Quality Labels for Interdisciplinary Studies Related to Chemistry

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The European Chemistry Thematic Network Association developed qualifications frameworks based upon the Budapest Descriptors, and aimed at enhancing excellence and tuning education and training in chemical sciences. Faced with the need for bridging subject areas, the quality labels Eurobachelor®, Euromaster® and Chemistry Doctorate Eurolabel® were designed with a focus on inter-disciplinary studies as a substantial target group. The paper is discussing the problems encountered while accrediting interface study programmes, and is defining prerequisites and evaluation criteria, in order to assure high quality and full openness in the overall context of the Bologna Process approach.

Eurobachelor®, a quality label for the first cycle, is defining minimum requirements. Although studies at the interface of chemistry with other disciplines are not very common in the first cycle, their possibility is taken into account in the qualifications framework. The Euromaster® quality label is awarded to programmes in chemical sciences. According to the needs of the institution, such programmes will be either broadly-based or specialised, and include a series of master’s courses at the interface of chemistry and other disciplines. Taking into account that European Ministers urge universities to ensure that their doctoral programmes promote interdisciplinary training, award of the Chemistry Doctorate Eurolabel® to interface structured third cycle studies is a responsibility carefully framing conditions and requisites.

Evaluating the quality of interface studies at any level is not an easy task. Thus, the European Chemistry Thematic Network Association has proceeded to the award of Quality Labels for interdisciplinary studies related to chemistry only after consolidating the relevant Descriptors, and within a frame combining the care for strict respect of rules and judicious adaptation to specific situations.

Quality assurance is the main requisite in implementing an effective European Higher Education Area, characterised by mutual recognition of study programmes within a transparent framework of harmonised practices. In this setting, the European Chemistry Thematic Network Association [1] developed qualifications frameworks aimed at enhancing excellence and tuning education and training in chemical sciences.

Multi-facetted by definition, the relevant evaluation procedures increase in complexity in the case of studies at the interface of chemistry and other subject areas.

At present, opportunities for education and research in specific interdisciplinary issues are increasing, since there is an obvious need for bridging branches of studies.

Faced with the issue, the quality labels Eurobachelor®, Euromaster® and Chemistry Doctorate Eurolabel® were designed with a focus on inter-disciplinary studies as a substantial target group.

Based on the expertise acquired by way of a considerable number of awards, the paper is discussing the problems encountered while accrediting interface study programmes, and is defining prerequisites and evaluation criteria, in order to assure high quality and full openness in the overall context of the Bologna Process approach.

Eurobachelor®, a quality label for the first cycle, is based upon the Budapest Descriptors [2], the recognised adaptation of the Dublin Descriptors [3] for chemical sciences. In this setting, first cycle degrees in chemistry are awarded to students who have shown themselves by appropriate assessment to:
- Have a good grounding in the core areas of chemistry, and in addition the necessary background in mathematics and physics.
- Have basic knowledge in several other more specialised areas of chemistry.
- Have built up practical skills in chemistry during laboratory courses, in which they have worked individually or in groups.
- Have developed generic skills in the context of chemistry which are applicable in many other contexts.
- Have attained a standard of knowledge and competence, which will give them access to second cycle programmes.

Such graduates will:

- Have the ability to gather and interpret relevant scientific data and make judgements that include reflection on relevant scientific and ethical issues.
- Have the ability to communicate information, ideas, problems and solutions to informed audiences.
- Have competences which fit them for entry-level graduate employment in the general workplace, including the chemical industry.
- Have developed those learning skills that are necessary for them to undertake further study with a sufficient degree of autonomy.

Within this overall framework, the Eurobachelor® quality label [4] is carefully defining minimum requirements. Although studies at the interface of chemistry with other disciplines are not very common in the first cycle, they are taken into account in the qualifications framework.

Indeed, in a total of 180 to 240 ECTS credits at least 90 ECTS credits should form the core of the study programme, and be allocated to compulsory modules on analytical, inorganic, organic, physical and biological chemistry, further on physics and mathematics.

Additional 60 ECTS credits should as well deal with other aspects of chemistry, mathematics, physics or biology in the following way: 15 ECTS credits are assigned to the bachelor thesis / industrial placement, an initial research experience in chemical sciences. It is further recommended that at least three additional chemistry-related subjects, equivalent to 15 ECTS credits, should be selected by students among semi-optional modules; and it is highly advisable that additional 30 ECTS credits should come from optional modules on natural and exact sciences. These semi-optional and optional modules may include biology, theoretical/computational chemistry, chemical technology, or macromolecular chemistry.

Biochemistry, industrial chemistry, food chemistry etc. form thus part of the study programmes that may be awarded the quality label, even if the remaining freely allocable 30 to 90 ECTS credits are not taken into account. In fact, a careful selection of modules covering these ECTS credits permits a number of interdisciplinary studies to be included in the frame of the Eurobachelor®. Science education, materials science and conservation science are examples.

The Quality Label Committee has several times evaluated programmes in industrial chemistry, biochemistry and biological chemistry.

In the case of the Euromaster® quality label the Budapest Descriptors state that:

Second cycle degrees in chemistry are awarded to students who have shown themselves by appropriate assessment to:
- Have knowledge and understanding that is founded upon and extends that of the Bachelor’s level in chemistry, and that provides a basis for originality in developing and applying ideas within a research context.
- Have competences which fit them for employment as professional chemists in chemical and related industries or in public service.
- Have attained a standard of knowledge and competence which will give them access to third cycle programmes.

Such graduates will:
- Have the ability to apply their knowledge and understanding, and problem solving abilities, in new/unfamiliar environments within broader/multidisciplinary contexts related to chemical sciences.
- Have the ability to integrate knowledge and handle complexity, and formulate judgements with incomplete or limited information, and to reflect on ethical responsibilities linked to the application of their knowledge and judgements.
- Have the ability to communicate their conclusions, and the knowledge and rationale underpinning these, to specialist and non-specialist audiences clearly and unambiguously.
- Have developed those learning skills that will allow them to continue to study in a manner that may be largely self-directed or autonomous, and to take responsibility for their own professional development.

The Euromaster® quality label [5] is awarded to programmes in chemical sciences involving 90 to 120 ECTS credits, at least 60 of which must be at master’s level, and including a thesis carrying at least 30 ECTS credits.

Since second cycle studies are much more flexible than first cycle ones, it is neither necessary nor advisable to list areas of subject knowledge, which should be covered by a master’s programme. According to the needs of the institution, such programmes will be either broadly-based or specialised; nevertheless all graduates are asked to have the following chemistry-related cognitive abilities and skills:

- Ability to demonstrate knowledge and understanding of essential facts, concepts, principles and theories relating to the subject areas studied during the master’s programme.

- Ability to apply such knowledge and understanding to the solution of qualitative and quantitative problems of an unfamiliar nature.

- Ability to adopt and apply methodology to the solution of unfamiliar problems.

Should the topic involve laboratory procedures, then the following competences are sought:

- Skills required for the conduct of advanced laboratory procedures and use of instrumentation in synthetic and analytical work.

- Ability to plan and carry out experiments independently, and be self-critical in the evaluation of experimental procedures and outcomes.

- Ability to take responsibility for laboratory work.

- Ability to use an understanding of the limits of accuracy of experimental data to inform the planning of future work.

In fact, the Quality Label Committee has evaluated master’s courses at the interface of chemistry and other disciplines, reaching from computational chemistry to science education or conservation science.

According to the Budapest Descriptors, third cycle (doctoral) degrees in chemistry are awarded to students who:
- Have demonstrated a systematic understanding of an aspect of the science of chemistry and mastery of those skills and methods of research associated with the topic of this research.
- Have demonstrated the ability to conceive, design, implement and develop a substantial process of research in chemical sciences with rigour and integrity.
- Have made a contribution through original research that extends the frontier of knowledge in chemical science by developing a substantial body of work, some of which merits national or international refereed publication.
- Have competences which fit them for employment as professional chemists in senior positions in chemical and related industries, or for a progression to a career in academic research.

Such graduates:
- Are capable of critical analysis, evaluation and synthesis of new and complex ideas.
- Can communicate with their peers, the larger scholarly community and with society in general about their areas of expertise.
- Can be expected to be able to promote, within both academic and professional contexts, scientific and technological advancement in a knowledge based society.

Therefore, the Chemistry Doctorate Eurolabel® [6] expects students being awarded the doctoral degree to:
- Demonstrate broad knowledge in and a systematic understanding of the field of research, together with deep and up-to-date specialist knowledge in a defined part of the field of research;
- Demonstrate familiarity with scholarly methods in general and with methods in the specific field of research in particular;
- Demonstrate an ability to engage in scholarly analysis and synthesis and in independent, critical examination and assessment of new and complex phenomena, issues and situations;
- Demonstrate an ability to identify and formulate issues, critically, independently and creatively, and proceeding with scientific precision, and to plan and - using appropriate methods - conduct research and other advanced tasks within specified time limits, and to scrutinise and evaluate such work;
- Demonstrate, in a dissertation, an ability to make a substantial contribution to the development of knowledge by their own research;
- Demonstrate an ability to present and discuss research and research results with authority, in dialogue with the scholarly community and society in general, orally and in writing, in both national and international contexts.

Taking into account that countries belonging to the European Higher Education Area urge universities to ensure that their doctoral programmes promote interdisciplinary training [7], award of the Chemistry Doctorate Eurolabel® to interface structured third cycle studies is a responsibility carefully framing conditions and requisites. Interdisciplinary curricula are indeed a complex issue, since the educational qualifications of teachers and students, as well as the learning outcomes expected and the pedagogical lines used, are far from homogeneous. Although Ph.D. candidates are supposed to have *a priori* the indispensable advanced scientific knowledge and skills, there are considerable variations in the depth of their acquaintance with concepts and issues required for the successful achievement of their goals, but not related to their former educational background.

In general, it is expected that candidates have demonstrated the knowledge and competences necessary for performing original research in the interdisciplinary area as a whole; while supervision, examination and assessment should cover all disciplines involved.
An overview of specific descriptors for interface subjects, as they have been implemented by a large number of European universities, permits emphasising the necessity for multiple supervision covering both subject areas, in order to address all needs the candidate may have. In addition, admission is commonly requiring either a master’s degree or equivalent qualification in the relevant interface subject; or a master’s degree in one of the interface subjects and master’s level preparatory courses in the subject not covered.

The award of a Chemistry Doctorate Eurolabel® to any type of interdisciplinary structured third cycle studies related to chemistry is cautiously adapting these general concepts into the reality of the concrete programme [8]. In fact, the Quality Label Committee has evaluated doctoral programmes at the interface of chemistry and other disciplines, dealing with industrial chemistry and science education.

As an overall conclusion, it may be pointed out that evaluating the quality of interface studies at any level is not an easy task. Thus, the European Chemistry Thematic Network Association has proceeded to the award of Quality Labels for interdisciplinary studies related to chemistry only after consolidating the relevant Descriptors, and within a context combining the care for strict respect of rules and judicious adaptation to specific situations.

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