC35: To interpret all data coming from observations and measurements in the lab.
SC36: To prepare, show and defend scientific reports both in written and oral formats and in front of an audience.
SC37: To evaluate the risks stemming from using chemicals and lab procedures, managing all generated wastes in a proper way.
SC38: To properly use the inductive and deductive methods applied to Chemical sciences.
SC39: To recognize and assess chemical processes in daily life.
SC40: To relate Chemistry with other disciplines.

ANNEX 2. COMPETENCES DISTRIBUTION IN FORMATIVE MODULES AND SUBJECTS OF THE PHYSICAL CHEMISTRY AREA (GRADE IN CHEMISTRY)

Module	Subject	ECTS credits	Competences	
			Generic	Specific
Basic	Chemistry I (CI)	6	GC03, GC04, GC08, GCUA02	SC01, SC04, SC06, SC07, SC25, SC28, SC30, SC37
	Basic Laboratory Procedures I (BLPI)	6	GC01, GC04, GC08, GCUA02, GCUA03, GCUA04	SC27, SC28, SC29, SC30, SC35, SC36, SC37
Fundamental	Chemical Thermodynamics (CT)	6	GC01, GC02, GC03, GC04, GC05, GC06, GC07, GC08, GC09, GCUA02, GCUA04	SC06, SC11, SC24, SC25, SC26, SC27, SC28, SC29, SC30, SC32, SC33, SC35, SC36, SC39, SC40
	Quantum Chemistry and Spectroscopy (QCS)	9	GC01, GC02, GC03, GC04, GC05, GC06, GC07, GC08, GC09, GCUA02, GCUA03	SC13, SC14, SC24, SC25, SC26, SC27, SC29
	Chemical Kinetics (CK)	6	GC01, GC02, GC03, GC04, GC05, GC06, GC07, GC08, GC09, GCUA02, GCUA04	SC07, SC11, SC24, SC25, SC26, SC27, SC29, SC30, SC32, SC33, SC35, SC36, SC38, SC39, SC40
	Advanced Physical Chemistry (APC)	6	GC01, GC02, GC03, GC04, GC05, GC06, GC07, GC08, GC09, GCUA02	SC03, SC06, SC07, SC18, SC24, SC25, SC26, SC27, SC29, SC30, SC32, SC33, SC35, SC36, SC38, SC39, SC40
Advanced	Electrochemistry and Sustained Development (ESD)	6	GC01, GC02, GC03, GC04, GC06, GC07, GC09, GCUA01	SC11, SC27, SC28, SC29, SC30, SC33, SC35
	Computational Chemistry (CC)	6	GC01, GC02, GC03, GC04, GC06, GC07, GC09, GCUA01, GCUA03, GCUA04	SC13, SC14, SC18, SC27, SC29

ANNEX 3. COMPETENCE WEIGHTING IN THE PHYSICAL CHEMISTRY SUBJECTS OF THE FUNDAMENTAL MODULE (GRADE IN CHEMISTRY)

Competences		Weight (%)			
		CT (6 ECTS)	QCS (9 ECTS)	CK (6 ECTS)	APC (6 ECTS)
Generic	GC01	22 %	34 %	22 %	22 %
	GC02	22 %	34 %	22 %	22 %
	GC03	22 %	34 %	22 %	22 %
	GC04	22 %	34 %	22 %	22 %
	GC05	22 %	34 %	22 %	22 %
	GC06	22 %	34 %	22 %	22 %
	GC07	22 %	34 %	22 %	22 %
	GC08	22 %	34 %	22 %	22 %
	GC09	22 %	34 %	22 %	22 %
	GCUA02	22 %	34 %	22 %	22 %
	GCUA03		100 %		
	GCUA04	50 %		50 %	
Specific	SC03				100 %
	SC06	50 %			50 %
	SC07			50 %	50 %
	SC11	50 %		50 %	
	SC13		100 %		
	SC14		100 %		
	SC18				100 %
	SC24	22 %	34 %	22 %	22 %
	SC25	22 %	34 %	22 %	22 %
	SC26	22 %	34 %	22 %	22 %
	SC27	22 %	34 %	22 %	22 %
	SC28	100 %			
	SC29	22 %	34 %	22 %	22 %
	SC30	33 %		33 %	33 %
	SC32	33 %		33 %	33 %
	SC33	33 %		33 %	33 %
	SC35	33 %		33 %	33 %
	SC36	33 %		33 %	33 %
	SC38			50 %	50 %
	SC39	33 %		33 %	33 %
	SC40	33 %		33 %	33 %

ANNEX 4. SAMPLE OF PHYSICAL CHEMISTRY AREA COMPETENCY REPORT (FUNDAMENTAL MODULE) PER ACADEMIC COURSE*

Competences	Subjects Levels												Area Levels
	CT			QCS			CK			APC			
	G1	G2	Av.	G1	G2	Av.	G1	G2	Av.	G1	G2	Av.	
GC01													
GC02													
GC03													
GC04													
GC05													
GC06													
GC07													
GC08													
GC09													
GCUA02													
GCUA03													
GCUA04													
SC03													
SC06													
SC07													
SC11													
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SC29													
SC30													
SC32													
SC33													
SC35													
SC36													
SC38													
SC39													
SC40													
GLOBAL													

* *G1* and *G2* stand for the average competency levels for groups/classes 1 and 2; *Av.* stands for the averaged group/class competency level. Shaded (grey) cells refer to non-evaluated competences in a particular subject.