Tuning

Latin America

Higher Education in Latin America: reflections and perspectives on **Chemistry**

Gustavo Pedraza Aboytes (ed.)

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Tuning Latin America Project

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Gustavo Pedraza Aboytes (editor)

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Tuning: past, present and future
An introduction

Major changes have taken place worldwide in higher education over the last 10 years, although this has been a period of intense reflection particularly for Latin America, insofar as the strengthening of existing bonds between nations has been promoted and the region has started to be considered as being increasingly close. These last 10 years also represent the transition time between Tuning starting out as an initiative that arose as a response to European needs and going on to become a worldwide proposal. Tuning Latin America marks the start of the Tuning internationalisation process. The concern with thinking how to progress towards a shared area for universities while respecting traditions and diversity ceased to be an exclusive concern for Europeans and has become a global need.

It is important to provide the reader of this work with some definitions of Tuning. Firstly, we can say that Tuning is **a network of learning communities**. Tuning may be understood as being a network of inter-connected academic and student communities that reflects on issues, engages in debate, designs instruments and compares results. They are experts that have been brought together around a discipline within a spirit of mutual trust. They work in international and intercultural groups and are totally respectful of independence on an institutional, national and regional level, exchanging knowledge and experiences. They develop a common language to problems in higher education to be understood and take part in designing a set of tools that are useful for their work, and which have been devised and produced by other academics. They are able to take part in a platform for reflection and action about higher education - a platform made up of hundreds of communities from different countries. They are responsible for developing reference points for disciplines that represent a system for designing top quality qualifications which are shared by many. They are open to the possibility of creating networks with many regions of the world within their own field and feel that they are responsible for this task.

Tuning is built on each person that forms part of that community and shares ideas, initiatives and doubts. It is global because it has pursued an approach based on worldwide standards while at the same time remaining both local and regional, respecting the specific features and demands of each context. The recent publication: *Communities of Learning: Networks and the Shaping of Intellectual Identity in Europe, 1100-1500* (Crossley Encanto, 2011) takes all the new ideas into consideration which are developed within a community context, whether of an academic, social or religious nature or simply as a network of friends. The challenge facing Tuning communities is to gain an impact on the development of higher education in its regions. Secondly, Tuning is a **methodology** with well-designed steps and a dynamic outlook that enables different contexts to be adapted. The methodology has a clear aim: to build qualifications which are compatible, comparable, are relevant to society and with top levels of both quality and excellence, while preserving the valuable diversity deriving from the traditions of each country involved. These requirements demand a collaborative methodology based on consensus which is developed by experts from different fields who are representatives of their disciplines, and who have the ability to understand local, national and regional situations.

This methodology has been developed around **three core themes**: the first is the **qualification profile**, the second is the **syllabus** and the third refers to the **trajectories of those who learn**.

The qualification profile enjoys a key position in Tuning. After a lengthy period of reflection and debate within Tuning projects in different regions (Latin America, Africa, Russia), the qualifications profile may be defined as being a combination of forces revolving around four core points:

- The region's needs (from local issues to the international context).
- The meta-profile of the area.

- The taking into consideration of future trends in the profession and society.

- The specific mission of the university.

The question of **social relevance** is essential for the design of profiles. Without doubt, any analysis of the relationship existing between university and society lies at the heart of the matter of relevance in higher education. Tuning's aim is to identify and meet the needs of the production sector, the economy, society as a whole and the needs of each student within a particular area of study – measured by specific social and cultural contexts. With a view to achieving a balance between these different needs, goals and aspirations, Tuning has consulted leading people, key local thinkers and experts from industry, both learned and civil society and working parties that include all those interested. An initial period of this phase of the methodology is linked to general competences. Each thematic area involves the preparation of a list of general competences deemed relevant from the standpoint of the region concerned. This task ends when the group has widely discussed and reached consensus about a selection of specific competences, and the task is also performed with specific competences. Once the means of consultation has been agreed and the process completed, the final stage in this practical exercise involving the search for social relevance refers to an analysis of results. This is done jointly by the group, and special care is taken not to lose any contributions from the different cultural perceptions that might illustrate understanding of the specific reality.

Once lists of the general and specific agreed, consulted and analysed competences had been obtained, a new phase got underway over these last two years that is related to the **development of meta-profiles for the area** under consideration. For Tuning methodology, meta-profiles represent the structures of the areas and combinations of competences (general and specific) that lend identity to the disciplinary area concerned. Meta-profiles are mental constructions that categorise competences in recognisable components and illustrate their inter-relations.

Furthermore, thinking about education means becoming involved in the present, while above all also looking towards the future – thinking about social needs, and anticipating political, economic and cultural changes. This means also taking into account and trying to foresee the challenges that those future professionals will have to face and the impact that certain profiles of qualifications is likely to have, as designing profiles is basically an exercise that involves looking to the future. Within the present context, designing degree courses takes time in order for them to be planned and developed and their approval obtained. Students need years to achieve results and mature in terms of their learning. Then, once they have finished their degree, they will need to serve, be prepared to act, innovate and transform future societies in which they will find new challenges. Qualification profiles will in turn need to look more to the future than the present. For this reason, it is important to take an element into consideration that should always be taken into account, which are future trends both in terms of the specific field and society in general. This is a sign of quality in design. Tuning Latin America embarked on a methodology so as to incorporate an **analysis of future trends into the design of profiles**. The first step therefore involved the search for a methodology to devise future scenarios following an analysis of the most relevant studies in education by focusing on the changing role of higher educational establishments and trends in educational policies. A methodology was chosen based on in-depth interviews with a dual focus: on the one hand, there were questions that led to the construction of future scenarios on a general society level, their changes and impact. This part needed to serve as a basis for the second part, which dealt specifically with the features of the area in itself, their transformation in general terms in addition to any possible changes in the degree courses themselves that might have tended to disappear, re-emerge or be transformed. The final part sought to anticipate the possible impact on competences based on present coordinates and the driving forces behind change.

There is a final element that has to be taken into account when constructing the profiles, which is linked to the **relationship with the university where the qualification is taught**. The mark and mission of the university must be reflected in the profile of the qualification that is being designed.

The second core theme of the methodology is linked to **syllabuses**, and this is where two very important Tuning components come into play: on the one hand, students' work volume, which has been reflected in an agreement to establish the Latin American Reference Credit (CLAR), and all studies are based on this and, on the other, the intense reflection process into how to learn, teach and assess competences. Both aspects have been covered in Tuning Latin America.

Lastly, an important area is opened up for future reflection about the **trajectories of those who learn** – a system that proposes focusing on the student leads one to consider how to position oneself from that standpoint so as to be able to interpret and improve the reality in which we find ourselves.

Finally, Tuning is a **project** and as such came into existence with a set of objectives and results and within a particular context. It arose from the needs of the Europe of 1999, and as a result of the challenge laid down by the 1999 Bologna Declaration. Since 2003, Tuning has become a project that goes beyond European borders, in so doing embarking on intense work in Latin America. Two very specific problems faced by the university as a global entity were pinpointed: on the one hand, the need to modernise, reformulate and make syllabuses more flexible in the light of new trends, society's requirements and changing results in a vertiginous world and, on the other, which is linked closely to the first problem, the importance of transcending limits imposed by staff in terms of learning, by providing training that would enable what has been learnt to be recognised beyond institutional local, national and regional borders. The Tuning Latin America project thus emerged which, in its first phase (2004-2007), sought to engage in a debate whose goal was to identify and exchange information and improve collaboration between higher educational establishments, with a view to developing the quality, effectiveness and transparency of qualifications and syllabuses.

This new phase of **Tuning Latin America (2011-2013)** started life on already-fertile terrain – the fruits of the previous phase and in view of the current demand on the part of Latin American universities and governments to facilitate the continuation of the process that had already been embarked on. The aim of the new Tuning phase in the region was to help build a Higher Education Area in Latin America. This challenge takes the form of four very specific central working themes: a deeper understanding of agreements involving **designing meta-profiles and profiles in the 15 thematic areas** included in the project (Administration, Agronomy, Architecture, Law, Education, Nursing, Physics, Geology, History, Information Technology, Civil Engineering, Mathematics, Medicine, Psychology and Chemistry); contributing to **reflections on future scenarios for new professions**; promoting the joint construction of **methodological strategies in order to develop and assess the training of competences**; and designing **a system of academic reference credits (CLAR-Latin American Reference Credit)** to facilitate recognition of studies in Latin America as a region that can be articulated with systems from other regions.

The Tuning door to the world was Latin America, although this internationalisation of the process wouldn't have gone far if it hadn't been for a group of prestigious academics (230 representatives of Latin American universities), who not only believed in the project, but also used their time and creativity to make it possible from north to south and west to east across the extensive, diverse continent that is Latin America. This was a group of experts in different thematic areas that would go on to study in depth and gain weight in terms of their scope and educational force, and in their commitment to a joint task that history had placed in their hands. Their ideas, experiences and determination paved the way and enabled the results which are embodied in this publication to be achieved.

Yet the Tuning Latin America project was also designed, coordinated and administered by Latin Americans from the region itself, via the committed work carried out by Maida Marty Maleta, Margarethe Macke and Paulina Sierra. This also established a type of *modus operandi*, conduct, appropriation of the idea and of deep respect for how this was going to take shape in the region. When other regions decided to join Tuning, there would henceforth be a local team that would be responsible for considering what to emphasize - specific features, the new elements that would need to be created to meet needs which, even though many of them might have common characteristics within a globalised world, involve dimensions specific to the region, are worthy of major respect and are, in many cases, of major scope and importance.

There is another pillar on this path which should be mentioned: the coordinators of the thematic areas (César Esquetini Cáceres-Coordinator of the Area of Administration; Jovita Antonieta Miranda Barrios-Coordinator of the Area of Agronomy; Samuel Ricardo Vélez González-Coordinator of the Area of Architecture; Loussia Musse Felix-Coordinator of the Area of Law; Ana María Montaño López-Coordinator of the Area of Education; Luz Angélica Muñoz González-Coordinator of the Area of Nursing; Armando Fernández Guillermet-Coordinator of the Area of Physics; Iván Soto-Coordinator of the

Area of Geology; Darío Campos Rodríguez-Coordinator of the Area of History; José Lino Contreras Véliz-Coordinator of the Area of Information Technology; Alba Maritza Guerrero Spínola-Coordinator of the Area of Civil Engineering; María José Arroyo Paniagua-Coordinator of the Area of Mathematics; Christel Hanne-Coordinator of the Area of Medicine; Diego Efrén Rodríguez Cárdenas-Coordinator of the Area of Psychology; and Gustavo Pedraza Aboytes-Coordinator of the Area of Chemistry). These academics, chosen according to the thematic groups to which they belonged, were the driving forces behind the building of bridges and strengthening of links between the project's Management Committee of which they formed a part and their thematic groups which they always held in high regard, respected and felt proud to represent. Likewise, they enabled there to be valuable articulation between the different areas, showing great ability to admire and listen to the specific elements attached to each discipline in order to incorporate, take on board, learn and develop each contribution – the bridges between the dream and the reality. Because they had to carve new paths in many cases to make the ideas possible, design new approaches in the actual language of the area and the considerations proposed, and to ensure that the group would think about them from the standpoint of the specific nature of each discipline. Following group construction, the process always requires a solid framework based on generosity and rigour. In this respect, the coordinators were able to ensure that the project would achieve specific successful results.

Apart from the contribution made by the 15 thematic areas, Tuning Latin America has also been accompanied by a further two transversal groups: the Social Innovation group (coordinated by Aurelio Villa) and the 18 National Tuning Centres. The former created new dimensions that enabled debates to be enriched and an area for future reflection on thematic areas to be opened up. Without doubt, this new area of work will give rise to innovative perspectives to enable those involved to continue thinking about top quality higher education that is connected to the social needs of any given context.

The second transversal group about which one should recognise the major role played comprises the National Tuning Centres – an area of representatives from the highest authorities of university policies from each of the 18 countries in the region. These centres accompanied the project right from the outset, supported and opened up the reality of their national contexts to the needs or possibilities developed by Tuning, understood them, engaged in dialogue with others, disseminated them and constituted reference points when seeking genuine anchors and possible goals. The National Centres have been a contribution from Latin America to the Tuning project, insofar as they have contextualised debates by assuming and adapting the results to local times and needs.

We find ourselves coming to the end of a phase of intense work. The results envisaged over the course of the project have succeeded all expectations. The fruits of this effort and commitment take the form of the reflections on the area of Chemistry that will be provided below. This process comes to an end in view of the challenge faced in continuing to make our educational structures more dynamic, encouraging mobility and meeting points within Latin America, while at the same time building the bridges required with other regions on the planet.

This is the challenge facing Tuning in Latin America.

July 2013

Pablo Beneitone, Julia González and *Robert Wagenaar*

1

Introduction

The subject area of chemistry in the Tuning Latin America project, *Educational and Social Innovation*, emerged in the first phase of Tuning Latin America, a project whose main objective was to define both the generic competences that all professionals graduating from higher educational institutions (HEIs) in Latin America must have, and the competences specific to each of the participant subject areas, in this case, the area of chemistry.

In the second phase of the project, four general meetings of all the participant thematic areas were held between 2011 and 2012, and in 2013 a meeting was held by the chemistry group in order to carry out a final review of the document and reflect upon the project's guidelines and our conclusions. At this meeting, in addition to the final review of the documents, a presentation was made to the teaching staff and senior management at the Pontificia Universidad Católica de Perú (PUCP) and a letter of intent was signed by the area members to create the «TUNING LATIN AMERICA CHEMISTRY NETWORK» (REQUITUAL), an academic and scientific collaborative network nurturing student mobility and intercultural and scientific exchange among institutions in the participant countries. The universities making up the Tuning LA Project in the area of chemistry will initially participate, but the network will be open to any other Latin American institution related to chemistry.

In this second phase of the project, a meta-profile was defined for the area of chemistry on the basis of generic and specific competences, so that the core themes of the curriculum could be defined. The meta profile can be applied to any professional career in order to help determine students' graduation profiles. In addition, experts in chemistry education from the participant countries were interviewed and asked to reflect on future scenarios which might alter and/or modify current professions, or generate new professions whose graduates will be able to rise to the new challenges posed by technological advances and globalisation, within an ethical and sustainable framework.

The chemistry group wishes to thank the representatives who participated in the first phase of the project, who offered interesting contributions to the definition of generic and specific competences which have been used as input for this phase of the project. We would also like to express our thanks and appreciation to the rectors and/or senior management of our Latin American HEIs for the unconditional support which allowed each institution's representatives to devote sufficient time to the group's working meetings and additional tasks undertaken in their workplaces in order to complete this publication.

2

Graduate meta-profile for a chemistry programme

One of the problems associated with defining a graduate profile in the majority of chemistry programmes at different HEIs in Latin America is that it is defined at a desk or at teaching staff meetings that involve plays on words and verbs which, more often than not, fail to define the desired profile clearly and, in a worst-case scenario, produces a profile that bears little relationship to curriculum policies, and even less to the thematic content of the subjects taught to students. Therefore, the intention of this work is to develop a methodology which can be used to provide a clearer definition of a chemistry degree graduate profile in Latin America.

2.1. Definition of the meta-profile

The term «meta-profile» in this work refers to the graduate profile that can be applied to any chemistry programme in any Latin American institution. When referring to the «graduate profile», we are referring to the professional profile of the chemistry programme of a particular institution.

On this basis, the meta-profile in the area of chemistry was defined as: *«the description of a professional graduating from a general chemistry programme in which the generic and specific competences characterising chemistry curricula in the Latin American region are clearly evident»,* taking into account factors such as scientific and economic development and globalisation; generating specialised knowledge with a regional, national and international focus; innovation and competitiveness in teaching, research and the economic and productive sectors; implementing new abilities and capacities based on the new challenges posed by technological advances and the changing environment, caring for the environment and with clearly defined social values, all of which must be carried out in a sustainable and ethical way.

The meta-profile for chemistry was obtained by reviewing the generic and specific competences classified in the first phase of the Tuning LA project. Thorough analysis was conducted into the specific competences, comparing them with Chemistry, Chemistry and Pharmacy, Food Chemistry and Industrial Chemistry, which are the most common programmes at the universities taking part in the project. Having compared the specific competences, the meta-profile was determined and once the methodology had concluded, it was compared with the profile of chemistry graduates from several universities in Latin America.

2.2. Review of generic competences and their classification according to factors

The redundancy and relevance of the agreed generic competences were reviewed first, based on the Tuning Latin America project's final document: *Reflections and Perspectives on Higher Education in Latin America* (2007). Of the 27 competences put forward, it was considered that several were repeated or included in the specific competences. After thorough analysis, the number was reduced to 19 generic competences, which were grouped into four factors associated with the teaching-learning process: learning process, social values, technological and international context, and interpersonal skills. Each factor was defined as shown below.

- *Factor 1: learning process.* Comprises the nature and properties of atoms and molecules, laws and regularities governing the interaction between them that causes chemical reactions and other interesting phenomena.

  Uses knowledge of chemistry to analyse, design, synthesise, characterise and mix chemical compounds for scientific or industrial uses.

- *Factor 2: social values.* Performs work showing a capacity for collaboration and independent and effective performance, with appropriate ethical practice. Shows a commitment to the better use and rational exploitation of renewable and non-renewable natural resources for the benefit of mankind.

- *Factor 3: technological and international context.* Speaks other languages and uses different information technologies to take full advantage of the possibilities and benefits available on an international level.

- *Factor 4: interpersonal skills.* Has comprehensive training, which enables them to take decisions, perform independently and work in an interdisciplinary and transdisciplinary way with regard to chemistry. They plan work both individually and in teams, and deal with new situations.

2.3. Generic competences

The generic competences were grouped into the four factors as follows, where the abilities are defined which a graduate from a programme relating to chemistry must demonstrate:

- *Factor 1: learning process [knowledge]:*

  1G. Capacity for abstraction, analysis and synthesis.

  2G. Ability to learn and keep up-to-date.

  3G. Critical and self-critical capacity.

  4G. Ability to search for, process and analyse information.

  5G. Capacity for oral and written communication.

- *Factor 2: social values [savoir-faire]:*

  6G. Commitment to their social and cultural environment.

  7G. Appreciation and respect for diversity and multiculturalism.

  8G. Social responsibility and citizenship.

  9G. Commitment to conservation of the environment.

  10G. Ethical commitment.

- *Factor 3: technological and international context [know-how]:*

  11G. Ability to communicate in a second language.

  12G. Ability to work within international contexts.

  13G. Skills in the use of ICTs.

- *Factor 4: interpersonal skills [savoir-faire and know-how]:*

  14G. Capacity for decision-making.

  15G. Interpersonal skills.

  16G. Ability to motivate and steer towards common objectives.

  17G. Capacity for teamwork.

  18G. Ability to organise and plan time.

  19G. Ability to act in new situations.

2.4. Specific competences

Similarly, an analysis and discussion was conducted on the specific competences defined in the first Tuning Latin America[1] project (2007). The 21 specific competences initially put forward were reduced to 16, since five were already included in the generic competences, reading as follows.

The graduate of a programme relating to chemistry must demonstrate:

- 1S. Ability to apply knowledge and understanding of chemistry to solve qualitative and quantitative problems.
- 2S. Ability to understand the fundamental concepts, principles and theories in the area of chemistry.
- 3S. Ability to interpret and assess data deriving from observations and measurements by relating them to theory.

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1 *Ibid.*

- 4S. Ability to acknowledge and analyse problems and plan strategies for their solution.

- 5S. Ability to develop, use and apply analytical techniques.

- 6S. Ability to keep up-to-date with regard to the development of chemistry.

- 7S. Ability to plan, design and execute research projects.

- 8S. Command of chemical and scientific terminology, conventions and units.

- 9S. Knowledge of the main synthetic routes in chemistry.

- 10S. Knowledge of other scientific disciplines which enable an understanding to be gained in chemistry.

- 11S. Ability to monitor, by means of the measurement and observation of chemical properties, events or changes and their systematic and reliable compilation and documentation.

- 12S. Command of Good Laboratory Practice.

- 13S. Ability to act with curiosity, initiative and entrepreneurship.

- 14S. Knowledge, application and judgement of the legal framework in the field of chemistry.

- 15S. Ability to apply knowledge of chemistry to sustainable development.

- 16S. Understanding the epistemology of science.

Once the generic and specific competences for the area of chemistry had been reviewed and classified, they were grouped together with a view to building the META-PROFILE. In order to do so, the following tables were compiled showing the combined knowledge the student should acquire for each of the defined factors, and the generic and specific competences and abilities deemed necessary to cover such knowledge.

2.5. Classification of specific competences according to their relationship with the generic competences associated with each factor

Knowledge	Generic competences	Specific competences
Factor 1: learning process		
Comprises the nature and properties of atoms and molecules, laws and regularities governing the interaction between them that causes chemical reactions and other Interesting phenomena. Applies knowledge in chemistry to analyse, design, synthesise, characterise and mix chemical compounds for scientific or industrial use.	1G. Capacity for abstraction and synthesis. 2G. Ability to learn and keep up-to-date 3G. Critical and self-critical capacity. 4G. Ability to search for, process and analyse information. 5G. Capacity for oral and written communication.	1S. Ability to apply knowledge and understanding of chemistry to solve qualitative and quantitative problems. 2S.Ability to understand the fundamental concepts, principles and theories of chemistry. 3S. Ability to interpret and assess data deriving from observations and measurements by relating them to the theory. 4S. Ability to acknowledge and analyse problems and plan strategies for their solution. 5S. Ability to develop, use and apply analytical techniques. 6S. Ability to keep up-to-date with regard to the development of chemistry. 7S. Ability to plan, design and execute research projects. 8S. Command of chemical and nomenclatural terminology, conventions and units. 9S. Knowledge of the main synthetic routes in chemistry. 10S. Knowledge of other scientific disciplines which enable an understanding to be gained in chemistry. 11S. Ability to monitor, by means of the measurement and observation of chemical properties, events or changes and their systematic and reliable compilation and documentation. 12S. Command of Good Laboratory Practice. 13S. Ability to act with curiosity, initiative and entrepreneurship. 16S. Understanding the epistemology of science.

Knowledge	Generic competences	Specific competences
Factor 2: social values		
Performs work showing a capacity for cohabitation and independent and effective performance, as well as the ethical practice of their expertise. Shows a commitment to the better use and rational exploitation of renewable and non-renewable natural resources for the benefit of man.	6G.Commitment to their social and cultural environment. 7G. Appreciation and respect for diversity and multiculturalism. 8G. Social responsibility and citizenship. 9G. Commitment to conservation of the environment. 10G. Ethical commitment.	13S. Ability to act with curiosity, initiative and entrepreneurship. 14S. Knowledge, application and judgement of the legal framework in the field of chemistry. 15S. Ability to apply knowledge of chemistry to sustainable development.
Factor 3: technological and international context		
Speaks other languages and uses different information technologies to take full advantage of the possibilities and benefits available on an international level.	11G. Ability to communicate in a second language. 12G. Ability to work within international contexts. 13G.Skills in the use of ICTs.	7S. Ability to plan, design and execute research projects. 12S. Command of Good Laboratory Practice. 13S. Ability to act with curiosity, initiative and entrepreneurship. 14S. Knowledge, application and advice on the legal framework in the field of chemistry. 15S. Ability to apply knowledge of chemistry to sustainable development.
Factor 4: interpersonal skills		
Has comprehensive training, which enables them to take decisions, perform independently and work in an interdisciplinary and transdisciplinary way with regard to chemistry. Plans work both individually and in teams, and deals with new situations.	14G. Capacity for decision-making. 15G. Interpersonal skills. 16G. Ability to motivate and steer towards common objectives. 17G. Capacity for teamwork. 18G. Ability to organise and plan time. 19G. Ability to act in new situations.	4S. Ability to acknowledge and analyse problems and plan strategies for their solution. 7S. Ability to plan, design and execute research projects. 12S. Command of good laboratory practice. 13S. Ability to act with curiosity, initiative and entrepreneurship.

Having carried out this classification, the specific competences in each of the four degree programmes initially put forward were then analysed, assuming that that all of the generic competences would feature in all four.

In the matrix below, it can be seen that 62.5% of the specific competences are allied to all four degree programmes and 93.7% are allied to at least two; it was therefore decided that the 16 specific competences previously defined be included in order to build the meta-profile.

Specific Competences	Chemistry	Chemistry and Pharmacy	Food Chemistry	Industrial Chemistry
1. Ability to apply knowledge and understanding of chemistry to solve qualitative and quantitative problems.	X	X	X	X
2. Ability to understand the fundamental concepts, principles and theories of the area of chemistry.	X	X	X	X
3. Ability to interpret and assess data deriving from observations and measurements by relating them to the theory.	X	X	X	X
4. Ability to acknowledge and analyse problems and plan strategies to solve them.	X	X	X	X
5. Ability to develop, use and apply analytical techniques.	X			X
6. Ability to keep up-to-date with regard to the development of chemistry.	X			X
7. Ability to plan, design and execute research projects.	X	X	X	
8. Command of chemical and nomenclatural terminology, conventions and units.	X	X	X	X
9. Knowledge of the main synthetic routes in chemistry.	X			X
10. Knowledge of other scientific disciplines which enable an understanding to be gained in chemistry.	X	X	X	X

Specific Competences	Chemistry	Chemistry and Pharmacy	Food Chemistry	Industrial Chemistry
11. Ability to monitor, by means of the measurement and observation of chemical properties, events or changes and their systematic and reliable compilation and documentation.	X	X	X	X
12. Command of good laboratory practice.	X	X	X	X
13. Ability to act with curiosity, initiative and entrepreneurship.	X	X	X	X
14. Knowledge, application and advice with regard to the legal framework in the field of chemistry.	X			X
15. Ability to apply knowledge of chemistry to sustainable development.	X	X	X	X
16. Understanding of the epistemology of science.	X			

2.6. Construction of a matrix for generic competences *versus* specific competences

On the basis of this analysis, a matrix of generic competences versus specific competences for the chemistry degree was built. As an outcome of reflection, discussion and analysis within the group, it was identified where a direct match emerged between each specific competence and all the generic competences which had previously been identified as being group related according to the classification factors. The matrix shown in table 1 is the result of this analysis, where the correlation of each specific competence with all the generic competences is shown by an «x».

Table 1
Correlation matrix between generic competences and specific competences for the chemistry degree programme
(GC: Generic competence, SC: Specific competence)

Factor	GC/SC	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1	X	X	X	X	X		X		X	X	X					X
	2				X	X	X	X	X	X	X	X	X	X			
	13			X	X			X			X	X	X	X			
	4	X	X	X	X	X	X	X	X	X	X	X	X	X			X
	5				X			X			X	X		X			
2	6													X		X	
	7													X			
	8													X	X	X	
	9													X	X	X	
	10													X	X	X	
3	11							X							X		
	12							X						X	X	X	
	13							X					X	X	X		
4	14				X			X					X	X			
	15							X						X			
	16				X			X						X			
	17				X			X					X	X			
	18				X			X					X	X			
	19				X			X					X	X			

Factor 1: learning process.
Factor 2: social values.
Factor 3: technological and international context.
Factor 4: interpersonal skills.

2.7. Construction of the meta-profile for the chemistry degree programme

Two maps were constructed based on the matrix obtained, as shown in Table 1. For the first, a 100% correlation was considered between each of the specific competences and generic competences. That is to say, if a specific competence relates to each of the generic competences of one factor, it is said to be 100% correlated. For factor 1, the 100% correlated specific competences are 4S, 7S, 10S and 11S. As can be seen in Table 2, these specific competences intersect all the generic competences in factor 1 (1G, 2G, 3G, 4G and 5G). The same criteria were applied to the other factors. Therefore, specific competence 13S displays a 100% correlation in factor 2, competences 7S and 14S correlate 100% in factor 3, and competences 7S and 13S correlate 100% in factor 4.

This result is shown graphically in the ellipse linkage model in Figure 1. The ellipses represent each of the factors and their intersections represent specific competences common to several factors with a 100% correlation.

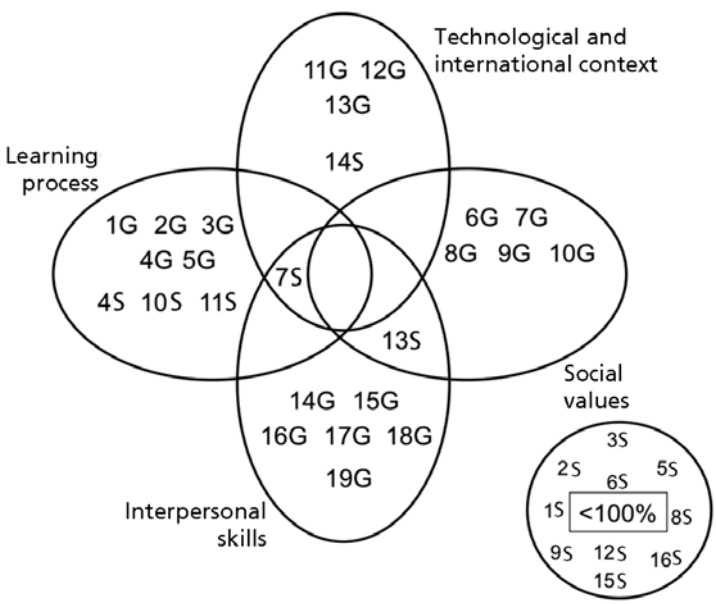

Figure 1
Map of the chemistry degree programme meta-profile with a coincidence equal to 100% correlation

Table 2
Correlation matrix between generic competences and specific competences for the chemistry degree programme with 100% weighting
(GC: Generic competence, SC: Specific competence)

Factor	GC/SC	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1	X	X	X	X	X		X		X	X	X					X
	2				X	X	X	X	X	X	X	X	X	X			
	3			X	X			X			X	X	X	X			
	4	X	X	X	X	X	X	X	X	X	X	X	X	X			X
	5				X			X			X	X		X			
2	6													X		X	
	7													X			
	8													X	X	X	
	9													X	X	X	
	10													X	X	X	
3	11							X							X		
	12							X						X	X	X	
	13							X					X	X	X		
4	14				X			X					X	X			
	15							X						X			
	16				X			X						X			
	17				X			X					X	X			
	18				X			X					X	X			
	19				X			X					X	X			

Factor 1: learning process.
Factor 2: social values.
Factor 3: technological and international context.
Factor 4: interpersonal skills.

For example, specific competence 7S has a 100% correlation with factors 1, 3 and 4. Competence 13S also has a 100% correlation with factors 2 and 4. This map is called the «100% META-PROFILE».

The outcome, according to this exercise, shows that there are specific competences showing a high correlation with the factors taken into consideration when constructing the graduate profile for a general chemistry programme and, on the other hand, the competences remaining in the outer circle are the specific competences which do not relate 100% to at least one factor. A meta-profile can therefore be defined from this exercise which should chiefly consider specific competences 13S and 7S. However, in this way, the meta-profile description would be extremely limited. The fact that a specific competence with a 100% correlation with the four factors was not observed led us to think that the construction of an ellipse map allowing a correlation with different weighting value could be taken into consideration.

In order to do so, a correlation of at least 50% was chosen, i.e. the specific competence analysed must relate to at least half of each factor's generic competences. For example, if there are five generic competences in a particular factor, when analysing a particular specific competence, it must relate to at least three of the generic competences.

Table 3, showing the «50% meta-profile», was obtained from this analysis, in accordance with the same criteria used for the map in figure 1.

This table shows the competences that were 100% related, with the competences which were at least 50% related being added. Thus, for example, competences 3, 5, 9, 12 and 13 are shaded for factor 1, which are added to competences 4, 7, 10 and 11 shown in Table 2, and the same was done for the other factors. The «50% meta-profile map» shown in Figure 2 was redrawn using this information.

Table 3
Correlation matrix between generic competences and specific competences for the chemistry degree programme with 50% weighting
(GC: Generic competence, SC: Specific competence)

Factor	GC/SC	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	1	X	X	X	X	X		X		X	X	X					X
	2				X	X	X	X	X	X	X	X	X	X			
1	3			X	X			X			X	X	X	X			
	4	X	X	X	X	X	X	X	X	X	X	X	X	X			X
	5				X			X			X	X		X			
	6													X		X	
	7													X			
2	8													X	X	X	
	9													X	X	X	
	10													X	X	X	
	11							X							X		
3	12							X						X	X	X	
	13							X					X	X	X		
	14				X			X					X	X			
	15							X						X			
	16				X			X						X			
4	17				X			X					X	X			
	18				X			X					X	X			
	19				X			X					X	X			

Factor 1: learning process.
Factor 2: social values.
Factor 3: technological and international context.
Factor 4: interpersonal skills.

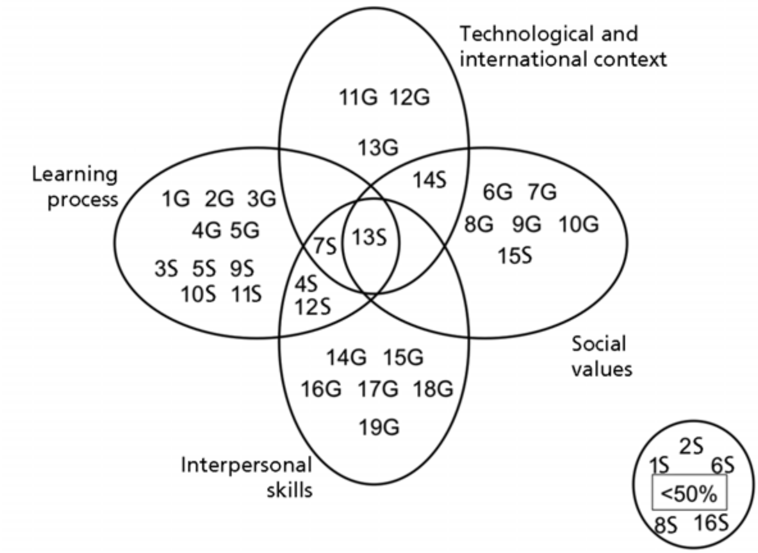

Figure 2
Meta-profile profile map for the chemistry degree programme
with coincidence greater than 50% correlation

Greater coincidence can be seen between the specific competences and generic competences in this map. It can therefore be deduced that competences 4S (Ability to acknowledge and analyse problems and plan strategies to solve them) and 12S (Command of good laboratory practice) coincide with factors 1 and 4; 14S (Knowledge, application and advice relating to the legal framework in the field of chemistry) coincides with factors 2 and 3; 7S (Ability to plan, design and execute research projects) coincides with factors 1, 3, and 4; and competence 13S (Ability to act with curiosity, initiative and entrepreneurship) coincides with all four factors. It can be seen from this exercise that specific competences 1S, 2S, 6S, 8S and 16S do not coincide with 50% or more of the generic competences for any of the four factors.

Based on this outcome, it is clear that the graduate profile in our model programme must explicitly contain competence 13S, and that competences 4S, 7S, 12S and 14S must also be taken into consideration. These competences uniquely characterise the graduate of this model chemistry programme.

Finally, and taking the established methodology into account, the proposed graduate meta-profile (profile) of a university student in Latin America was described as follows:

> «The graduate of a chemistry programme at a Latin American University is a professional who has the ability to act with curiosity, initiative and entrepreneurship; the ability to acknowledge and analyse problems and plan strategies to solve them; the ability to plan, design and execute research projects and advise businesses within the legal framework of the field of chemistry, and has command of good laboratory practice».

These exercises show that the correlation between the factors and generic and specific competences depends on the emphasis each educational establishment wishes to place within their programmes. Therefore, the establishment must decide on the following: the number of factors, the generic and specific competences, the relationship between the competences and the expected degree of correlation between the competences and factors and, without forgetting that the competences remaining outside the ellipse diagram must not be excluded from the student's training. Emphasis on the graduate profile is simply stressed on the basis of the outcomes obtained from the methodology. In this way, and with the help of this meta-profile model, preparing graduate profiles of professionals in chemistry programmes is made easier.

2.8. Contrasting the meta-profile in Latin America

The meta-profile created was used to compare the graduate profiles officially shown by the Latin American universities on their websites. The representatives of each of the ten universities found the graduate profiles of their country's HEIs that offer chemistry, or chemistry-related programmes. On the basis of these profiles, the correlation matrix for each university was constructed, as shown in Table 1.

Given that the volume of information is extremely large, it was decided that all the information from the chosen universities should be consolidated in Tables 4 and 5.

Table 4
Correlation matrix of general competences for several universities in the participant countries

Generic competences																											
No.	AR						BR	CO				CH			CR	EC	ME				PE				UR	VE	%
Com	BA	UC	UT	NE	RC	FK	T	UI	UN	UA	LA	SC	CC	AF	UR	UE	NM	CH	EM	IT	SM	NI	CHI	CP	RP	CV	
1			X	X			X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	81
2	X	X		X	X		X	X		X	X	X		X		X	X	X	X		X	X	X	X	X	X	77
3		X		X	X		X	X	X		X	X	X	X	X	X	X				X	X	X	X	X	X	73
4	X	X	X	X	X	X	X	X		X	X		X	X		X	X	X		X	X	X	X	X	X	X	85
5				X	X		X	X	X	X	X	X				X	X				X	X	X	X	X	X	62
6		X		X	X		X	X	X	X	X	X		X		X	X	X	X				X	X	X	X	69
7				X	X			X				X	X			X		X					X	X	X	X	42
8		X		X	X	X	X	X				X	X	X		X	X				X	X	X	X	X	X	65
9	X	X	X	X	X	X	X	X	X			X		X	X	X	X	X	X		X	X	X	X	X	X	85
10					X		X	X			X	X		X	X	X	X				X	X	X	X	X	X	58
11					X	X	X	X		X	X					X	X						X	X	X	X	46
12					X			X		X	X					X	X				X	X	X	X			38
13		X			X	X	X	X				X				X	X				X	X	X	X	X		50
14	X	X	X	X	X	X	X	X	X				X			X	X	X		X	X	X	X	X	X		73
15		X			X		X	X	X		X	X	X			X	X	X	X		X	X	X	X	X		65
16	X	X		X	X			X	X		X	X				X			X		X	X	X	X	X		58
17	X	X		X	X		X	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X	X		81
18					X			X	X	X	X					X		X			X	X	X	X	X		46
19					X		X	X				X	X	X		X	X	X	X		X	X	X	X	X		58
%	32	58	21	63	99	32	79	100	48	48	68	74	47	53	21	100	84	68	37	2	84	84	100	100	95	58	

Table 5
Correlation matrix of specific competences for several universities in the participant countries

Specific competences																													
No.	**AR**						**BR**				**CO**				**CH**			**CR**	**EC**	**ME**				**PE**				**UR**	**VE**	**%**
	BA	**UC**	**UT**	**NE**	**RC**	**FK**	**EC**	**EP**	**RG**	**FP**	**UI**	**UN**	**UA**	**LA**	**SC**	**CC**	**AF**	**UR**	**UE**	**NM**	**CH**	**EM**	**IT**	**SM**	**NI**	**CH**	**CP**	**RP**	**CV**	
1	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X		X		X	X		X	X	X	X	X	X	86
2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X			X	X	X	X	X	X	90
3	X	X	X	X	X	X	X	X	X	X	X		X		X	X	X		X		X	X	X	X	X	X	X	X	X	86
4	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	97
5	X	X	X	X	X	X	X	X	X		X		X	X	X	X	X		X	X	X		X	X	X	X	X	X	X	86
6	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X			X	X		X		X	X	X	X	X	X	83
7	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	93
8	X	X	X		X	X	X	X	X	X	X		X	X	X	X	X		X					X	X	X	X	X	X	76
9	X	X	X		X	X	X	X	X	X	X		X	X	X	X	X		X	X	X		X	X	X	X	X	X	X	86
10	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				X	X				X	X	X	X	X	X	79
11	X	X	X		X	X	X	X	X		X	X	X		X	X	X		X	X	X		X	X	X	X	X	X	X	83
12	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X					X	X	X	X	X	X	83
13		X		X	X		X	X		X	X	X	X	X	X	X	X	X	X	X					X	X	X	X	X	76
14	X	X	X		X	X	X	X	X		X	X	X	X	X		X	X	X	X			X	X	X	X	X	X	X	79
15	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X		X		X	X	X	X	X	86
16		X		X	X		X	X		X	X	X	X	X	X				X					X				X	X	41
%	88	100	88	75	100	88	100	100	88	56	100	75	100	81	100	81	75	31	100	69	56	31	11	88	94	94	94	100	100	

In each table, each country is shown in alphabetical order. Each of the columns corresponds to the HEIs whose chemistry programmes were taken into account for this analysis. An explanation of the abbreviation is given below:

AR: Argentina (BA, Universidad de Buenos Aires; UC, Universidad Nacional de Córdoba; UT, Universidad Nacional de Tucumán; NE, Universidad del Noreste; RC, Universidad Nacional de Río Cuarto; FK, Universidad John F. Kennedy); BR: Brazil (T; Promedio; EC, Universidad Estatal de Campinas; EP, Universidad Estadual Paulista; RG, Universidad Federal do Rio Grande do Sul; FP, Universidad Federal do Paraná); CH: Chile (SC, Universidad de Santiago de Chile; CC, Pontificia Universidad Católica de Chile; AF, Universidad de Antofagasta); CO: Colombia (UI, Universidad Industrial de Santander; UN, Universidad Nacional de Colombia; UA, Universidad de Antioquia; LA, Universidad de los Andes); CR: Costa Rica (UR, Universidad de Costa Rica); EC: Ecuador (Universidad Central del Ecuador); ME: México (NM, Universidad Nacional Autónoma de México; CH, Universidad Autónoma de Chihuahua; EM, Universidad Autónoma del Estado de México; IT, Instituto tecnológico de Estudios Superiores de Monterrey); PE: Perú (SM, Universidad Nacional Mayor de San Carlos; NI, Universidad Nacional de Ingeniería; CH, Universidad Peruana Cayetano Heredia; CP, Pontificia Universidad Católica del Perú); UR: Uruguay (RP, Universidad de la República del Uruguay); VE: Venezuela (CV, Universidad Central de Venezuela).

The bottom of the table shows the percentage of coincidence between the specific and generic competences of each university's programme in each country. The percentage of the appearance of the generic and specific competences in the academic programmes was calculated in the last column.

With regard to the generic competences, it can be seen that not all the programmes include them. In fact, there are some which do not give great importance to these types of competences in their graduate profiles and/or their programmes.

Regarding the specific competences, it can be seen that all the programmes take a high percentage of these into consideration in their graduate profiles. Those with a percentage of coincidence higher than 90% in the programmes are 3S, 4S and 7S; 7S is associated with three factors (learning, technological and international context, and interpersonal skills), 4S with two factors (learning and interpersonal skills) and 3S with just one factor (learning).

With a percentage of at least 80% appearance in the programmes, competences 1S, 2S, 5S, 6E and 9S are added, which relate to the learning factor. It follows from the above that there is acceptable coincidence between the generic and specific competences in the programmes analysed and the competences proposed in this meta-profile model. Nonetheless, it must be stressed that each country needs to carry out a thorough analysis of the most relevant competences and factors in order to create professional profiles in chemistry according to the required specificity and relevance to each region.

3

Observations concerning student workload

The different experiences of measuring student workload in chemistry programmes at each participant educational establishment were presented. Having reviewed and discussed the methodology to be applied to the proposed measuring instrument, an overall proposal was prepared for all the areas and applied to the chemistry programmes at the participant establishments.

The instrument was given to students taking the fifth semester at the universities within the network in Argentina, Brazil, Chile, Colombia, México, Uruguay and Venezuela, while in Colombia, Costa Rica, Ecuador and Perú, it was given to students taking the sixth semester.

The instrument was applied to all the teaching staff of all subjects in the selected semester, including those which are not, in themselves, related to chemistry, such as humanities, physics, mathematics, sport and the arts, but nonetheless form part of the programme in the chosen semester. In the event that the subjects in the semester had several timetables or assignments, the questionnaire was applied to all the teaching staff that had the selected chemistry students under their charge or within their timetable.

The following activities were taken into consideration in the assessment instrument and estimated clock hours used to encourage students' independent work: reading texts or bibliographies, preparing and developing practical work, fieldwork, laboratory, preparing and developing written work, virtual activities and study for assessment purposes.

The questionnaire was standardised by the organising committee and was only tailored to each institution with regard to the areas, subjects and degree programmes and courses to which it would be applied. At the end of the chapter, the documents used for the chemistry programmes for students and graduates at the Universidad Industrial de Santander, Colombia, are shown as examples.

The instrument was given to the group of lecturers and students at each HEI after the objective of the project had been explained. In most cases, the explanation was given in groups; in others, it was given individually or online, according to the distribution of academic workload at the time of implementation. Having conducted the questionnaires, the results were then sent to the project general coordinating group to be processed and the data obtained was distributed to every participant in the project.

Table 6 shows the opinions concerning total hours (contact and non-contact) used by students throughout the period subject to consideration, of both the teaching staff and students surveyed. The last row shows the averages for each group and the difference of opinion and variation percentage based on the teaching staff opinions are calculated in the last two columns. The negative symbols in the «diff» and «% diff» mean that students consider a total workload, expressed in hours, heavier than that considered by teaching staff, and the positive symbols indicate that teaching staff consider the workload heavier than students do. In this column («% diff»), absolute variations can be seen from very small amounts, from 0.5% up to as much as 43%. For the area of chemistry, the variation is –2.3%, being within 33.3% of areas with an absolute difference lower than 5%, meaning that there is agreement of opinion between students and teaching staff. It can also be seen that 46.7% of areas show a difference greater than 20%, reaching a maximum difference of 43%, meaning that, in these cases, there is no agreement of opinion between teaching staff and students. In 33.3% of the areas, the teaching staff undervalue the workload compared with the students' opinion, i.e. the teaching staff considers that the timetable load is lighter than that considered by the student.

The area of chemistry falls into this context, though the difference is very small: –2.3%.

Table 6
Total hours set aside by the student for each profession

Area	Teaching staff	Student	Diff	% diff
Law	425,59	435,54	–10,0	–2,3
Mathematics	525,25	753,39	–228,1	–43,4
Psychology	545,47	463,05	82,4	15,1
History	560,00	515,43	44,6	8,0
Education	575,86	509,82	66,0	11,5
Nursing	597,43	423,71	173,7	29,1
Medicine	606,33	807,70	–201,4	–33,2
Information technology	663,73	690,56	–26,8	–4,0
Chemistry	676,80	692,15	–15,4	–2,3
Agronomy	677,41	623,58	53,8	7,9
Administration	681,10	529,08	152,0	22,3
Physics	683,00	679,46	3,5	0,5
Civil engineering	695,51	689,97	5,5	0,8
Geology	743,71	646,36	97,4	13,1
Architecture	871,63	718,31	153,3	17,6
AVERAGE:	635,30	611,90		

Figure 3 shows the total number of hours judged by teaching staff compared to the total number of hours judged by students. The 45° diagonal line shows the ideal situation, where teaching staff think the same as the students. For the area of chemistry, the coincidence is very close to ideal, while this is not the case with other areas. The information above the line shows that teaching staff in these areas think that students invest more time than the students themselves consider they do, while the areas below the line show that teaching staff take an opposite view to students with regard to their investment in hours of activity. The further away the area is from the diagonal line, the greater the discrepancy between teaching staff and students.

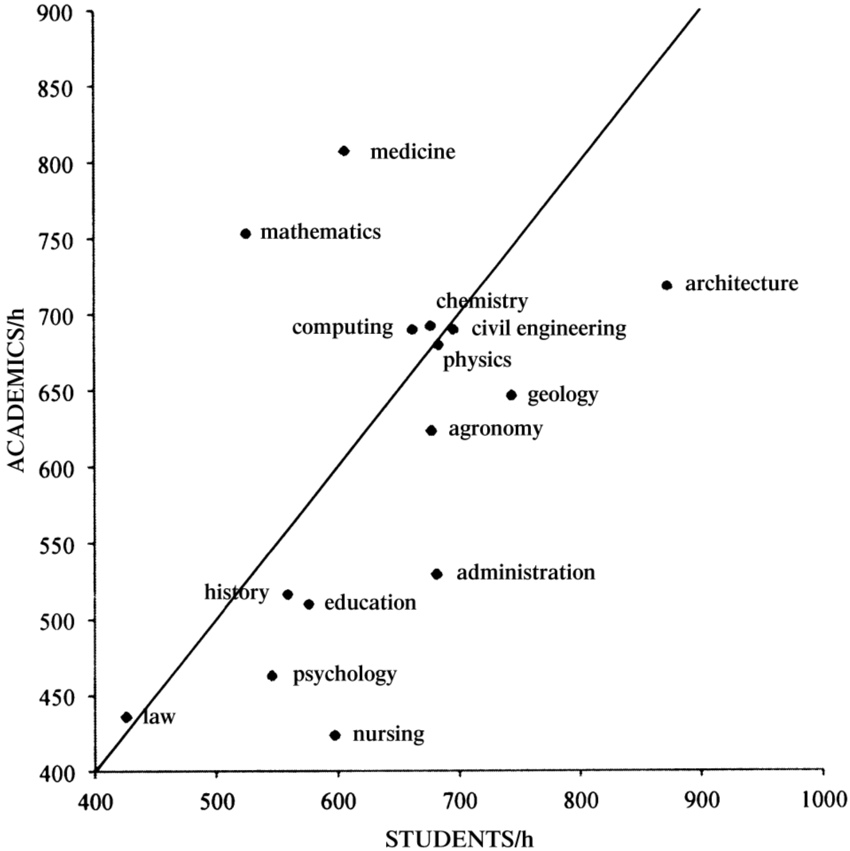

Figure 3
Correlation between the number of hours defined by academics *versus* the number of hours defined by students for each profession

Figure 4 shows the average considered by teaching staff, represented by a horizontal line, and the average considered by students, represented by a vertical line.

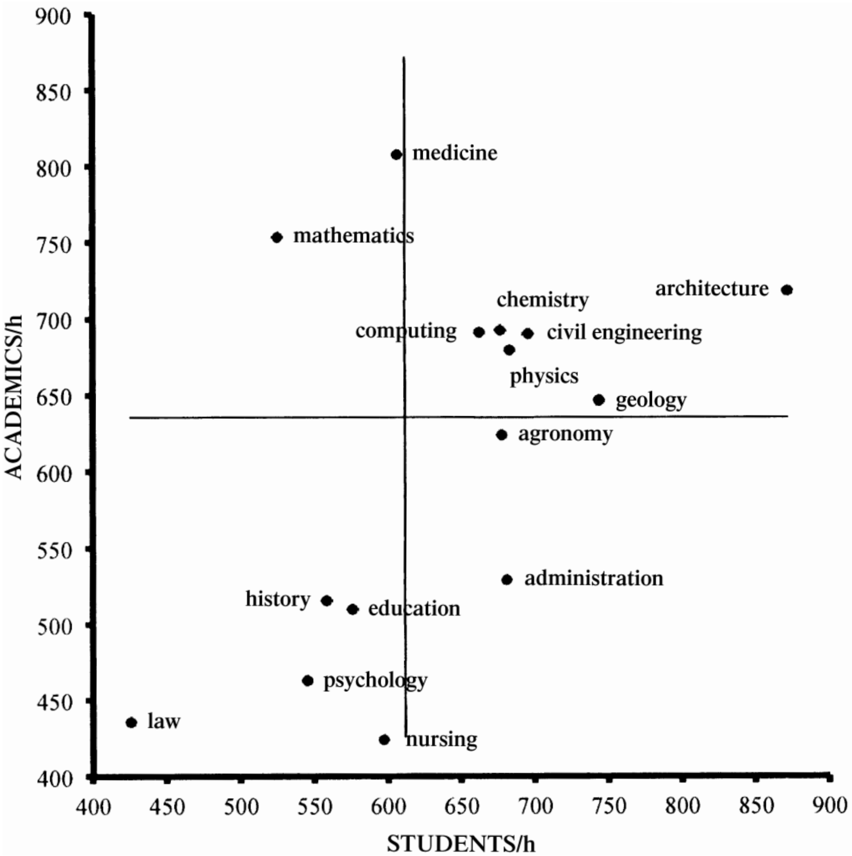

Figure 4
Correlation of total hours considered by lecturers
in relation to the average (horizontal line) and total hours considered
by students in relation to the average (vertical line)

In the case of the area of chemistry, despite there being major agreement of opinion between teaching staff and students, it appears that there is a 6.6% excess with regard to the average obtained for teaching staff and 13.1% excess with regard to the average obtained for students. Behaviour in the area of chemistry coincides with other areas: information technology, civil engineering and physics, and areas relating to applied sciences, where there is expected to be such agreement.

The outcome of this exercise is that teaching staff and students think that the total number of hours students set aside for their professional training is similar and does not exceed 15% in relation to the overall average obtained. This number of hours is therefore appropriate for chemists. Furthermore, it can be seen that the areas of chemistry, engineering, physics and information technology evidence very similar behaviour, and are positioned in the same part of the diagrams.

Example of the documents used for the chemistry syllabus at the Universidad Industrial de Santander, Colombia

Teaching staff questionnaire

Part of the TUNING Latin America project consists of a study to get an approximate idea of the reality of student workload in this area and university by compiling information on teaching staff and students. We would be most grateful if you could answer some questions regarding the subject you taught during the last academic period. The information obtained will be treated as completely anonymous and confidential.

1. Area: Physicochemical.
2. University: Universidad Industrial de Santander.
3. Degree: Chemistry.
4. Subject: Introduction to Quantum Chemistry.
5. Duration in WEEKS of the academic period (quarterly, four-month, semester, annual) according to syllabus: one 16-week semester.

6.	How many minutes' duration is the academic hour in your subject?	minutes	... don't know/ no answer
7.	How many academic hours of contact[2] teaching activities did your subject have?	hours	... don't know/ no answer
8.	How many weeks of actual contact teaching activities did your subject have, including assessments?	weeks	... don't know/ no answer
9.	How many hours of contact teaching activities per week did your subject have?	hours	... don't know/ no answer

[2] CONTACT is understood as activities with the physical presence of the lecturer and student. It normally relates to the hours the student spends with the lecturer in the classroom.

10. How many total hours do you estimate that students used in the academic period to pass your subject, taking into account ALL contact and non-contact activities?			hours	... don't know/ no answer
11. Of the following non-contact activities, please indicate which you used to encourage students to work independently. Please indicate the clock hours you estimate the students needed to carry them out.				
a) Reading texts or bibliographies	...yes	... no	hours	... don't know/ no answer
b) Preparing and developing work	...yes	... no	hours	... don't know/ no answer
c) Fieldwork	...yes	... no	hours	... don't know/ no answer
d) Laboratory	...yes	... no	hours	... don't know/ no answer
e) Preparing and developing written work	...yes	... no	hours	... don't know/ no answer
f) Virtual activities	...yes	... no	hours	... don't know/ no answer
g) Studying for assessment	...yes	... no	hours	... don't know/ no answer
h) Others: specify:	...yes	... no	hours	... don't know/ no answer
i) Others: specify:	...yes	... no	hours	... don't know/ no answer
j) Others: specify:	...yes	... no	hours	... don't know/ no answer
12. How many hours on average per week do you consider that students set aside for contact and non-contact activities in the subject?			hours	... don't know/ no answer
13. When planning your subject, did you consider the number of non-contact hours the students would need to carry out the activities?	yes	no		... don't know/ no answer
14. Did you check this estimate of hours with students?	yes	no		... don't know/ no answer

Student questionnaire

Good morning/afternoon; this forms part of the TUNING Latin America project and we are carrying out a study to get an approximate idea of the reality of student workload in this area and university by compiling information on teaching staff and students. We would be most grateful if you could answer some questions regarding the subjects you have studied during the last academic period. The information obtained will be treated as completely anonymous and confidential.

1. Area: Physicochemical.
2. University: Universidad Industrial de Santander.
3. Degree: Chemistry.
4. Subject: Introduction to Quantum Chemistry.
5. Duration in WEEKS of the academic period (quarterly, four-month, semester, annual) according to syllabus: one 16-week semester.

1. How many minutes' duration is the academic hour in the subject?	minutes	... don't know/ no answer
7. How many academic hours of contact[3] teaching activities did the subject have?	hours	... don't know/ no answer
8. How many weeks of actual contact educational activities did the subject have, including assessments?	weeks	... don't know/ no answer
9. How many hours per week of contact educational activities did the subject have?	hours	... don't know/ no answer
10. How many total hours do you estimate you used to pass the subject, taking into account ALL contact and non-contact activities?	hours	... don't know/ no answer

[3] CONTACT is understood as activities with the physical presence of the lecturer and student. It normally relates to the hours the student spends with the lecturer in the classroom.

11. Of the following non-contact activities, please indicate which you carried out throughout the course of the subject. Please indicate the clock hours you estimate you needed to carry them out.					
a) Reading texts and bibliographies	...yes	... no	hours		... don't know/ no answer
b) Preparing and developing work	...yes	... no	hours		... don't know/ no answer
c) Fieldwork	...yes	... no	hours		... don't know/ no answer
d) Laboratory	...yes	... no	hours		... don't know/ no answer
e) Preparing and developing written work	...yes	... no	hours		... don't know/ no answer
f) Virtual activities	...yes	... no	hours		... don't know/ no answer
g) Studying for assessment	...yes	... no	hours		... don't know/ no answer
h) Others: specify:	...yes	... no	hours		... don't know/ no answer
i) Others: specify:	...yes	... no	hours		....don't know/ no answer
j) Others: specify:	...yes	... no	hours		... don't know/ no answer
12. How many hours on average per week did you set aside for contact and non-contact activities in the subject?			hours		... don't know/ no answer
13. Did you plan the number of non-contact hours you would invest in carrying out the activities?			yes	... no	... don't know/ no answer
14. Did the lecturer check the estimate of non-contact hours with you, the students?			yes	... no	... don't know/ no answer

4

Teaching, learning and assessment strategies for competences

Although there are indications that some programmes in Latin American countries have begun to establish competence-based graduate profiles, there is still a lack of forums for discussion, reflection and analysis to ensure that these profiles coincide among universities, both within countries and among countries. There are countries which are concerned and interested in this educational model and have started processes involving the renewal of curricular structures and defined special graduate profiles for all their degree programmes using the competence-based approach. However, in practice, only through isolated local efforts have some academics designed a limited number of programmes using the competence-based approach, while a significant number of them remain unconcerned about competence-based teaching, since such processes are seen to be tortuous and take a long time to implement. Other countries have introduced academic reforms involving all higher educational establishments as a national policy, which has contributed to the fact that degree programmes, both graduate profiles and curriculums, are being designed using a competence-based approach that is concerned about clearly defining the transferable credits taken into consideration by direct teaching and independent work undertaken by the student. In order to get all teaching staff involved in competence-based review and subject adaptation processes, greater dissemination is needed of this type of teaching alternative. Although there is interest on the part of several academics to implement such changes, there is also resistance on the part of others. Undoubtedly such resistance is due to habits and customs regarding lectureship and «fear» of change, and, on the other hand, change and educational updating mean updating media and information systems.

Some academics consider these processes to be fruitless as far as they are concerned. It has been observed that some educational establishments have taken the «Tuning» model proposals into consideration, both the generic and specific competences, and some have begun to develop their own methodology. Moreover, some lecturers with experience in these kinds of topics are orienting academics in methodological developments. In other countries, local, regional and national forums have been set up with the intention of sharing the «Tuning» methodology with teaching staff and senior management at faculties and educational establishments, which has raised awareness about the fact that an educational change needs to be made so that the entire region of Latin America forms part of «Tuning». Those educational establishments which have begun their competence-based reviews and adaptations, bringing benefits to the overall training of their students, have a significant advantage in a number of aspects, which are discussed below.

4.1. Graduate profiles

Establishing competence-based graduate profiles enables there to be more defined and strengthened programmes with regard to student interests, and their more accessible introduction into the production and government sectors, and the academic-scientific field. It is important that the graduate profile is established using the opinions of employers, academics and graduates, which might break with the tradition of «desktop curricular modification» or lecturers' ideas, commonly used when reviewing the curriculum.

4.2. Definition of credits

The definition of academic credits and their equivalence with other educational establishments is essential as it will permit an increase in student mobility. While it is clear that institutions in Latin American countries sometimes set up exchanges with those in Europe or North America more easily and directly, an increase in student mobility has also been observed among Latin American institutions, which has been achieved thanks to discussions and agreements on academic credit.

It is important to point out that the «Latin American credit system» still needs to be clearly defined and understood by every educational establishment in Latin American countries so that it can develop and encourage student mobility and, in the future, offer the student involved the chance of dual qualifications.

4.3. Flexible plans

One strategy that several educational establishments have established and which is related to competence-based subjects is academic flexibility, i.e. flexible programmes, where the student pieces together their curricular structure and makes progress on the basis of their learning skills and abilities. This type of curricular flexibility is useful for students with high academic performance, since they have the option to complete their studies in less time than that set by non-flexible programmes.

4.4. Programme accreditation

A framework which has allowed programmes to be tailored to competences is national and international accreditation by recognised agencies and accredited by a more senior body. In some countries, the accrediting agencies propound that all programmes should be competence-based in order to be worthy of such recognition. While other agencies still do not see this as a requirement, they do nonetheless make the proposal as a recommendation in their assessments.

4.5. Common strategies for the assessment, teaching and learning of competences

All of the above led to reflection and debate on how competences should be assessed in teaching-learning processes. To do so, a course was selected which was common to all the universities participating in the project and the specific competences were defined that related to some of the generic competences defined in the project.

The course considered was the «technical course in general chemistry», which is common to all the participant universities, as well as being a course which should be included in any degree relating to chemistry.

After reflection and debate, the chemistry group concluded that there are four specific competences relating to five generic competences. The list of each competence is as follows:

Specific competences

1S. «Ability to apply knowledge and understanding of chemistry to solve qualitative and quantitative problems», relates to the generic competences:

1G. Capacity for abstraction, analysis and synthesis.

4G. Ability to search for, process and analyse information.

2S. «Ability to understand the fundamental concepts, principles and theories of the area of chemistry», relates to the generic competences:

1G. Capacity for abstraction, analysis and synthesis.

4G. Ability to search for, process and analyse information.

8S. «Command of chemical and nomenclatural terminology, conventions and units», relates to the generic competences:

2G. Ability to learn and keep up-to-date.

4G. Ability to search for, process and analyse information.

10S. «Knowledge of other scientific disciplines which enable an understanding to be gained in chemistry», relates to the generic competences:

1G. Capacity for abstraction, analysis and synthesis.

2G. Ability to learn and keep up-to-date.

3G. Critical and self-critical capacity.

4G. Ability to search for, process and analyse information.

5G. Capacity for oral and written communication.

From this matrix, generic competences 1G and 4G were analysed because they are the competences that most coincide with the specific competences defined. These generic competences were analysed on the basis of teaching-learning processes, and the most important aspects relating to the assessment of this competence were taken into consideration.

4.6. Analysis of generic competences

Competence 1G: «Capacity for abstraction, analysis and synthesis»

The professional will have the capacity for:

a) Abstraction when:

- The fundamental concepts, principles and theories in the area of chemistry are understood.

b) Analysis when:

- Information deriving from observations and measurements is related to the theory, interpreted and assessed.
- Problems are acknowledged and analysed, and strategies planned in order to solve them.
- Events or changes are monitored by measuring and observing chemical properties, and their documentation is systematically and reliably compiled.

c) Synthesis when:

- Research projects are planned, designed and executed.
- Acting with curiosity, initiative and entrepreneurship.

Time:

This competence develops throughout the degree programme at different, increasingly complex levels.

Teaching and learning methodology

- Lectures.
- Forums and seminars.
- Bibliographic review.
- Problem-solving
- Group discussion of problem areas.
- Laboratory practice.
- Research project design.

Assessment. The competence achievement indicators are:

- Preparation of concept maps.
- Resolution of practical exercises and specific problems raised.
- Preparation of academic seminars and presentations and bibliographic reviews.
- Preparation and interpretation of data correlation tables and graphs.
- Interpretation and synthesis of scientific information.

Competence 4G: «Ability to search for, process and analyse information»

The professional will have the ability to:

a) Assess when they:

  - Calculate and judge information.
  - Establish theoretical models based on observable data.

b) Interpret when they:

- Organise and explain the meaning of results by relating them to the theory.
- Validate hypotheses based on observable data.

Time:

This competence develops throughout the degree programme at different, increasingly complex levels.

Teaching and learning methodology

- Lectures.
- Forums and seminars.
- Bibliographic reviews.
- Discussion, analysis and interpretation of bibliographic or generated data.
- Planning experimental designs.

Assessment. The competence achievement indicators are:

- Solution of problems associated with the handling, observation and interpretation of data generated by experimental phenomena.
- Discussion and interpretation of bibliographic data.
- Development of proposals for numerical information models from bibliographic data or observations.

An analysis of each of the participant institutions was then conducted, considering generic competence 5G: «capacity for oral and written communication»; and the specific competence 5S: «ability to develop, use and apply analytical techniques». These competences were chosen as they are the most characteristic ones to be covered by professionals taking any degree programme in the area of chemistry.

Year 1 Basic module		Year 2 Basic module		Year 3 Degree module		Year 4 Degree module	
Semester 1	**Semester 2**	**Semester 3**	**Semester 4**	**Semester 5**	**Semester 6**	**Semester 7**	**Semester 8**
Mathematics II	General Chemistry LOW	Inorganic Chemistry I MEDIUM	Inorganic Chemistry II LOW	Physical Chemistry III No information	Spectroscopy and Structure MEDIUM	Instrumental Analysis II LOW MEDIUM	Chemical Processes MEDIUM
Experimental Chemistry LOW	Mathematics II	Physical Chemistry I MEDIUM	Physical Chemistry II No information	Organic Chemistry II MEDIUM	Organic Chemistry III HIGH	Inorganic Chemistry III MEDIUM	Environmental and Ecological Chemistry
Mathematics I	Physics I	Mathematics III	Organic Chemistry I LOW MEDIUM	Analytical Chemistry No information	Instrumental Analysis I No information	Unit Operations I	Research Unit HIGH
English I	English II	Physics II		Applied Statistics	Business Administration	Biology and Biochemistry	
Introduction to University							

An initial analysis was conducted impact level of each competence on programmes relating to the area of chemistry, taking three impact levels into consideration: LOW, MEDIUM or HIGH, although some educational establishments included two additional intermediate levels: LOW-MEDIUM and MEDIUM-HIGH. By way of example, the analysis conducted of the competence «ability to develop, use and apply analytical techniques», corresponding to specific competence 5S, is included for the subjects in the discipline of chemistry in the programme for the Chemistry degree offered at the Universidad de Santiago de Chile.

An analysis of the programme chosen by each participant was then conducted, in which the learning outcome and teaching, learning and assessment strategies for each subject involving the specific competence were analysed.

By way of example, the first three semesters of the Chemical Engineering in Foodstuffs degree at the Universidad Autónoma de Querétaro are included, where the generic competence 5G: «capacity for oral and written communication» is analysed. For this competence, it was determined that the learning outcome should be defined on the basis of the following aspects in order to consider that the learning objectives have been met:

1. Being able to convey critical opinions supported by textual references.

2. Being able to express oneself orally with clarity and precision.

3. Being able to convey one's own points of view, and those of others if need be.

4. Relating what has been mentioned and learnt to life experiences and previous knowledge.

5. Expressing oneself clearly in writing, using the appropriate structures and rules of grammar, syntax and spelling.

6. Developing ideas in writing, presenting the thesis clearly with supporting arguments and logical and coherent textual organisation.

7. Developing the ability to review written work and identify errors.

Sem	Subject	Level of Develop-ment	Learn-ing Out-come (see list)	Strategies		
				Teaching	Learning	Assessment
1	General chemistry	Low	6	Oral presentation, use of multimedia.	Assignments, biblio-graphic review.	Exams, assignments and class participation.
1	Gen. chemistry lab.	Medium	1-6	Oral presentation and de-velopment of flow charts so as to better under-stand the practice being carried out.	Bibliographic review and study of previous knowl-edge relating to practical work, preparing a written record.	Open-ended questions on previous work, quick ex-ams and reports.
1	States of aggregation	N/A	N/A	N/A	N/A	N/A
1	Linear algebra					
1	Differential calculus	Low	6	Procedures to solve prob-lems.	Learning to solve prob-lems and keeping organ-ised, written records.	Written exam.
1	Reading and writing					
1	Career guidance					
2	Quantitative chemistry	Low	5 and 7	Thematic oral presenta-tions.	Assignments.	Presentations, assign-ments, participation and group exams.
2	Quantitative chemistry lab.					
2	Basic inorganic chemistry					
2	Organic chemistry I	N/A	N/A	N/A	N/A	N/A
2	Experimental methods					
2	Thermodynamics					
2	Thermodynamics lab.	Medium	1-6	Oral presentation and de-velopment of flow charts so as to better under-stand the practices being carried out.	Bibliographic review and study of previous knowl-edge relating to practical work, preparing a written record.	Open-ended questions on previous work, quick ex-ams and reports.

Sem	Subject	Level of Develop-ment	Learn-ing Out-come (see list)	Strategies		
				Teaching	Learning	Assessment
2	Integral calculus					
2	Bioethics	High	Submission of written work	Methodology. Presentation by the lecturer followed by queries and debates, discussion in class on current problem areas.	Presentation of selected topics by students.	Attendance. Written exam, submission of written work, participation in class debates and discussions.
3	Analytical chemistry					
3	Analytical chemistry lab.					
3	Organic chemistry II	N/A	N/A	N/A	N/A	N/A
3	Organic chemistry lab. II					
3	Phase solutions and systems					
3	Lab. solutions and phase systems	Medium	1-6	Oral presentation and development of flow charts so as to better understand the practice being carried out.	Bibliographic review and study of previous knowledge relating to practical work, preparing a written record.	Open-ended questions on previous work, quick exams and reports.
3	Differential equations					
3	Mechanics					
3	Mechanics lab.					
3	Drawing					
3	Drawing	Medium	Presentation of individual and team projects	Use of the AUTOCAD programme to undertake projects.	Field trips to carry out real measurements. Library use for research.	Weekly projects and/or practice.

Year (Sem)	Subject	Level of competence development	Learning outcome	Strategies		
				Teaching	Learning	Assessment
1. (1)	General Physics I					
	Mathematics I					
	Princ. Chemistry I	Low	a) Studies the basic concepts of the properties of matter and its properties (atoms, molecules, intensive and extensive properties). b) Studies the nomenclature of chemical compounds and their different forms. c) Studies chemical reactions and the laws of conservation of masses associated with such reactions. d) The thermodynamic principles dominating physical and chemical processes are shown.	a) ClasMaster classes. b) Exercise and problem-solving classes. c) Advisory classes with trainers. d) Guides to electronic problems.	a) Resolving exercises and problems in class. b) Raising interesting issues in class for discussion. c) Completing assignments electronically.	a) Presentation of short exams. b) Presentation of long exams. c) Short assignments with problem type. d) Short assignments with essays on fundamental theoretical subjects.

Year (Sem)	Subject	Level of competence development	Learning outcome	Strategies		
				Teaching	Learning	Assessment
1. (2)	General Physics II					
	Mathematics II					
	Princ. of Chemistry II	Low	a) Studies the principles of chemical balance and its applicability to real systems. b) Studies the ionic balance associated with pH and salt precipitation reactions. c) Studies the dynamics of processes, their thermodynamics and the association of the changes in balance with thermodynamic	a) ClasMaster classes. b) Exercise and problem-solving classes. c) Advisory classes with trainers. d) Guides to electronic problems.	a) ReResolving exercises and problems in class. b) Raising interesting issues in class for discussion. c) Completing assignments electronically. d) Encouraging the reading of theoretical basics via electronic assignments.	a) Presentation of short exams. b) Presentation of long exams. c) Short assignments with problem type. d) Short assignments with essays on fundamental theoretical subjects.
	Princ. of Chemistry	Low	a) UtiUses top loading balances. b) Uses materials and incipient analytical techniques. c) Becomes familiar with acid/base and redox titration techniques. d) Begins to differentiate qualitative measurements from quantitative measurements. e) Understands the importance of concentration measurements and their quantification.	a) Performing 6-hour weekly sessions of laboratory practice. b) Presenting seminars on experimental practice, prior to its execution.	a) Discussion in seminars on the different theoretical aspects of the experiment, their interpretation and expectations. b) Performing weekly laboratory experiments.	a) Observation of student performance in seminars. b) Observation by the teacher of student performance in the laboratory. c) Individualised questions by the lecturer for every student. d) Short exams. e) Presentation of written reports.
	Princ. of Biology					

Year (Sem)	Subject	Level of competence development	Learning outcome	Strategies		
				Teaching	Learning	Assessment
2. (3)	General Physics III					
	Mathematics III					
	Inorganic Chem. I	Low	a) Understanding the concepts associated with atomic, electronic and molecular structure. b) Using the periodic table. c) Command of the main bonding models: ionic bonding, covalent bonding and metallic bonding, and their consequences on the properties of matter.	a) Master classes. b) Exercise and problem-solving classes. c) Guides to electronic problems.	a) Resolving exercises and problems in class. b) Raising interesting issues in class for discussion.	a) Short exams. b) Short exams.
	Physics lab. I					

Analysis of the specific competence 5S: «ability to develop, use and apply analytical techniques» was conducted in the same way. This competence is extremely important for any professional graduating from a programme relating to chemistry since it empowers them with tools to elucidate chemical concepts and structures, and evaluate the composition of chemical matters in all sample types. By way of example, analysis is shown of the first three semesters of the chemistry programme at the Universidad Central de Venezuela.

It can be concluded that the competence-based curricular design proposed by Tuning has been warmly welcomed by many higher educational establishments in Latin America. Nonetheless, it will take time for this system to be put into practice in many universities.

To illustrate the application of competence-based methodology to teaching, learning and assessment strategies, one generic and one specific competence were chosen. The generic competence chosen was 5G: «capacity for oral and written communication» and the specific competence was 5S: «ability to develop, use and apply analytical techniques». These competences were identified as the most characteristic ones that professionals studying any degree in the area of chemistry must possess.

The relationship of these competences with the programmes at the participant universities was analysed, taking three impact levels into consideration: LOW, MEDIUM and HIGH, as illustrated in the Chemistry programme at the Universidad de Santiago de Chile. Furthermore, the first 3 semesters were chosen from the Chemistry programme at the Universidad Autónoma de Querétaro to illustrate the generic competence, while the specific competence was illustrated by using the Chemistry programme at the Universidad Central de Venezuela, again for the first three semesters.

The following strategies were identified as being the most common in order to teach the generic competence: oral presentation, multimedia, flow charts, problem solving and class debates and discussions.

The following strategies were identified as being the most common in order to learn the generic competence: assignments, reviewing bibliography, preparing written records, solving problems and making an organised, written record of them, student presentations on specific subjects, fieldwork and library use.

The following strategies were identified as being the most common in order to assess the generic competence: written and oral exams, assignments, participation, class debates and discussions, open-ended questions on previous work, presentations, attendance, projects and practice.

The following strategies were identified as being the most common in order to teach the specific competence: oral presentations, exercises and problems, advisory classes, electronic guides, laboratory practice, student presentations on specific subjects.

The following strategies were identified as being the most common in order to learn the specific competence: resolving exercises and problems in class, class discussions, reading basic theoretical principles to complete electronic assignments and laboratory practice.

The following strategies were identified as being the most common in order to assess the specific competence: short and long exams, assignments with problems and essays, assessing seminars and laboratory work, and written reports.

5

Future scenarios for the Area of Chemistry

To present the possible future scenarios for chemistry degrees, each group member interviewed one or two individuals from their country who had experience in the academic and research fields, production sector or government and/or political sector. A summary of the interviewees' global view of an «analysis system to anticipate new, emerging professions and the competences they require» is provided below. The shared view we have observed is that the profession of chemist will continue to exist in the future with as much, if not greater, preponderance than at present. In this respect, although opinions are expressed about some characteristics of future professions, the interviewees placed the most emphasis on the characteristics of the professional chemist and related professions in the future.

This outcome should, in fact, come as no surprise. Since the emergence of the first rudiments of chemistry, namely, *khēmia* or alchemy, its practitioners, alchemists, gradually changed as they perfected their expertise, without ever being anything different from what they were right from the start: chemists practising the rudiments of chemistry. In 650BC, Greeks such as Thales of Miletus, Anaximenes and Aristotle, wisely and with subtle intelligence, offered contributions which would later lead to the understanding of many phenomena that can only be described as chemical nature. Two thousand years later, in 1661, Robert Boyle was to publish a fundamental work: «The Sceptical Chymist», where he permanently broke away from the alchemist belief in the *four elements*: earth, air, water and fire, and appropriated *atomism* (a forgotten concept at the time, introduced by Democritus circa 400BC), introduced the terms «chymistry» and «chymist» by removing the first syllable of the term alchemist (from alchemist to chemist), laid the foundations of scientific experimentation (all theory must be tested experimentally to be accepted), introduced the first ideas regarding the kinetic theory of gases and was the originator of modern chemistry.

Thousands of years before Christ, the Egyptians were making exquisitely handmade items, unearthed from several pyramids, which can only be classified as the forerunners of what we call technology. The transformation of iron and copper ore at the time of Alexander the Great confirms these assumptions. Since then and up to this day, chemists have been intervening, transforming matter and driving technological innovation and development and basic science forward, increasingly perfecting the profession. Thousands of years of a profession which has progressively become more specialised and contributes to the development and quality of life of humanity, leads one think that it will continue to exist in the next twenty, thirty, fifty or hundred years.

Nevertheless, we owe a debt to society. Chemists produce hazardous materials, at odds with the environment and the well-being of mankind. Aspects to this effect are included in the concepts conveyed by the interviewees. The call is clear, in this respect, for the need to make concerted, innovative and systematic efforts to change this situation by integrating ourselves into what has been called *green or sustainable chemistry,* by researching and designing more efficient and safer chemical processes, and environmentally-friendly products by reducing or removing hazardous materials. The role played by elements as important as catalysers, solvents and nanoparticles, as well as many others, needs to be reviewed comprehensively and systematically and jointly by the different groups of corporate bodies.

5.1. Characterisation of future scenarios taken into consideration

1. Present-day professions will require increasing levels of perfection but, at the same time, will be intensely interdisciplinary and in constant interaction with society, due to the fact that the future will demand that societies be highly flexible towards changes in attitude and social responsibility, and ethical and aesthetic frameworks. There will be rapid political, economic, and even religious change.

2. The chemist must play an important role in the development and assurance of quality and innocuousness, especially of commodities, new forms of energy, new, responsible and appropriate ways of using water, new food production processes or foodstuffs, with an increasing tendency towards the manufacturing of products through clean agriculture (organic food) and sustainable products and services. The chemist should also play an important role in the fields of bioengineering, nanotechnology and aerospace materials and, to do so, chemistry degree programmes must be restructured into degrees that are more in touch with modern times by focusing, in addition to the areas of pure or theoretical basic chemistry, on the fields of materials, food, health, environmental conservation, and derive any other profession relating to chemistry from these areas.

3. Collective work that focuses on formulating and solving problems will be progressively demanding. We will see chemists capable of generating models that will be predictive or will at least set trends.

4. The progress made in information and communications technologies (ICTs) and their incorporation into everyday work will reach unprecedented proportions. This will entail intensification in the speed of communications, allowing the virtual disappearance of borders between countries and greater interaction among researchers from different parts of the planet. New technologies will allow current socio-economic and environmental problems to be solved, as well as other problems yet to come.

5. Progress and common good: we will live in a better world, with a drastic decrease in poverty and greater balance between human beings and the latter with nature, with the full development of less polluting, alternative energy sources and the stabilisation of the global economy. The means will be established to be able to reconcile progress with improvements to our quality of life harmoniously. New materials and basic, more environmentally-friendly resources will be developed using processes framed within sustainable environmental management, with the minimal and appropriate generation of reusable waste in other processes. This will demand education which strengthens scientific and technological development geared towards reinforcing the search and optimisation of new resources and productive changes, including undertakings which contribute to the conservation, preservation and improved use of water.

6. More globalised and international society: in the same way that there has been a globalisation of the economy, a globalisation of education will be needed, an educational globalisation which some countries have already experienced and others are making attempts to generate. Hence, we will see what could be called world universities, where universities and businesses go into partnership in order to carry out applied research by researchers and students working together despite being in different parts of the world, with the resulting decrease in face-to-face type activities. In other words, society will be more globalised and international, with increased mobility and exchange with other nations of the globe. The current scenario, whose pacesetters are the USA and Europe, will be joined by Asia and Latin America. Our nations will strengthen their bonds with one another and will project themselves as leaders in the region, which will change from a scenario of being the suppliers of commodities to a scenario of being the provider of intelligence, capable of generating, developing and using expertise and technologies, improving exportable goods and creating business niches.

7. Increase in life expectancy: people will live longer with a better quality of life with a resulting increase in demand for medical care. This will result in an increase in the world population, massive populations in cities and a decrease in birth rates, which will lead to an increase in the construction of vertical cities, and thus, the need for tougher, lighter, smarter low-cost materials. There will therefore be a notable increase in consumption, especially in food, raw materials, minerals, and, in general, new, cheaper high quality products, within the context of a more competitive and globalised market which demands that businesses be more efficient, sustainable and competitive. None of this will be possible without the concerted development of science and technology in all fields, such as robotics, nanotechnology, communications, medicine and new materials. Great developments and applications will be introduced in connectivity, information technology and genomics: personalised genomic medicine and nutrition, the molecular diagnosis of diseases and so on.

8. There will be remarkable progress in personalised medicine and in controlling «orphan diseases». Advances in biochemistry will permit early diagnoses, detection and treatment of many extremely paralysing and impairing pathologies, such as multiple sclerosis

and Duchene muscular dystrophy. Enzyme replacement therapy has already begun, and in the future gene therapy will find a solution to many pathologies that are currently subject to difficult and costly treatment. Early diagnoses and corresponding therapies will be available to everybody. The use of biotechnology will enable new medicines based on the synthesis of suitable carriers that will be able to reach specific areas of intervention less invasively and with reduced systemic action.

9. We will see important advances in the understanding of how the brain works and the mechanisms of consciousness and learning. The concept of dark matter will be understood, and the origin of mass and a unified theory of physics (integrating gravitation and quantum mechanics) will emerge. Bio-inorganic organisms will be built. The essential nature of the transition from organised matter to matter with the vital ability to self-replicate will be understood. A scientific-technological convergence or oneness will take place involving the use of information, bioinformatics, nanotechnology and cognitive science systems.

10. A negative aspect that might arise in this context is the potentially more intense dependence of societies on those enterprises that have the greatest power of worldwide product distribution, as a result of globalisation. Legislative alignment of the worldwide community will play a fundamental role in regulating this and improving costs and delivery periods.

11. From one particular viewpoint, there is concern that the trend observed over the last 150 years seems to indicate that the current model of the pollution-creating, materialistic user, consumer and abuser of natural resources will prevail, so the previous allusions to the use of water and production of energy, food and commodities will be of the utmost importance. We call upon the capacity of the democratic nations to address their conflicts correctly and prevent the establishment and advance of retrograde regimes, enabling us to approach a new situation of equilibrium, in which the overriding issue of poverty is overcome.

12. Equipment and instruments will be more powerful and capable of automation and processing in all the different specialities of chemistry, even though the basics of detection, analysis or execution will remain. More advanced and robust hardware

and software systems will emerge, aimed at: a) reducing the consumption of reagents or solvents and minimal waste production, b) the highest number of samples per unit of time, c) improved resolution of the raw data obtained, d) higher generation and processing speeds, and, e) greater independence of operation (totally digitalised automation). Instruments and systems will require invulnerable remote operation, including the use of mobile devices. In short, the equipment and instruments will dispose of complete operational independence, leading to extremely high levels of automation.

Professionals will have to operate in a highly competitive environment that will demand quick and assertive responses from them, which may even include legal requirements or regulations concerning their environment, and will set out quality and safety standards by which to work. Methods of analysis, extraction, operation, or those linked to this process, must have corroborated validity and recorded technical foundations, without which the respective outcome will not be shared or used.

Professionals in this area will be drawn into the need to protect ground-breaking discoveries. To do so, they will need to work and be familiar with the legal grounds relating to intellectual property, which will undoubtedly provide protection for their intervention in fields where others also operate.

Two scenarios emerge within this context:

In the first scenario, future society will demand more sustainable, rapid and precise responses of professionals. Qualified scientific personnel will be required who use equipment and instruments that are able to remove ambiguities to a maximum in the shortest possible laboratory time, work in extremely reduced scales or volumes, with specific and sensitive analysis techniques, in such a way as to reduce laboratory operational costs and the generation of hazardous waste and residues. Chemistry should tend towards being sustainable in this way (green chemistry).

In the second, future society will require that our universities understand and act according to an employment scenario that is constantly changing due to the digital operational area, which is automatised and demanding, with extremely high and variable standards of quality and safety, and regulatory affairs. In addition to the formal basic/technical programme, universities will need to establish training areas that are complementary, flexible and evolving, enabling professionals to train in emerging areas.

With regard to foreseen digitalisation and automation, the implications of the first scenario are, irrespective of how advanced the techniques and equipment are, that the professional will always be in control and have the last word. As for the second scenario, universities are envisaged as being fully connected to networks where quality, safety and regulatory affairs are incorporated into the curriculum. The different types of expected connections are: a) one-way: multiple networks with commercial (industries) and educational (e.g. online search services) bodies; b) multi-directional, with other universities promoting exchanges and the merging of programmes, projects or systems, attending to the immediacy of response, efficiency of the programmes and optimisation of costs.

5.2. Professions that can be envisaged in each scenario

1. The implications for our professional areas will be huge in any scenario because society will demand increasingly more of the scientific disciplines, educators and those generating knowledge. Everything related to the technological convergence taking place is highlighted, which essentially involves nanotechnology, cognitive sciences and bioinformatics. In this respect, it should be noted that all the interviewees coincided in the interdisciplinary nature of future professions, whether they be geared towards the basic sciences or technology: physicochemists, nanochemists, biochemists, materials chemists, biotechnologists, nanotechnologists, chemical bioengineering, cheminformatics, environmental chemistry, genomic chemistry and medicine, the development of personalised drugs in order to make progress in molecular therapy, chemistry and biology. The intensive use of complex instrumental systems is expected, such as mass spectrometry, gas chromatography, high resolution chromatography, nuclear magnetic resonance, X-ray diffraction, scanning electron microscopy, chromatography-mass spectrometry coupled systems, atomic spectroscopic systems and so on. All of these will be accompanied by the full use of information technology, analytics, physicochemistry and the handling and

interpretation of data. Scientific communicators specialising in different disciplines are also mentioned, such as specialist computer experts, (bioinformaticians, chemometricians, ontological engineers and so on). It is considered that professionals will not only master theoretical and monitoring aspects but also the ability to deal with modelling, information systems and applications for agriculture. The expectation that environmental studies will be mainstreamed into the curriculum was expressed. One interesting point should be made: the need to train teachers specialising in natural sciences (physics, chemistry, biology and so on) in primary and secondary education.

2. There was also mention of professions relating to: a) industrial chemistry to develop new medicines, food for human and pet consumption, new textile fibres, personal care products, cosmetics, perfumes, facial care creams and hydroponic crops; b) the chemistry of enzymatic and chemical biotransformation processes to develop more efficient and less pollutant fuels and biofuels, new methods of extracting and purifying metals, natural products, more efficient methods of producing commodities, and new, tougher and lighter building materials; c) the chemistry of new technologies of product synthesis, water and waste treatment and clean technologies; d) the development of new energy systems and sources (there could be a pronounced shift towards the use of natural gas), environmental control and mitigation and climate change: e) biomathematics, molecular medicine and genomic sciences, bioethics and environmental sciences.

3. In more holistic terms, the validity of the following professions is envisaged: physicists, chemists, mathematicians, biologists, biochemists, environmental engineers, materials engineers, statisticians, toxicologists, psychologists, systems engineers or computer experts, ecologists, automation process engineers, anthropologists, sociologists and educators. Professionals will be needed who are capable of using both water resources and irrigation systems efficiently. Emphasis is placed on the ability to work in an interdisciplinary way and the chemistry degree is highlighted as being the driving force behind and backbone of these new professions.

4. To some interviewees, more than new professions, what will be required will be new, socially responsible professionals in order to

optimise the solving of practical problems and to consolidate the transfer of technology, highlighting the following, on the basis of international models: civil engineering, medicine and health sciences, education to train talented university students, foreseeing the professional focuses in areas of hard sciences or informatics over those of a social nature.

5. Placing emphasis on the technical aspects of the future professional, without anticipating any new professions whatsoever: professionals will be required with solid training in robotics, enabling them to link the necessary chemical or physical phenomenon for unassisted emulation and execution. They will need to have complete knowledge of the mechanical steps leading to a chemical performance or efficiency of extraction that meets the established success requirements or criteria, with high operational efficiency, quick response, low energy consumption (sustainability) and minimal environmental impact. The high degree of automation will allow the professional to devote more of their time to improving, creating, designing or innovating programmes or systems that already exist or are yet to exist.

Professionals will be required who are familiar with the industrial environment surrounding them and even the overview that a potentially globalised regulatory body demands they know. Safety, quality and the regulatory aspect are the three elements which will be essential for the successful and proper performance of future professionals and, consequently, they will have to be incorporated into the curriculum.

5.3. Competences required by these professions

The traditional boundaries between the different scientific disciplines will continue to be eroded. It will therefore be increasingly necessary to turn to multidisciplinary approaches to meet scientific and technological challenges. The boundaries of scientific research are now spreading, with the particular participation of multidisciplinary teams. The complexity of systems will demand new ways of understanding and applying knowledge.

It can be seen that, right from the beginning of the degree programme, there will be the need to work on interaction with the environment, whether it be educational, scientific, productive or social, so that, among other benefits, the response of human beings to changes in consumption patterns can be improved. Degree programmes should be more open and participative with the community, and should contain a component of social sciences (including those relating to statistical and management sciences). It is highly desirable that new professionals, as well as being talented, should be concerned with achieving a healthy inner balance (by cultivating reading, conversation, leisure activities and so on) which may position them as valued and educated professionals - not only because of the specific contribution of their discipline, but also because they collaborate as human beings to the growth of the community.

Within the framework of these complex expectations, the following competences highlighted by the interviewees are predicted as being the most important for future professionals. It would, perhaps, be better to refer to some of these competences as qualities. They have been summarised as shown below:

1. Capacity for analysis, synthesis and self-learning.
2. Ability to search for new, more efficient production methods.
3. Social responsibility and commitment to society and the environment.
4. Professional ethics when faced with different cultures.
5. Awareness and knowledge of how to conduct oneself in different cultures.
6. Ability to work within international environments.
7. Social tolerance.
8. Ability to adapt.
9. Leadership, empathy, emotional intelligence.
10. Ability to plan, organise and persevere.
11. Entrepreneurship.

12. Ability to use new information and communications technology.

13. Ability to act with curiosity, drive, proactivity and perseverance, to put forward innovative solutions and be sociable.

14. Capacity for oral and written communication in several languages, particularly English.

15. Ability to work under extreme pressure.

16. Ability to be analytical, practical and competitive.

17. Having flexibility and versatility.

18. Pursuing applied studies, while increasing the basic general knowledge that equips them with solid foundations and a sound training in chemistry.

19. Ability to define the metascience behind each discipline (chemistry, physics, biology, etc.) that enables true interdisciplinarity.

20. Intellectual rigour, professional maturity, ingenuity and commitment to their work and company. Pleasure from «a job well done».

21. Ability to work with new technologies.

22. Applying molecular knowledge and techniques with expertise, skill and ethical rigour.

23. Knowledge of biomedicine, neurochemistry and nanotechnology.

24. Ability to arrange coordination with other disciplines and sectors of society, in addition to the academic sector.

25. Ability to interact with the State and national, regional and local governments.

26. Knowledge of legal and regulatory aspects relating to invention (e.g. intellectual property).

27. Ability to solve complex problems by means of simple, economical or practical approaches or solutions.

28. Ability to simplify pre-existing systems/methods/procedures - for example, directly or remotely operated automated systems.

29. Ability to harmonise systems.

30. Ability to work in multifunctional groups.

Lastly, we would like to mention that the competences required for such professionals are provided by the international framework: Australian universities (Bradley Report), UK (Dearing Report and Robinson Report), USA (Margaret Spellings Report) and the Arizona State University.

5.4. Other relevant comments about the future

Possible but improbable scenarios

1. Coordination between the State and areas of education in science and technology and the resulting relationship with the social and productive environment will generate highly relevant and rigorous work objectives aimed at the improvement of human development, leaving arms spending to one side (conflict hypothesis).

2. New degree programmes more closely linked to other, more open programmes which are less academic, with universities focusing more on processes and strategies (knowledge management) than structures and procedures. Degree programmes in which the prime concern will be the demand for knowledge instead of the demand for professions.

3. *Teleportation.*

4. Possibility of implanting chips in textiles in order to communicate even more rapidly.

5. Within an overall context, a vision of the future of the field of chemistry could be the possible scenario where political and economic interests do not go hand-in-hand when establishing rules/procedures governing industrial and public sectors or agencies alike. Assuming that both sectors abide by the regulations

and laws in force (according to applicability) whilst aiming at the industrial development of the country in question, this possible scenario becomes rather improbable, although it will need professionals with sound knowledge of their area who also have highly developed management and negotiation skills. Universities will have to train our future professionals with an increasingly globalised, technical and integrated world in mind, which they will be faced with. Training areas in close connection with the public or private working environment will also have to be developed and perfected.

6. A more cohesive society living far more rationally, with a far less materialistic and consumerist viewpoint- a return to the things that are truly important. However, this would lead to a catastrophe because it would dismantle all our life patterns. In this ideal scenario, educators with other, completely different points of views are needed who advocate different values. And there is also the view of the major areas: food, water, energy and commodities.

7. A drastic decrease in world population due to natural cataclysms, world wars and global pandemics owing to the appearance of new or mutant viruses. In this utterly undesirable scenario, chemists with expertise in nanotechnology and biotransformation, enzymatic and chemical processes will be needed. There will also be a need for chemists with sound knowledge of nuclear chemistry, who specialise in emission control, nuclear reactors and soil, water and air decontamination. The following competences will be of interest: (a) the ability to synthesise basic products, medicines from natural products, cleaning products and disinfectants; (b) the ability to search for, process and analyse; (c) the ability to develop products from the most basic elements.

8. There is concern regarding problems of terrorism, drug trafficking, social inequality, deficient education, integrity and ethics, which could lead to a situation of insecurity that threatens economic development and gives rise to a regression or downturn in the region's progress and an increase in social unrest. A great deal of emphasis is placed on an integrated approach to problems with long-term solutions, whilst respecting and caring for natural resources, and on the need to improve the quality of education provided at all levels, especially at school level, in order to have a positive impact on the development of science and technology. In

this respect, there is a call for the training of teachers in natural sciences (physics, chemistry and biology) in order to teach these disciplines at primary and secondary levels.

9. Universities with low levels of bureaucracy, with the resulting impact on student training. In this scenario, the use of the Internet will be of paramount importance, as will the command of several languages, including Mandarin. Mathematics will play a fundamental role, not only for calculus, but also as a tool to learn how to think and carry out assessments.

10. Creation of a regional reference centre for the diagnoses of rare pathologies, for which good communications enabling the rapid transport of samples will be needed, irrespective of the patient's location in the region. Biochemists, doctors, computer experts and laboratory technicians will be needed for this.

The following aspects should also be considered:

1. In the future, more will need to be learnt from nature and attempts made to mimic it, especially aspects relating to energy use.

2. Society will be characterised by three elements: a) far more globalised and international, b) highly technical, where knowledge will play a central role, and c) increased awareness of the need to look after nature and the common good.

3. The chemist will need to be able to prepare and set in motion innovative projects which aim to solve macro-problems that are far-reaching and sustainable over time.

4. Laboratories equipped, from manufacture to quality control, with technologies enabling higher productivity, but with safety, efficiency and speed of control.

5. Society will undergo radical transformations as a result of environmental changes, water and energy issues, increased life expectancy, insufficient vegetation cover, a decrease in food availability and its shortage, the high cost of energy and its dwindling production, unemployment and so on. The value of knowledge and know-how will increase and specialisation geared

towards generating goods and services will prevail. Specialisation in human activities will be increasingly needed and development requirements will increase. Taking into consideration reports by the Organisation for Economic Cooperation and Development (OECD), World Bank and organisations such as the FAO and WHO, a notable increase is envisaged in technology serving the economies and development of countries where the education sector will be of paramount importance, especially tertiary education obtained in world-class universities or technical institutes, which are lacking in our countries. Society will tend towards increased computerisation which will, in some ways, entail a loss in social relations.

6. A progressive epistemological rupture will take place in the scenario of basic sciences, and the global technology gap will widen. Life expectancy at birth will increase for privileged sectors of postmodern societies, which will determine the need for technological progress and the globalisation of demands and opportunities to train professionals.

7. Universities will have to adapt to the new realities of higher education and research costs. There will be room for institutions with different institutional formats, for example, cooperatives and more traditional formats with free exercise; both must survive and grow, because they play different roles in the opening-up of new horizons to human creation and the use of knowledge. Universities with successful programmes will probably be those applying both operational philosophies - an opinion based on the concept of full complementary nature of differentiated systems - as a factor leading to the strengthening of the finished product, i.e., the whole is greater than the sum of its parts.

6

General Conclusions

A methodology was developed to generate a META-PROFILE, which can serve as a guide to design, tailor or modify competence-based programmes, considering a certain percentage of coincidence between generic and specific competences on the basis of the policies and guidelines implemented in each educational establishment. This guide will enable there to be a lot of coincidence between the chemistry programmes at different educational establishments in the same country and between different countries. Thus, the hope is to generate similarities or tuning between programmes, promoting student mobility in such a way that students would have the chance to study subjects which would be recognised by their original universities.

On the other hand, universities must create new degree programmes or professions in response to the current needs of the labour and scientific sectors. However, the generation of graduates has arrived at the labour market just at the wrong time, when needs have changed. Universities need to work through more dynamic mechanisms (improvement, interdisciplinarity, etc.) with increased integration among the actors (the productive sector, social sector, society, academic sector and government sector). The most important thing is that chemists must guarantee quality work that is sustainable, ethical and socially responsible in the new degree programmes where they will be the main actors.

It is clear that there is a need for new degree programmes in the area of chemistry which satisfy these sectors' new needs or requirements.

Competences to assess the teaching-learning process were also defined and the most common strategies applied were identified - for example, oral presentation, discussion and debate forums, problem solving, fieldwork, assessments, laboratory practice and bibliographic reviews.

The most common strategies to teach generic competences are oral presentation, multimedia, flow charts, problem solving and class debates and discussions. The most common strategies to learn generic competences were identified as the following: assignments, reviewing bibliography, preparing written records, dealing with problems and making an organised, written record of them, student presentations on specific subjects, fieldwork and library use. The most common strategies to assess generic competences were identified as follows: written and oral assessments, assignments, active participation, class debates and discussions, open-ended questions on previous work, presentations, attendance, projects and practice. The most common strategies to teach specific competences were identified as follows: oral presentations, exercises and problems, advisory classes, electronic guides, laboratory practice and student presentations on specific subjects. The most common strategies to learn specific competences were identified as follows: solving exercises and problems in class, class discussions, reading basic principles to resolve electronic assignments, laboratory practice. The most common strategies to assess specific competences were identified as follows: oral and written assessments, bibliographic reviews, active participation, class debates and discussions, open-ended questions on previous work, presentations, attendance, projects and practice.

Finally, with regard to student workload, it is observed that students and teaching staff in the area of chemistry are of fairly similar opinions regarding the total amount of time students set aside for their professional training; the difference between the two views does not exceed 15% in relation to the overall average obtained. It can therefore be concluded that the total amount of time for the area of chemistry is highly appropriate. Furthermore, it can be seen from the results of the correlation diagram that the areas of chemistry, engineering, physics and information technology are located in the same part of the graph, meaning they evidence very similar behaviour.

As an outcome of this exercise of reflection, discussion and analysis concerning subjects on higher education in universities in Latin America, the creation of a «TUNING LATIN AMERICA CHEMICAL NETWORK» (REQUITUAL) has been put forward. Its overall aim is to encourage scientific and academic cooperation among students, teaching staff and researchers at the educational establishments that make up the Chemistry group in the ALFA TUNING LATIN AMERICA network, in the area of improving programmes, research into chemistry teaching, priority lines of research identified by the group and, in particular, encouraging student and teaching staff mobility - all within the framework of competences and the Latin American Credit Reference system.

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