THE IMPLEMENTATION OF THE BOLOGNA PROCESS INTO PHYSICS IN EUROPE: THE MASTER LEVEL

EPS Report

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THE IMPLEMENTATION OF THE BOLOGNA PROCESS INTO PHYSICS IN EUROPE: THE MASTER LEVEL

This study was carried out in 2009/10
Results were published in September 2010

Submitted to the **European Physical Society** by

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EXECUTIVE SUMMARY

1. This study is an analysis of the implementation of **Bologna reform** goals into **Master Programmes in Physics** (Bachelor programmes were analysed in a previous study) at 129 universities in 24 Bologna signatory countries. The analysis comprised two steps: (a) an online questionnaire was sent to programme coordinators to be filled in (response rate: 57 %); and (b) an analysis of curricula on the basis of printed or electronic material supplied by programme coordinators (response rate: 58 %). The curricular material is biased towards British and German universities who submitted the highest number of curricula (71 from Germany, 183 from the UK). Most universities participating in the study offer more than one Master programme in Physics (63 % offer between two and five Master programmes).

2. The **basic characteristics** of Master programmes in Physics included in the study can be described along three features: (a) the majority (77 %) is **research-oriented**; (b) somewhat more than half (56 %) are offering a **standard Physics** curriculum and somewhat less than one quarter each (22 % for both) are either specialised or interdisciplinary; (c) the overwhelming majority (97 %) of programmes is **consecutive** while only three percent were continuing education programmes. However, also standard Master programmes in Physics clearly have a higher degree of specialisation if compared to Bachelor programmes.

3. The **majority** of Master level programmes in Physics have a **duration of two years** in continental Europe and the Nordic countries. In contrast the UK sample showed that 47 percent of the programmes have a duration of one year and 46 percent a duration of four to five years (integrated Master programmes).

4. The **use of ECTS is widely established**. UK/Ireland, Lithuania and Belarus are exceptions, either using their own credit point system (UK/Ireland) or none at all. Typically one ECTS credit point requires a student workload of 25 to 30 hours. However, the responses to the questionnaire also showed that **credit point calculation on the basis of workload is not understood everywhere** and by everyone, despite the fact that in most countries national regulation exists.

5. The **most elusive concept** is that of **modularisation**. 67 percent of respondents to the questionnaire said that all their programmes were modularised. In two countries modularisation has not been introduced at all. In other countries some programmes are modularised others not. **Considerable differences** can be found **among countries and programmes** when trying to determine the time unit that constitutes a module. Here variations can be found ranging from one to six ECTS credit points up to larger study blocks of several weeks or even months.

6. The provision of a **Diploma Supplement** upon graduation is becoming more **widespread**. 70 percent of the respondents stated that Physics graduates are supplied with a Supplement. Of these the vast majority (87 %) said the Supplement was provided automatically, the rest said upon request.

7. Master programmes in Physics – even when characterised as 'standard Physics' – have a **high level of specialisation** which is either integrated or constitutes an independent curriculum. Somewhat less than one quarter (22 %) of the respondents also stated that their department was offering **interdisciplinary** Master programmes in Physics mostly combined with other natural sciences (64 %), followed by engineering (55 %), and medical sciences (24 %). Combinations with other subjects from the social sciences and humanities occurred less frequently.

8. **Mobility and internationalisation** of Master programmes in Physics was analysed in four respects: First, 11 percent of respondents stated that their university offered **double and joint degree** programmes with an integrated period of **study abroad** in Physics. In addition there were another 22 percent of respondents stating that study abroad was part of the curriculum of some or all Master level Physics programmes. Second, high numbers of international students can be found in Master level Physics programmes in Spain, Germany, Sweden, the UK and Ireland. Third, high numbers of outgoing students can be found in Germany, the Netherlands, and Slovakia. Finally, 41 percent of the respondents stated that **teaching** was done at least partially in a **foreign language**. Only UK and Ireland are an exception in this respect. Respondents generally observed an increase in incoming and outgoing students at the Master level and perceive a linkage to the Bologna reforms.

9. Typically **student performance** is assessed **after each module** (91 % of respondents stated this) and in 75 percent student performance during the course of study is included into the calculation of the final mark or the final degree classification. In contrast to many Bologna reform discussions still 44 percent of respondents said that only **subject knowledge** was assessed (56 % stated that both subject knowledge and **transferable skills** are assessed). The **concept of learning outcomes** and the question how to assess them is **still rather unclear**.

10. **Cooperation with employers** during the design and development of all or some Master level Physics curricula was sought by 46 and 17 percent respectively of respondents to the questionnaire. 37 percent stated that this was not the case. Also almost one quarter of respondents from universities (22 %) said that transferable skills were not part of their curriculum. For technical universities this was the case only in 10 percent of respondents. Typical **transferable skills** that students can acquire in Master level Physics programmes are communication skills (77 %), social skills (62 %), international competences (62 %), and self-organisation competences (59 %).

11. The most dominant criterion for **access into Master programmes** in Physics is the **grade point average** from the Bachelor degree (63 %) or – for integrated Master programmes – from the school leaving certificate (73 %). However, 34 percent of respondents also stated that they carry out **interviews** with eligible candidates or have established other **additional criteria** (32 %).

12. A **European mainstream** is emerging which requires successful completion of a **Master degree for admission into a doctoral qualification** phase. Transition rates of Master graduates into the labour market have not (yet) changed very much, while transition rates into a doctoral qualification phase show a more varied picture but are not sufficiently valid yet.

13. **Quality management** has been on the agenda of institutions in most countries already **before signing the Bologna Declaration**. A broad range of quality assessment and improvement mechanisms have been introduced by now. **Accreditation** is the only mechanism which is perceived to be closely **related to the Bologna reform process**.

14. Overall, we found some degree of **harmonisation at the macro level** (two-cycle structure, ECTS) but a high amount of **heterogeneity at the institutional and the programme level**. This has **implications for** the question whether **recognition** should be based on similarity (standards) or on equivalence.

PHYSICS MASTER STUDIES

1. Introduction: Description of the Project

In 2007 the European Physical Society received funding from the European Commission to carry out a study of the implementation of the two-cycle (Bachelor/Master) study and degree structure into Physics programmes in European Universities. It was envisaged to cooperate with the National Physical Societies of at least 15 European countries to collect relevant Physics curricula for in-depth analysis and conduct an online survey addressed to coordinators of Physics programmes in a representative sample of universities in each of the countries involved in the study. The International Centre for Higher Education Research (INCHER-Kassel) at Kassel University was subcontracted as a partner in this project to analyse the curricula and administer the survey. Representatives of the European Physical Society acted as members of the steering group of the project as a whole and as contact persons to the national Physical Societies.

Originally it was envisaged to include both standard Physics programmes and Engineering Physics programmes into the analysis, however, during a first meeting of project partners and steering group it was decided to concentrate in the first year of the project on standard Physics Bachelor programmes only and exclude Engineering Physics and teacher training programmes in Physics in order to arrive at a relatively homogeneous sample of programmes for the analysis (*cf.* European Physical Society 2009). In this report the results of the second phase of the study are presented concentrating on Master level Physics programmes. A decision was taken by the steering group to include Engineering Physics as long as a Physics degree was awarded at the end but to continue to exclude teacher training programmes in Physics.

The aims of the project can be summarised as follows:

- to provide an overview of the state of implementation of Bachelor and Master structures in Physics programmes in Europe;
- to analyse possible regional differences in the structures;
- to determine to what extent common standards and appropriate examinations have been introduced as an element of quality assurance;
- to provide information about the extent of modularisation that can be found in the new structures;
- to assess whether professional qualifications can be obtained within the framework of Master programmes in Physics; and
- to determine whether Master programmes offer a higher degree of specialisation and, thus, diversity.

Due to the specific character of Physics programmes in most European countries which have introduced the Bachelor/Master structure only in recent years, there will also be a special focus on the interfaces and transitions, *i.e.* the transition from Bachelor Physics programmes into Master Physics programmes and the transition either into the labour market or into a doctoral qualification phase [1].

Overall, the study aims to provide a profile of the implementation of the Master structure in European Physics programmes and arrive at conclusions pertaining to the following issues:

- an assessment whether major goals of the Bologna Process have been addressed and whether the aims of the European Commission's "Education and Training 2010" Work Programme will be met;
- yielding the basis for advice to students interested in changing university or spending some time of study abroad;
- providing a basis for modifications and amendments which might become necessary to achieve the overall reform goals.

[1] All references to the doctoral phase will talk about doctoral candidates rather than doctoral students because in the majority of countries involved in this study the doctoral phase is not considered as 'studies' but as the first step in a researcher's career. In the UK the standard route to a PhD is a 4-year integrated Master programme. There is also much variety with regard to the structuring of the doctoral phase. It can be organised within programmes or graduate schools, as an individual but supervised research phase or within the framework of project teams. Thus the status also varies and depends on the kind of funding available.

2. Design of the Study

After having determined the sample size – approximately 60 percent of all universities offering Physics programmes in the large countries involved in the study and as close as possible to 100 percent of all universities offering Physics programmes in the small countries – contact persons in the respective National Physical Societies were asked to select the respective number of universities and ask the local programme coordinators to send their Master Physics curricula to INCHER-Kassel. Where necessary they were also asked to help with translations into English. The curricular material was analysed according to a list of criteria (*cf.* chapter 4) which had been derived from the main structural dimensions of the Bologna reform process.

In a second step an online questionnaire was designed covering altogether nine areas:

- personal details of the respondent (status and function),
- institutional details (type, size),
- implementation of the tiered (two-cycle) structure (accreditation status, duration, number of programmes on offer),
- implementation of complementary measures (ECTS, workload, modularisation, mobility opportunities),
- characteristics and structure of the curriculum (generalised/specialised, use of foreign languages in teaching and learning, extent of interdisciplinarity),
- forms of student assessment and examinations,
- mechanisms of quality assurance,
- employability and acquisition of transferable skills,
- number of international students, completion rates and transition into a doctoral qualification phase or into the labour market.

Due to reasons of data protection all universities having submitted curricular material as well as all persons filling in the online questionnaire were assured of complete anonymity[2].

3. The Bologna Process and Physics Programmes

3.1 The Bologna Process: Structures and Elements of the New Study Programmes

The overall goal of the Bologna Declaration and the resulting reform process (for short: Bologna Process), namely to create a European Higher Education Area (EHEA) by the year 2010 has been described as a "target on the move" (*cf.* Kehm/Huisman/Stensaker 2009). And indeed, with every ministerial meeting after the one in Bologna in 1999 when the original Declaration was signed by 26 European countries, goals were added to the agenda and targets refined increasingly moving from a mostly structural level to also include content related goals.

By now, 47 countries in all have signed the Declaration and the Bologna Process is regarded as the biggest and most far reaching reform of curricula and study structures since possibly the period after World War II. In addition to ever more countries joining the reform, stakeholder inclusion was extended as well. Starting as an intergovernmental initiative of ministers responsible for (higher) education, deliberations, follow-up and stocktaking now include the European Commission, the European University Association (EUA), the European Student Union (ESU, formerly ESIB), and a number of other actors (*e.g.* ENQUA, EURASHE, the Council of Europe).

Despite the growing complexity of the reform agenda, there are a few core issues which can be said to have constituted the main targets for 2010:

- the adoption of a system of easily readable and comparable degrees, also through the implementation of the Diploma Supplement (Bologna Declaration 1999);

[2] It is necessary here to keep in mind that some programmes have adopted the model of undergraduate and graduate education which implies that graduate education comprises Master students and doctoral candidates without statistically differentiating between the two (at least not during the taught part of a programme).

- the adoption of a system essentially based on two main cycles, undergraduate and graduate, the first cycle lasting a minimum of three years and being relevant to the European labour market as an appropriate level of qualification (Bologna Declaration 1999);
- the establishment of a system of credits (such as in the ECTS system) to promote student mobility (Bologna Declaration (1999);
- the promotion of mobility of students, teachers, researchers and administrative staff including recognition and valorisation of periods abroad (Bologna Declaration (1999);
- the promotion of European cooperation in quality assurance to develop comparable criteria and methodologies (Bologna Declaration 1999) further refined in the Berlin Communiqué 2003);
- the promotion of the necessary European dimensions in higher education with regard to curriculum development, inter-institutional cooperation, mobility schemes, and integrated programmes of study, training and research (Bologna Declaration 1999);
- to promote lifelong learning as an essential element of the European Higher Education Area (Prague Communiqué 2001);
- involvement of higher education institutions and students as competent, active and constructive partners in the reform process (Prague Communiqué 2001);
- to promote the attractiveness of the European Higher Education Area to students from Europe and other parts of the world (Prague Communiqué 2001);
- the establishment of a link between the Bologna reforms and the Lisbon Strategy to create a European Research Area (Berlin Communiqué 2003);
- the adoption of an overall framework for qualifications comprising three cycles (Bergen Communiqué 2005);
- the inclusion of a social dimension in the Bologna Process (Bergen Communiqué 2005);
- the establishment of a European Register of Quality Assurance Agencies (London Communiqué 2007);
- to promote the attractiveness and competitiveness of the European Higher Education Area in a global context (London Communiqué 2007).

In order to be able to analyse the structures and elements of Bachelor and Master programmes we have concentrated on those Bologna reform goals that are targeting study programmes and have to be implemented at the institutional level. We have not dealt in detail with goals that have to be implemented at the national level and through policy.

3.2 Previous Analyses

In addition to the national reports submitted for the Bologna stocktaking exercise in 2005 and the Trends I – VI reports prepared as background information about the state of implementation of the Bologna reforms for each of the ministerial meetings, the Bologna reform process has generated a plethora of studies and analyses so far. The majority of these studies and analyses are policy oriented and either focuses on one country or a few countries for comparative reasons or on the European level. There are a few subject specific analyses available: *e.g.* one doctoral dissertation about Bologna reforms in the subject of history (Mangset 2009), a recently published study on the choice of study options after the Bologna reforms in Political Sciences in Germany and Switzerland (Schneijderberg and Steinhardt, 2010), and a larger study commissioned by the European Commission in order to gain insight into curriculum reform development in five study areas: medicine, law, engineering, teacher training and history in 32 European countries (for the executive summary see Huisman and Witte 2007 and further Probst, de Weert and Witte (2008) and Witte and Huisman (2008).

Concerning Physics, we find the results of the *Tuning* Project (2007) for Physics providing a template for how it should be done and the study by Ulrich Nienhaus (2007) about the actual implementation of Bachelor and Master structures into Physics education at German universities (see Appendix 2) .

Recent analyses have shown that in most Bologna signatory countries policies are in place and that there is a certain amount of convergence on the level of macro structures while there is a clear trend

towards considerable diversity and divergence at the level of the micro structures (institutions, programmes). In addition, policy makers of many Bologna signatory countries have attached national reform agendas to the Bologna reform process so that not everything subsumed under the "Bologna label" actually is part of the Bologna reform agenda.

This study is a first attempt of a comprehensive and comparative analysis of Master Physics education at universities in 26 Bologna signatory countries and how it is implemented on the basis of the Bologna reform goals.

3.3 Sample Size, Responses, Specificities of the Curriculum Analysis

Basically through the promotion of the project by the European Physical Society the number of countries involved in the project could be extended from the envisaged 15 to 26. The following table contrasts what we ideally had hoped for and what we have actually received in terms of curricula submitted for analysis as well as responses to the online survey.

The following factors prevented us from having our ideal type sample:

(a) the implementation of the Bachelor and Master structure in some countries had not yet started at all or was in its preparatory stages (*e.g.* Spain);
(b) some countries had opted to implement Bachelor programmes first and Master programmes at a later stage (or vice versa);
(c) implementation of the new structure does not happen at the same time in every university across some countries so that some universities have changed to the new structure already while others have not yet (*e.g.* Spain);
(d) in two countries the Bologna reforms are being implemented by designing one national template for a curriculum which has to be implemented by all universities (Belarus, Ukraine);
(e) in a few cases pure Physics programmes are not offered at all universities but are concentrated in some institutions only (*e.g.* Czech Republic).

Table 1 shows that there are altogether somewhat less than 1,000 universities in the 26 countries involved in the study of which 362 (39 %) offer (Master) Physics programmes according to information of the European Physical Society and the national Physical Societies involved in the project. From among these we selected (as described above) a sample of about 60 percent. The response rate of the universities having answered the online questionnaire has been 57 percent and of the universities that submitted curricula 58 percent; however we also should note the inherent bias in the sample. Almost half of the universities having submitted curricula are from Germany and the UK. The high number of curricula received from the UK (183) is related to the fact that there is (a) a variety of different types of Master programmes and (b) every specialisation constitutes an individual programme. The majority of the Master level Physics curricula received from the UK (144 out of 183) are so called "integrated" four- to five-year Master programmes after which students can directly gain access to PhD programmes. Because the curriculum analysis in the first part of this project has included these programmes, our curriculum analysis in this report concentrates on the other types of UK Master level programmes in Physics, namely one to two year so called "taught" Master programmes and Euro-Masters (*cf.* Appendix 2 for further details).

Altogether the analysis of Master programmes in Physics is based on 129 universities having submitted one or more Master curricula until March 2010. Altogether we have received 343 Master level Physics curricula, among them 71 from 35 German universities and 183 from 27 UK universities. Determining the actual numbers is riddled with problems. Thus, for example, one Physics programme can have several curricula in one country, while in another country each curriculum would constitute a separate programme. In addition, France typically has two curricula for a two year Master programme (for the first and for the second year) (also *cf.* chapter 3.6). There is no unified concept of what constitutes a programme and in which way programme and curriculum are related to each other.

▼ Table 1: Countries, number of universities involved in the study, response rates

Country	Total number of universities	Number of universities offering Physics programmes	Number of universities to be included in the project	Number of universities having submitted curricula	Number of received curricula[3]	Number of analysed curricula	Number of respondents to the questionnaire	Percentage: curricula[3]	Percentage: questionnaire
Albania	36	4	4	2	2	2	2	50%	50%
Austria	31	6	6	6	10	10	3	100%	50%
Belarus	28	6	4	1	1	1	1	25%	25%
Belgium	15	10	6	6	6	6	4	100%	67%
Croatia	5	4	4	2	3	2	1	50%	25%
Czech Republic	24	12	5	2	2	0	5	40%	100%
Denmark	12	4	4	0	0	0	3	0	75%
Finland	13	11	8	8	8	1	7	100%	88%
France	87	37	19	7	6	6	7	37%	37%
Germany	97	59	35	35	71	14	28	100%	80%
Greece	23	5	5	0	0	0	0	0	0
Hungary	26	5	5	3	3	3	5	60%	100%
Ireland + UK	139	57	34	27	183	39	21	79%	62%
Italy	89	36	20	9	9	8	7	45%	35%
Lithuania	15	4	4	1	1	1	3	25%	75%
Macedonia	5	2	2	2	2	2	1	100%	50%
Netherlands	14	9	5	5	7	4	2	100%	40%
Poland	18	12	8	0	0	0	8	0	100%
Portugal	34	15	10	0	0	0	0	0	0
Slovenia	4	3	2	2	3	0	1	100%	50%
Slovakia	33	14	2	2	15	15	2	100%	100%
Spain	73	21	12	0	0	0	6	0	50%
Sweden	21	9	6	1	1	1	6	17%	100%
Switzerland	12	7	8	8	10	2	3	100%	38%
Ukraine	81	10	3	0	0	0	1	0	33%
Total	935	362	221	129	343	117	127		
In Percent			61% of the sample (362)	58% of the universities to be included in the project (221)		34 % of the received curricula (343)	57% of the universities to be included in the project (221)		

[3] This can be different from the "Number of universities having submitted curricula", if one university offers more than one Physics programme.
[4] With regard to the column „Number of universities having submitted curricula", since we don´t know the total number of programs offered by universities which were included in the project.
[5] In France only 37 universities offer Master programmes in Physics.
[6] The 183 programmes from which we have curricula are subdivided as follows: four- to five-year integrated Masters Programmes (144), one- to two-year taught Master Programmes (34), two-year Euro-Master/Erasmus Mundus Master Programmes (5) (see Appendix 2 for further details).
[7] only taught Master Programmes and Euro-Master/Erasmus Mundus Master Programmes
[8] The results for Sweden only reflect the situation at universities and not at technical universities which didn´t participate in the study.

The high number of Master level Physics programmes can be explained by the fact that each specialisation constitutes a separate programme of study. Furthermore, it is widely known that the number of Master level programmes in many European countries and in many subjects is higher than the number of Bachelor level programmes. In order to deal with the ensuing complexity each table or graph referring to results from the questionnaire indicates in the title whether the analysis is by institution (*i.e.* number of universities per country or altogether) or by programme. We have a total number of 127 institutions who filled in the questionnaire (see Table 1) and these 127 institutions offer all together 382 Master programmes.

The same logic is true for the curriculum analysis: We have a total number of 129 institutions having submitted 343 curricula (see Table 1).

► **Conclusion:** **The introduction of the Bachelor and Master model of study programmes and degrees resulted in an increase of programmes at the Master level in Physics. The UK which has this model as the traditional structure has the highest number of Physics programmes at the Master level.**

3.4 Sample Size, Responses, Specifities of the Online Survey

In November 2009 a cover letter with a link to the online questionnaire and a number of PINs (generated by chance) were sent to the contact persons in the National Physical Societies with the request to send the cover letter and one PIN to each of the programme coordinators of Master level study programmes in Physics in the universities selected for inclusion in the project. The deadline for submitting the filled in questionnaires was set for 22 January 2010. Two reminder emails on 10 December 2009 and 6 January 2010 were sent out.

Altogether 221 PINs were provided to programme coordinators at universities offering Physics programmes in 26 European countries. The response rate was 127 valid filled in questionnaires from 24 countries (57 %) which are included in the analysis. A specificity is that the UK National Physical Society (Institute of Physics) is also organising the Irish universities and since the PINs were generated to guarantee anonymity and confidentiality, we can not differentiate between responding UK universities and responding Irish universities.

The distribution of responding institutions or better Physics departments across the countries involved in the study is shown in Table 2.

▼ **Table 2: Respondents to the Online Questionnaire according to country**

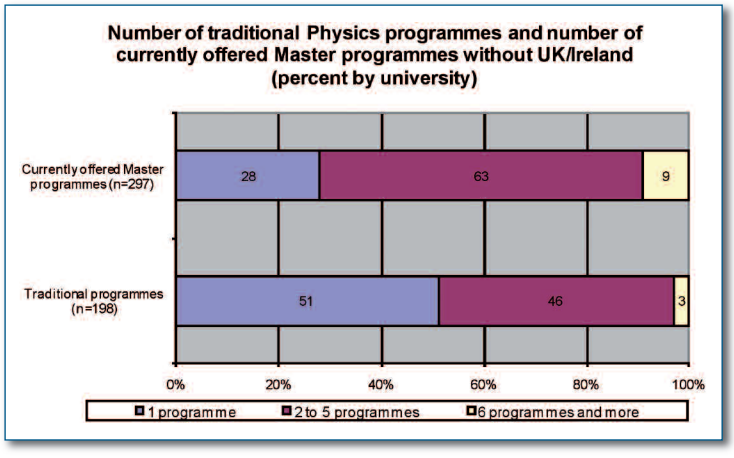
Country	Number of respondents	In percent
Albania	2	1.6
Austria	3	2.4
Belarus	1	0.8
Belgium	4	3.2
Croatia	1	0.8
Czech Republic	5	3.9
Denmark	3	2.4
Finland	7	5.5
France	7	5.5
Germany	28	22.1
Greece	0	0
Hungary	5	3.9
Italy	7	5.5
Lithuania	3	2.4
Macedonia	1	0.8
Netherlands	2	1.6
Poland	8	6.3
Portugal	0	0
Slovenia	1	0.8
Slovakia	2	1.6
Spain	6	4.7
Sweden	6	4.7
Switzerland	3	2.4
UK/Ireland	21	16.5
Ukraine	1	0.8
Total	127	100

3.5 Sample Description Institutions and Respondents

The majority of our respondents to the online questionnaire had a double function as teachers in the programmes and programme coordinators. It might also be noteworthy to say something about the institutions and departments (faculties) who participated in the survey. 39 percent of the participating institutions were established after World War II, *i.e.* mostly expansion phase institutions. About one quarter (23 %) were established between 1850 and 1950, 23 percent were established between 1550 and 1850, and 15 percent belong to the very old group of institutions established in the middle ages, i. e. between 1210 and 1510. This distribution is a good balance between old and new higher education institutions.

Altogether 90 percent are universities and 10 percent are technical universities. More than half of the respondents are working in universities with a relatively broad spectrum of subjects (Natural Sciences: 98 %, Engineering: 62 %, Humanities: 70 %, Social Sciences: 71 %, Law: 61%: Medicine: 55 %). Only Arts (44 %) and Agriculture (21 %) were ticked by less than 50 percent of the respondents as being part of the subject groups offered by their institution (multiple replies were possible to this question). Concerning the size of the institutions participating in the survey we have a mean of 23,123 students (including doctoral candidates) and of 1,997 staff. In these institutions the Physics departments or faculties consist on average of 466 Physics students, 78 academic staff members and 79 doctoral candidates.

▼ Figure 1



Excluding UK and Ireland (because in these two countries the tiered degree system existed already before the Bologna reforms) 28 percent of institutions in our sample offer one Physics programme at the Master level, 63 percent offer between two and five programmes and nine percent offer six programmes and more. Comparing the number of traditional Physics programmes (again without UK and Ireland) and these currently offered Master programmes, it is worth mentioning that in many continental European countries obviously the traditional one-cycle programmes have not just been split into a Bachelor and a Master programme but that in many cases more than one Master programme was created (see Figure 1).

3.6 Sample Description Physics Programmes

In this chapter some of the main trends are reported which emerged from the curriculum analysis and the online questionnaire. A notoriously difficult issue for the analysis of curricula was that we had to make a distinction between Physics programmes and Physics curricula. In some countries one Physics programme can consist of several specialisations which each have their own curriculum (Italy) while in other countries the specialisations are part of one albeit internally differentiated curriculum. In France the first and the second year of the Master programmes each have their own curriculum although it counts as one programme. This is a remnant of the old degree structure which separated the advanced study phase (after the licence) into two further phases, the first finishing with an intermediate degree, and the second with the maîtrise.

In our curriculum analysis we have tried to work out to which extent the mechanisms (*e.g.* ECTS, modularisation etc.) of the Bologna reform process to create a European higher education area and ease mobility have been established and introduced in a unified way. The result is – as was expected – a considerable heterogeneity. In the following some examples are provided concerning the classification of the main concepts or mechanisms:

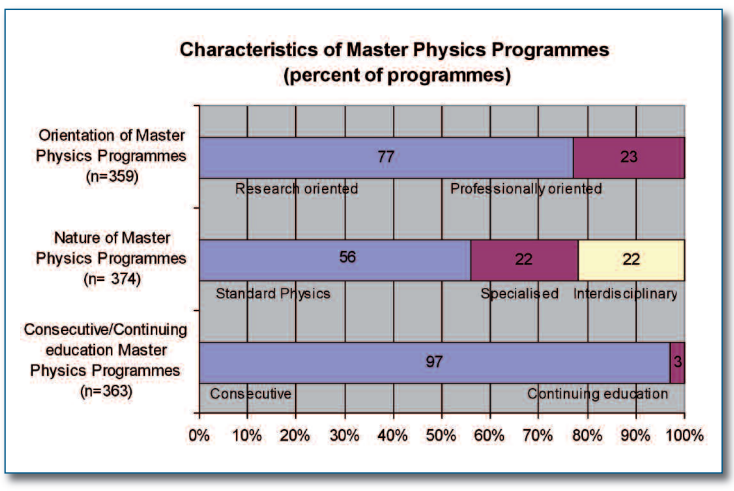
- The number of ECTS credit points is relatively unified with 120 credit points for a two year Master programme. However, there are some exceptions: In the UK there are four- to five-year integrated Master programmes and one to two year taught and research Master programmes; there are Master programmes requiring 90 credit points in Switzerland (1.5 years), and there are one year Master programmes in Belarus;
- The workload concept is insufficiently reflected in the curricula; there might be other documents available elaborating it.
- Modularisation is not practiced everywhere and where it is, the size of a module and the understanding of what constitutes a module vary considerably. The dominant interpretation of the concept is that it is composed of two or more classes or courses which are thematically related to each other.
- There are hardly any second-cycle Master programmes in Physics which do not have a specialisation. This is different for integrated Master programmes in the UK – some of these programmes don't have a specialisation. However, in those programmes which do have a specialisation (whether integrated or second cycle programmes) the forms in which specialisation takes place vary to a considerable extent. We have identified five main models (see chapter 4.4).
- Interdisciplinary programmes are common in Physics. Physics is most often combined with another natural science or with engineering. However, there are also a few examples in which Physics is combined with economics to prepare for managerial tasks in industry or with communication to prepare for careers in (science) journalism or other media professions.
- Degrees and titles upon graduation vary as well. Standard Physics programmes typically award a "Master of Science in Physics", in Belgium and the Netherlands sometimes a "Master of Physics and Astronomy" is awarded. We also find the specialisation mentioned in the degree, *e.g.* "Master of Science in Physics, orientation Astrophysics" (Croatia). Interdisciplinary programmes like Nano-Science sometimes add it as a specialisation to the more general degree, *e.g.* Master of Science in Physics – Specialisation Nanotechnology (Netherlands).
- Concerning choices and elective course we also do not find any common concepts and approaches. In some curricula the field of specialisation is covered in form of obligatory choices (*i.e.* students must select from a limited list of offers), in other curricula both general Physics and specialisation is offered by a combination of obligatory and obligatory choice courses. In some programmes we find free electives through which normally key qualifications or transferable skills are provided.
- The issue of employability is typically taken into account in two ways: either through practically oriented aspects during the course of study (internships, projects, laboratory work) and/or through the transmission of key or transferable skills.
- In most countries there are 30 ECTS credit points attached to the Master thesis. However, there are also some exceptions (esp. in the Netherlands). Sometimes the Master thesis is part of a larger research module consisting of exploration, methods and project planning, thesis (*e.g.* in Germany). We also found one curriculum in which the Master thesis is a "reflection of a traineeship at one of the research departments."
- Most curricula provide little information about quality assessment and accreditation. This does not mean that these quality management instruments are absent. An exception here are the one or two year Master programmes in the UK (taught and research) which are until now not accredited although the introduction of such a scheme is envisaged in the near future.

Concerning the character of the Physics programmes included in our survey we find that approximately 12 percent (in our UK/IE sample altogether 46 percent) are called "integrated" Master programmes (see Table 3). In the UK integrated Master programmes are consecutive programmes culminating in a Master Physics degree designated as MPhys (Master in Physics) or MSci (Master in Science). The typical duration is four years (in some case, according to the different regions, *e.g.* in

Scotland: five years) during which students earn both a Bachelor (BSc) and a Master degree. Students have the option to exit the programme after completion of the Bachelor requirements (3 years) or to continue to complete the Master requirements (one, sometimes two additional years). The requirements and curricula for the Master degree can not be understood as separate from the Bachelor because the coursework and grading system is cumulative. Students are assessed and awarded the Master degree based on work done throughout the programme, not solely on work done in a distinct "Master phase". It is not possible for a student having previously completed a Bachelor Physics degree to apply for entry into an MPhys or MSci degree programme.

In contrast to the integrated Master programmes UK universities also offer so called "taught" Master Physics programmes designated MSc (Master of Science) with a typical duration of one or two years. Taught Master Physics programmes in the UK can best be understood as independent and structured for direct entry upon completion of a separate Bachelor degree in Physics. Assessment and award of the MSc degree is based solely on work completed during the one- or two-year taught Master Physics programme. Furthermore, there is a third type of programme in the UK designated as "research" Master. These programmes vary from university to university but share one important commonality which is the absence of a structured curriculum. It is important to note that taught and research Master Physics programmes are not mutually exclusive. Taught programmes usually include some level of independent research and research programmes usually involve some type of structured and/or classroom learning but research Master programmes in Physics are generally obtained with a high level of independent work on the part of the student and usually without regular or scheduled course work. It is important to note that all above mentioned types of Master programmes in the UK are at the same level within the Framework for Higher Education Qualifications (see QAA 2008).

▼ **Figure 2: Characteristics of Master Programmes (in percent)**



According to the above definitions only taught one-year and two-year Master Physics programmes have been considered for the curriculum analysis because integrated and research master programmes lack distinct curricula that can be extrapolated and understood in terms of the indicators and parameters used for the curriculum analysis. In contrast to the curriculum analysis, integrated Master programmes from the UK are represented in the survey (46 percent of the programmes from UK have a duration of four to five years and 54 percent have a duration of one to two years, see Table 3) and in some questions different answer options for second cycle and integrated master programmes were included.

However, integrated Master programmes in Physics can also be found in Finland, Poland and Sweden. It can safely be assumed that at least some of these programmes are still the traditional ones which have not been restructured, while others might have been newly created. In Germany and Austria the introduction of Bologna type programmes and degrees happened parallel to the continued provision of traditional one-cycle four- to five-year programmes. This was due to the fact that students had the right to finish their studies under the same conditions under which they started them. In Austria for example students were given the choice of switching to the new Bachelor/Master programmes or completing the old "Diplom" programmes and the vast majority chose to do the latter. In 2006 or 2007 all departments offering Physics or Technical Physics in Austria switched to the Bachelor/Master

system and students starting their studies after the introduction of the new system had to enrol in the new Bachelor/Master programmes.

Figure 2 shows a threefold classification of Physics Master programmes which can be found most commonly across Europe.

The first classification is the distinction between research-oriented and professionally-oriented programmes. More than three quarters (77 %) of the programmes included in the survey are of the former type and 23 percent are of the latter type. Professionally-oriented Master programmes in Physics are found at both universities and technical universities and typically are combined with engineering or entrepreneurship, economics, or business administration. Thus they have a more applied character. It is important to mention here that in some countries, for example in the UK, the research- and professionally-oriented programmes can not be separated accurately. In France, 25 percent of the Physics Master programmes are both research- and professionally-oriented. The difference between the two types is only the training part: training in labs (for research-oriented programmes) and in companies (for professionally-oriented programmes). In the future this distinction is expected to be given up (see the national report in Appendix 2).

The second classification distinguishes between standard, specialised, and interdisciplinary Physics programmes. While the majority of programmes in the survey have a profile of being 'straight' or 'pure' Physics (56 %), there is also a considerably proportion of specialised and interdisciplinary programmes (22 % each).

The final classification is distinguishing between consecutive Master programmes (*i.e.* into which Bachelor graduates can enter directly after completion of the first cycle) and continuing education provisions at the Master level in Physics geared towards professional development, sometimes offered in part-time study mode or in form of evening and weekend classes. Special continuing education offers at the Master level in Physics comprise only a very small proportion (3 %) in our sample.

4. Results of the Curriculum Analysis and the Survey

4.1 Duration of Master Programmes in Physics

The questionnaire asked about the scheduled duration of currently offered Master Physics programmes. Table 3 shows that a high proportion of programmes have a duration of two years and only 17 percent of one year. However, there are also a number of countries, predominantly the UK but some continental European countries as well, which have single-cycle Master level programmes of four or five year duration. These are typically called integrated Master programmes. Frequently these programmes are research-oriented and often lead directly into the doctoral phase. In the UK the integrated Master programmes are an established type of programme while the occurrence of one-cycle four- or five-year programmes in continental Europe mostly indicate the traditional mode which has not yet been changed (see Table 3).

There are other exceptions from the two-year rule as well. In Switzerland, for example we find Master level Physics programmes having a duration of 1.5 years. Belarus considers its traditional five-year specialist education as the first cycle after which students can continue into one-year Master programmes which mainly serve as a preparation for the doctoral phase.

Additionally another question in the online survey resulted in the information that on average 40 percent of the students complete their studies in the prescribed period of the programme, while 21 percent took about six months longer and six percent one year longer. Still, 32 percent of the respondents could not answer this question, possibly due to the more recent introduction of second-cycle Master programmes.

► **Conclusion:** The majority of Master level programmes in Physics has a duration of two years in continental Europe and in the Nordic countries. In the UK/IE 54 percent of the programmes have a duration of one or two years (1 year: 47 %; 2 years: 7 %) and 46 percent a duration of four to five years (4 years: 38 %; 5 years: 8 %). In the four- to five-year programmes Ireland is not represented, because here integrated Masters don't exist. The vast majority of one-year Master programmes are UK programmes.

4.2 Use of Credit Points, Workload, Modularisation

The use of ECTS is now widely established. Typically for the second cycle Master programmes 120 ECTS credit points are required which is equivalent to a duration of two years, as shown in Table 3.

86 percent of the respondents stated that they use ECTS (or another credit point system which is one to one compatible with ECTS, *e.g.* Sweden) in all of their Master Physics programmes for all students (see Table 4). UK/Ireland, Lithuania and Belarus are exceptions.

▼ Table 3: Scheduled Duration of Master Physics Programmes (percent and count by programme and by country)

	1 year (%)	1.5 years (%)	2 years (%)	3 years (%)	4 years (%)	4.5 years (%)	5 years (%)	Total (%)
Albania (N=4)*	25	0	75	0	0	0	0	100
Austria (N=9)*	0	0	78	11	0	0	11	100
Belarus (N=5)*	100	0	0	0	0	0	0	100
Belgium (N=10)*	30	0	70	0	0	0	0	100
Croatia (N=4)	0	0	100	0	0	0	0	100
Czech Republic (N=19)	0	0	95	5	0	0	0	100
Denmark (N=6)	0	0	100	0	0	0	0	100
Finland (N=28)	0	0	96	0	0	0	4	100
France (N=8)	0	0	100	0	0	0	0	100
Germany (N=66)	0	0	100	0	0	0	0	100
Hungary (N=16)	0	0	100	0	0	0	0	100
Italy (N=17)	0	0	100	0	0	0	0	100
Lithuania (N=11)	0	0	100	0	0	0	0	100
Macedonia (N=5)	100	0	0	0	0	0	0	100
Netherlands (N=7)*	71	0	29	0	0	0	0	100
Poland (N=18)	0	0	78	0	0	0	22	100
Slovakia (N=15)	0	0	100	0	0	0	0	100
Slovenia (N=3)	0	0	100	0	0	0	0	100
Spain (N=14)	50	14	29	0	0	0	7	100
Sweden (N=12)	0	0	92	0	0	0	8	100
Switzerland (N=7)	0	71	0	0	0	14	14	100
UK/Ireland (N=85)	47	0	7	0	38	0	8	100
Ukraine (N=10)	0	0	100	0	0	0	0	100
Total (%)	17	2	67	1	8	0	4	100
Total (N)	66	7	255	2	32	1	16	379

Question 3.3: Please state the name of the Master programme(s) (and degrees) in Physics currently offered at your institution (please in English translation), the scheduled duration in years, the number of Credit Points to be earned and the total number of students enrolled.

* It is regulated by national law that all Master programmes (in Belgium and Albania), Master pro-grammes in Natural Sciences and Technical Sciences (in Austria), and Master programmes at re-search universities (in the Netherlands) have a duration of two years. The column "2 Years" in Table 3 should therefore indicate 100 percent for these countries. Discrepancies in the answers to our ques-tionnaire indicate either a lack of knowledge of the respondents with regard to such regulations or that the change to the new structures has not (yet) been finished at a given institution.

- In the UK the UK CATS (credit accumulation and transfer system) is more common, where one academic year of full-time studies is equivalent to 120 CATS.
- In Lithuania one academic year of full-time studies corresponds to 40 national credit points.
- In Belarus no credit system has been introduced yet.

Another difference is the calculation of credit points. In the majority of programmes (92 %) credit points are calculated on the basis of contact hours plus independent study, but in some institutions (the Czech Republic, Poland and Switzerland) credit points are calculated on the basis of contact hours exclusively (see Table 5). Looking at those Physics Master programmes in which credit points are based on a combination of contact hours and independent study we can assume that we have a workload based calculation. Many curricula do not include a specification of the workload concept. Where such a specification is provided it is normally expressed in the number of hours of student work required to earn one or more credits. Student work is then defined as a combination of presence in class, self study, and laboratory or project work. Each module is completed by one or more assessments or examinations.

69 percent of the respondents stated that in their Master Physics programmes 25 to 30 hours are required to earn one credit point (see Table 6). This constitutes the general framework indicated in the Bologna guidelines (between 25 and 30 hours of student workload for one

▼ **Table 4: Application of ECTS Credit Points (percent and count by university and by country)**

	Yes , in all of them (%)	No, for ERASMUS students only (%)	No, we don't apply ECTS Credit Points (%)	Total (%)
Albania (N=2)	100	0	0	100
Austria (N=3)	100	0	0	100
Belarus (N=1)	0	0	100	100
Belgium (N=4)	100	0	0	100
Croatia (N=1)	100	0	0	100
Czech Republic (N=5)	100	0	0	100
Denmark (N=3)	100	0	0	100
Finland (N=7)	100	0	0	100
France (N=6)	100	0	0	100
Germany (N=28)	100	0	0	100
Hungary (N=5)	80	20	0	100
Italy (N=7)	100	0	0	100
Lithuania (N=3)	0	100	0	100
Macedonia (N=1)	100	0	0	100
Netherlands (N=2)	100	0	0	100
Poland (N=8)	100	0	0	100
Slovakia (N=2)	100	0	0	100
Slovenia (N=1)	100	0	0	100
Spain (N=6)	100	0	0	100
Sweden (N=6)	100	0	0	100
Switzerland (N=3)	100	0	0	100
UK/Ireland (N=20)	35	10	55	100
Ukraine (N=1)	100	0	0	100
Total (%)	86	5	10	100
Total (N)	107	6	12	125

Question 4.1: Do you apply ECTS Credit Points in the framework of your Master Programme(s) in Physics for all students?

ECTS credit point). Exceptions are universities in UK and Ireland which use different credit systems: 67 percent stated that in their Master Physics programmes 10 hours are required to earn one UK CATS credit point. Another 20 percent stated a workload of 15 to 20 hours and 13 percent a workload of 25 to 30 hours (both groups use ECTS: In the UK ECTS is normally considered equal to 1 credit point reflecting 20 hours of work, with 60 ECTS for a full-time academic year. In Ireland some universities have changed to ECTS but count 1 credit point as reflecting 25 hours of work).

Modularisation is another one of the Bologna reform concepts which is rather elusive. In about two thirds of all Physics departments or faculties included in our survey (67 %) of all programmes are modularised, in four percent some programmes are modularised and in 29 percent programmes are not modularised (in Figure 3 both positive answers (modularisation of all programmes + modularisation of some programmes) have been taken into consideration, leading to an average percentage of 71 percent of positive answers for all countries). This, however, is not uniform within countries. Respondents from only two countries (Belarus and Slovenia) answered that none of their programmes are modularised, while respondents from five countries stated that all of their programmes are modularised (Denmark, Germany, Macedonia, Netherlands and Ukraine)[9]. In the other countries some programmes are modularised and others are not.

▼ **Table 5: Calculation of Credit Points (percent and count by university and by country)**

	On the basis of contact hours and independent study (%)	Only on the basis of contact hours (%)	Total (%)
Albania (N=1)	100	0	100
Austria (N=3)	100	0	100
Belgium (N=3)*	67	33	100
Croatia (N=1)	100	0	100
Czech Republic (N=5)	80	20	100
Denmark (N=1)	100	0	100
Finland (N=6)	100	0	100
France (N=5)*	40	60	100
Germany (N=27)	100	0	100
Hungary (N=5) *	80	20	100
Italy (N=7)	100	0	100
Lithuania (N=3)	100	0	100
Macedonia (N=1)	0	100	100
Netherlands (N=2)	100	0	100
Poland (N=6)	83	17	100
Slovakia (N=2)	100	0	100
Spain (N=5)	100	0	100
Sweden (N=4)	100	0	100
Switzerland (N=2)	50	50	100
UK/Ireland (N=19)	100	0	100
Total (%)	92	8	100
Total (N)	99	9	108

Question 4.4: How are the Credit Points calculated?

*** In Hungary and Belgium it is regulated by national law that the calculation is based on contact hours and independent study. In France the calculation of Credit Points also is done on the basis of both, contact hours and independent study. The column "On the basis of contact hours and independent study" in Table 5 should therefore indicate 100 percent for these countries.**

The tricky question here is what time unit constitutes a module. Our curriculum analysis resulted in very different concepts. The following classification provides an overview.

(a) In many of the countries included in the study modules tend to be rather small (between 1 and 6 ECTS). Often the term "module" is not even used for such units. Bigger modules are used in relationship to practical phases (*e.g.* in Italy nine credit points for training, in France 12 credit points for training). We think that traditional courses or classes in these countries have just been linked to credit points.

(b) In some countries (*e.g.* Austria, Netherlands, Belgium and Switzerland) and at some universities classes or courses have been put together into larger study blocks. These study blocks are sometimes called modules (*e.g.* a module called "compulsory courses" and a module called "elective courses" or even a whole specialisation, like "Medical Physics"). This differs from the German understanding of modules which are composed of two or more courses (lectures, seminars, etc.) or classes which are linked through content. Such a definition was also found in the curricula of taught Master programmes in Physics in the UK.

[9] Due to a comment of the representative of the national Physical Society, in France all Master pro-grammes consist of modules. The fact that only 83 percent of the respondents stated that their Master Physics Programmes are modularised shows that the term or the concept "modules/modularisation" is not yet well understood in all universities across Europe.

▼ Table 6: Workload Equivalent for One Credit Point (percent and count by university and by country)

	10 hours (%)	15-20 hours (%)	25-30 hours (%)	40 hours (%)	Total (%)
Albania (N=2)	0	0	100	0	100
Austria (N=3)	0	0	100	0	100
Belgium (N=2)	0	50	50	0	100
Croatia (N=1)	0	0	100	0	100
Czech Republic (N=4)	0	50	50	0	100
Denmark (N=1)	0	0	100	0	100
Finland (N=6)	0	0	100	0	100
France (N=2)**	0	100	0	0	100
Germany (N=27)	0	0	100	0	100
Hungary (N=4) *	0	25	75	0	100
Italy (N=7)	0	14	86	0	100
Lithuania (N=2)	0	0	0	100	100
Netherlands (N=2)*	0	50	50	0	100
Poland (N=6)	33	50	17	0	100
Spain (N=3)*	0	33	67	0	100
Sweden (N=4)	0	0	100	0	100
Switzerland (N=2)	0	0	100	0	100
UK/Ireland (N=15)	67	20	13	0	100
Total (%)	13	16	69	2	100
Total (N)	12	15	64	2	93

(c) In Germany we also find larger modules with 10, 20 or even 25 credit points; example: Particle Physics I and II (20 ECTS).

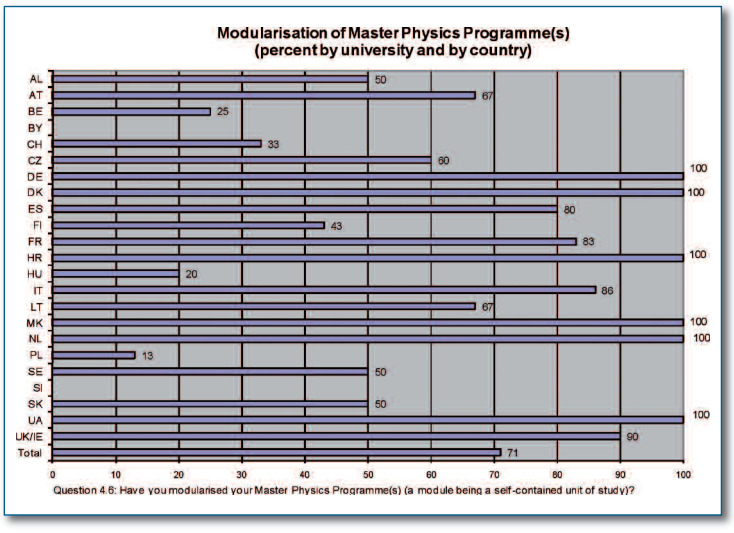
An open question was included in the questionnaire asking respondents to define what a module consists of as a rule in their Physics department. The majority stated that a module typically consists of different teaching formats (lectures, exercises, seminars etc.) and is completed by an examination or another form of assessment. While the assessment normally refers to the whole module we also found exceptional cases in which every course within a given module is assessed independently or in which there is a midterm and a final examination pertaining to the module.

► **Conclusion:** The use of ECTS is widely established and mainly in accordance with the Bologna guidelines. The modularisation in Physics Master programmes as well as concepts what a module consist of, vary considerably from country to country and from university to university within countries.

Question 4.5: How many hours of student workload are required to earn one Credit Point?

*** The number of hours of student workload to earn one credit point is regulated by law in several countries:**
• in Hungary: 1 CP is equivalent to 30 hours
• in the Netherlands: 1 CP is equivalent to 28 hours
• in Spain: 1 CP is equivalent to 25 to 30 hours
• in Slovakia: 1 CP is equivalent to 25 to 30 hours
For these countries, the column "25 to 30 hours" should indicate 100 percent.
****In most of the universities in France 1 CP is equivalent to 25-30 hours. The answers of the French respondents in Table 6 are therefore not representative for the general situation in France.**

▼ Figure 3: Modularisation



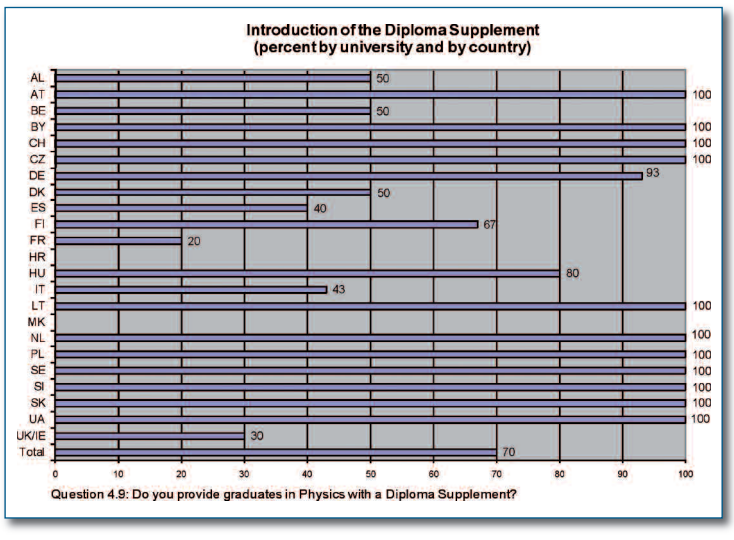
4.3 Diploma Supplement

A Diploma Supplement is a document provided in addition to the final degree certificate describing in various degrees of detail the content of the course of study, the profile of the institution at which the degree was earned, the overall grade, and the number of credit points. It also includes personal information about the degree holder, the mode of study (*e.g.* part-time or full-time) and the level of qualification. In many institutions the information is provided in the home country language and in English. The Diploma Supplement was specifically introduced as a document to ease recognition of qualifications and degrees in case of border crossing mobility for employment. Most curricula do not include any information about the Diploma Supplement. Therefore, a respective question was included in the questionnaire.

70 percent of the respondents to our survey stated that they already provide Physics graduates with a Diploma Supplement. 30 percent stated that the introduction of the Diploma Supplement is either envisaged for a later point in time or that the introduction has not yet been discussed yet. In the latter group we find Croatia, a number of respondents from Denmark, France, and Spain, and some institutions in Finland, Italy, and UK/Ireland (see Figure 4).

From the group of respondents who stated that they provide a Diploma Supplement, the vast majority (87 %) do this automatically, the rest only upon request.

▼ **Figure 4[10]: Diploma Supplement**



► **Conclusion: The provision of a Diploma Supplement upon graduation is becoming more widespread.**

4.4 Specialisation and Interdisciplinarity

More than half (56 %) of the Master Physics programmes included in our survey have been characterised as standard Physics programmes. 22 percent were characterised as specialised programmes and 22 percent as interdisciplinary programmes (Engineering Physics included here) (see Figure 2 above). The interdisciplinary programmes can, however, be combined with a variety of other subjects (multiple replies were possible). Our respondents stated that Physics can be combined first and foremost with other natural sciences (64 %), followed by engineering sciences (55 %), medical sciences (24 %), but also with economics (12 %), social sciences (7 %), and humanities (2 %). 19 percent of the respondents stated that their Physics programme can be combined with yet another area of study.

Typically, in second-cycle programmes the degree of specialisation is much higher at the Master level than it is at the Bachelor level. The curriculum analysis has shown that there are basically no second-cycle Master programmes in Physics which do not have some kind of specialisation. This is different for integrated Master programmes in the UK – some of these programmes don't have a specialisation. With regard to second cycle programmes we were able to identify five main models of specialisation:

(a) Master Physics programmes with one or more specialisations which are added to a general Physics part (*e.g.* in the first two semesters) or are offered parallel to it.

(b) Master Physics programmes with a variety of independent specialisation curricula. There is no

[10] In Albania, Germany, Hungary and Spain the provision of the Diploma Supplement has been regu-lated by national law. The responses in Figure 4 don´t reflect the situation correctly for these countries and should therefore add up to 100 percent.

general Physics part but students study their specialisation from the beginning. Other areas of Physics can be studied in form of electives.

(c) Specialisations are independent programmes with their own degrees and titles. In this type specialisations are no longer integrated in a Physics programme but are separate and independent programmes; *e.g.* there might be a more general Physics programme but also a separate Astrophysics programme, a Geophysics programme, Meteorology, Climate Physics *etc.* (Germany, Slovakia).

(d) Master Physics programmes are differentiated into research-oriented programmes (possibly with specialisations), interdisciplinary programmes, and teacher training programmes. Here the distinction between professional- and research-orientation is of importance. Examples can be found in Belgium, the Netherlands, and the UK.

(e) France as a special case: separate curricula for the first and the second year of Master-level studies. If specialisations are offered in the second year (for example three specialisations) the programme has four curricula, one for the joint first year and three for the specialisations[11].

Apart from the distinction between research-oriented (77 % of the programmes included in the survey) and professionally-oriented programmes (23 % of programmes included in the survey) another form of specialisation is the distinction between consecutive programmes (being studied immediately after the Bachelor degree) and continuing education programmes (being studied after some time of professional experience outside the university). The vast majority of the programmes included in our survey (97 %) have been characterised as consecutive programmes by our respondents and only three percent as continuing education programmes (see Figure 2 above).

Accordingly, an equally high proportion of the respondents (98 %) stated that they deliver their programmes in the classical presence delivery mode while four percent use a distance learning mode and eight percent a blended learning mode (multiple replies were possible to this question).

► **Conclusion: There is a high level of specialisation at the Master level. Somewhat less than one quarter of the respondents stated that they also offer interdisciplinary programmes in their department or faculty.**

4.5 Mobility and Internationalisation

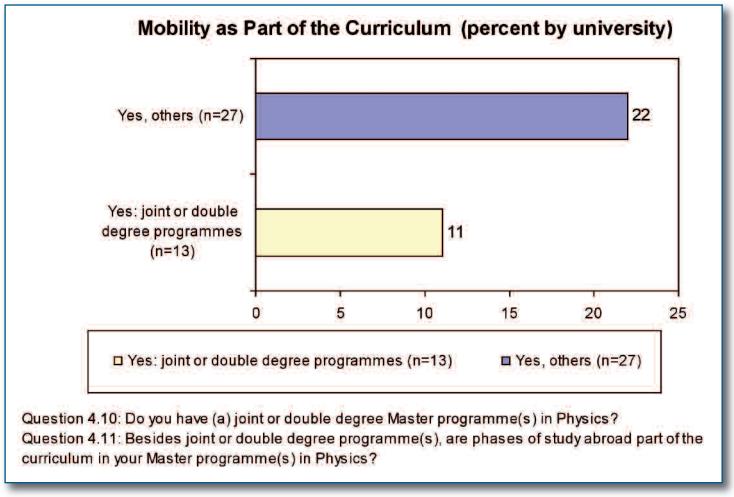
In the *Tuning* Project 2007 the importance of mobility is highlighted as follows: *"An important aspect of the Physics community is its international character, in both research and education, which suggests the need for Physics students to be mobile during their learning path, almost compulsory in the final cycle. Attending examinations, carrying out placements, enjoying research activity during project work or while preparing a Master thesis or doctoral dissertation, all these activities at a host university add true value to the achievement of the physicist's competencies and skills"* (*Tuning* Project 2007).

Concerning mobility and internationalisation of Master programmes in Physics the questionnaire looked at four dimensions: first, the proportion of double and joint degree programmes which typically have an integrated period of study abroad as well as other forms of integrated mobility; second, the international composition of the student body; third, mobility of own students; and fourth, teaching in a foreign language.

Eight percent of the respondents stated that there is a double-degree programme offered in Physics and three percent stated that there is a joint-degree programme (together 11 %, see Figure 5). Programme coordinators responding to the online questionnaire were further asked whether phases of study abroad

[11] In France there are three types of Master programmes distinguished by their provision in the second year: research-oriented, professionally-oriented and rather generalised programmes, where no distinc-tion is made concerning the overall orientation of the programme, but where the distinction happens to a certain extent due to the place where the training takes place (in companies or in research laborato-ries) (for further information see Appendix 2).

▼ Figure 5: Mobility

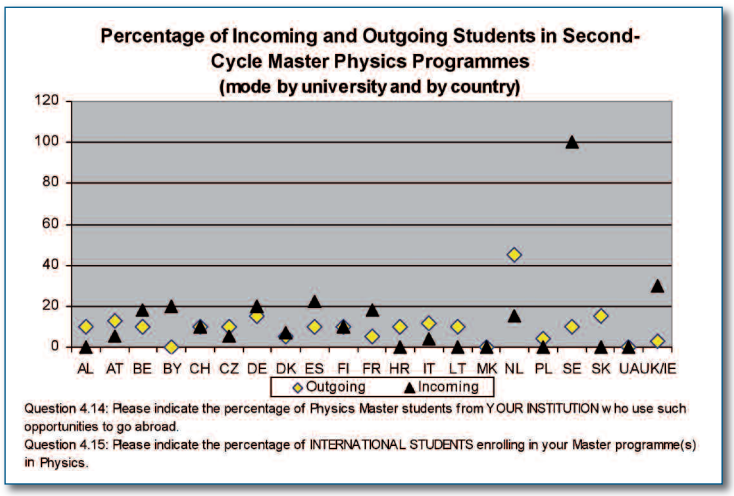


Question 4.10: Do you have (a) joint or double degree Master programme(s) in Physics?
Question 4.11: Besides joint or double degree programme(s), are phases of study abroad part of the curriculum in your Master programme(s) in Physics?

were part of the Master curriculum in Physics, besides joint or double-degree programmes. 14 percent stated that study abroad was part of the curriculum of some programmes, and eight percent said that study abroad was part of all Physics curricula at the Master level, altogether 22 percent positive answers (in Figure 5, these 22 percent figure as "Yes, others", see also Table 7). Together with the 11 percent of respondents who stated that they offer a joint or double degree programme in Physics there is a total of 33 percent of respondents who stated that mobility is a required part of the curriculum.

In Table 7 answers from respondents who answered that in their Physics Master programmes phases of study abroad are part of the curriculum (besides joint- or double-degree programmes) are illustrated according to countries. Countries in which all respondents (100 %) stated that study abroad was not part of the curriculum are: Albania, Austria, Belarus, Croatia, Finland, Hungary, Macedonia, Poland, Slovenia, Switzerland, and Ukraine. High levels of responses that study abroad was part of all Physics Master curricula came from the Netherlands (50 %) and from Belgium, Denmark, France, Lithuania, and Sweden (33 % each). In UK/Ireland about the same proportion of integrated and stand-alone[12] Master programme indicated that phases of study abroad were part of the curriculum. These are probably the two-year Master programmes (see Table 7).

▼ Figure 6: Incoming and Outgoing Students



Question 4.14: Please indicate the percentage of Physics Master students from YOUR INSTITUTION who use such opportunities to go abroad.
Question 4.15: Please indicate the percentage of INTERNATIONAL STUDENTS enrolling in your Master programme(s) in Physics.

Concerning the international composition of the student body in second-cycle Master Physics programmes respondents from Spain, Germany, Sweden, and the UK and Ireland indicated high proportions of international students: in Spain (22 %), in Germany (20 %), in Sweden (100 %), and in the UK and Ireland (30 %) (indicated is the mode, see Figure 6). The fact that Sweden has such a high proportion of international students is related to the fact that at the point in time the questionnaire was administered no Swedish Bachelor graduates in Physics had yet been produced. So the Master programmes were opened to international students to get them started.

High percentages of mobile students from the own institution for second-cycle Master programmes can be found in Germany, the Slovakia and the Netherlands (see Figure 6).

We were also interested in the typical time windows for mobility, *i.e.* in what phase of their studies do students normally go abroad. Then 57 percent of the respondents stated that mobility is envisaged in the first year of the Master programme and 34 percent said that it was envisaged for the second year. Still, 37 percent stated that the time window for mobility was between the Bachelor and the Master phase of studies (see Table 8). (These 37 percent don't include answers from integrated Master programmes from UK/Ireland. Responses from these countries can be found in the option "Other (for integrated Master programmes)": The majority of respondents stated that students go abroad in the third year).

[12] Stand-alone Master programmes are one- or two-year taught or research Master programmes.

▼ Table 7: Compulsory Study Abroad (percent and count by university and by country)

	No (%)	Yes, in all programmes (%)	Yes, in some programmes (%)	Total (%)
Albania (N=1)	100	0	0	100
Austria (N=3)	100	0	0	100
Belarus (N=1)	100	0	0	100
Belgium (N=3)	67	33	0	100
Croatia (N=1)	100	0	0	100
Czech Republic (N=5)	80	0	20	100
Denmark (N=3)	67	33	0	100
Finland (N=6)	100	0	0	100
France (N=6)	50	33	17	100
Germany (N=28)	93	0	7	100
Hungary (N=4)	100	0	0	100
Italy (N=7)	71	29	0	100
Lithuania (N=3)	67	33	0	100
Macedonia (N=1)	100	0	0	100
Netherlands (N=2)	50	50	0	100
Poland (N=7)	100	0	0	100
Slovakia (N=2)	50	0	50	100
Slovenia (N=1)	100	0	0	100
Spain (N=5)	80	0	20	100
Sweden (N=6)	67	33	0	100
Switzerland (N=3)	100	0	0	100
UK/Ireland (N=20)	45	0	55	100
Ukraine (N=1)	100	0	0	100
Total (%)	77	8	14	100
Total (N)	92	10	17	119

Question 4.11: Besides joint or double degree programme(s), are phases of study abroad part of the curriculum in your Master programme(s) in Physics?

Half of our respondents indicated an average duration of mobility between three and five month, 40 percent said it was longer than five months and 10 percent stated that it was only between one and two months on average.

Increased intra-European mobility and a higher degree of attractiveness for students from outside Europe are among the important goals of the Bologna Process. In many continental European countries, however, the new study structures have been implemented with more rigidity in the content and the amount of course work. This has led to criticism that time windows for mobility were being reduced.

Almost half of our respondents to our survey (48 %) stated, that they observed changes in the mobility patterns at their institutions in recent years. Among these, only 20 percent stated that they see these changes linked to the Bologna Process though (see Figure 7).

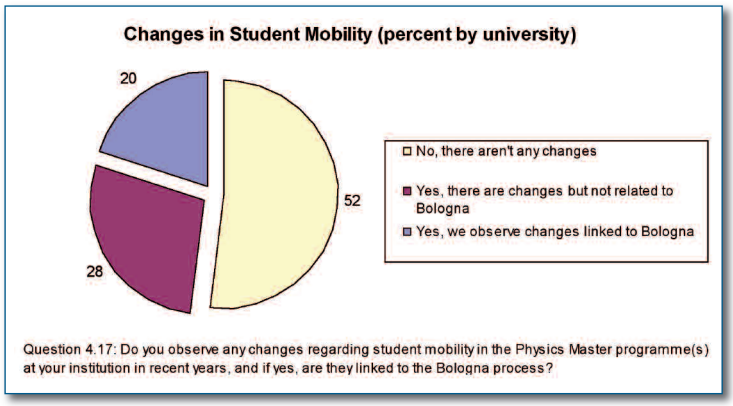
The respondents which stated that they see changes in student mobility which are clearly linked to the Bologna

▼ Table 8: Point of Study Abroad (percent and count/multiple reply by university)

	%	count
Between the Bachelor and the Master	37	(33)
1st year of the Master	57	(51)
2nd year of the Master	34	(31)
Other (for SECOND-CYCLE Master programmes)	10	(9)
Other (for INTEGRATED Master programmes)	18	(16)

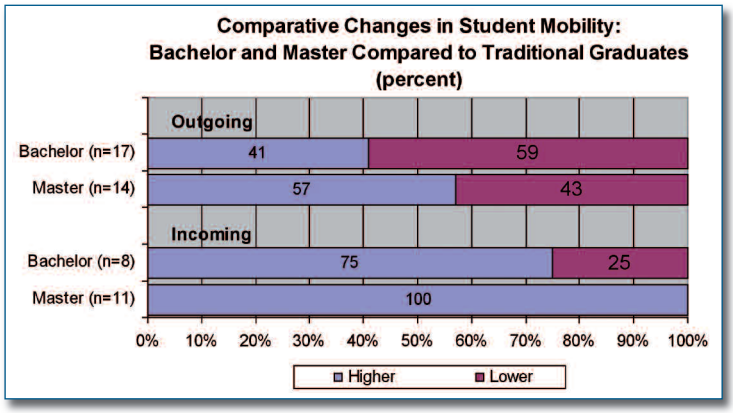
Question 4.12: At what point in time do students go abroad?

▼ Figure 7: Changes in Student Mobility



Process (the 20 percent indicated above) were further asked if they see an increase or decrease of mobility in the new Bachelor and Master programmes (both incoming and outgoing) compared to the traditional programmes (see Figure 8). While all respectively the majority of respondents stated that in their Master Physics programmes incoming as well as outgoing mobility is higher compared to traditional programmes, there is a different picture concerning Bachelor programmes:

▼ Figure 8: Changes in Mobility (Bachelor and Master Programmes compared)



Question 4.17: Do you observe any changes regarding student mobility in the Physics Master programme(s) at your institution in recent years, and if yes, are they linked to the Bologna process?
Yes, we observe changes which are clearly linked to the Bologna process:

- The number of students in our BACHELOR Physics programme(s) going abroad is higher/lower compared to the number of students in our traditional programmes going abroad.
- The number of students in our MASTER Physics programme(s) going abroad is higher/lower compared to the number of students in our traditional programmes going abroad.
- The number of international students in our BACHELOR Physics programme(s) is higher/lower compared to the number of international students in our traditional programmes.
- The number of international students in our MASTER Physics programme(s) is higher/lower compared to the number of international students in our traditional programmes.

Here we have a clear majority of respondents who indicated an increase of mobility for incoming students but a decrease concerning outgoing students when compared to traditional programmes.

The fourth dimension to cover various aspects of internationalisation is teaching in a foreign language. 41 percent of the programmes included in our survey offered teaching in a foreign language. None of the respondents for UK and Ireland stated that teaching is provided in a foreign language. But 100 percent of the respondents from the following countries stated that teaching is taking place in a foreign language, though often not exclusively: Albania, Austria, Croatia, Denmark, Finland, the Netherlands, Slovakia, Slovenia, Sweden, and Switzerland. However, some of these countries have produced only one response (see Table 9).

▼ Table 9: Instruction in a Foreign Language (percent and count by university and by country)

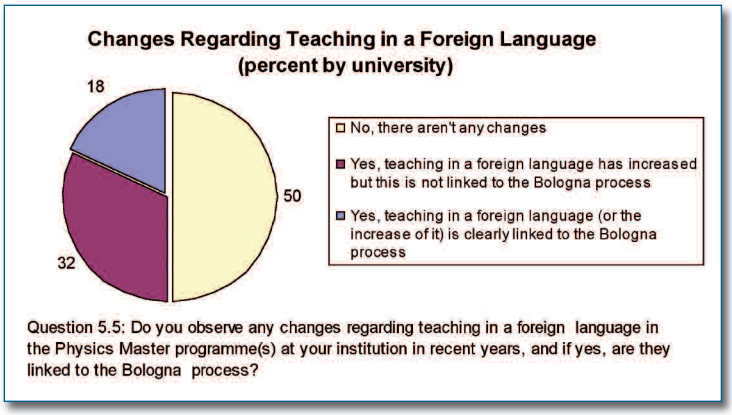
	No (%)	Yes (%)	Total (%)
Albania (N=1)	0	100	100
Austria (N=3)	0	100	100
Belarus (N=1)	100	0	100
Belgium (N=3)	67	33	100
Croatia (N=1)	0	100	100
Czech Republic (N=5)	20	80	100
Denmark (N=3)	0	100	100
Finland (N=7)	0	100	100
France (N=5)	40	60	100
Germany (N=27)	11	89	100
Hungary (N=5)	80	20	100
Italy (N=7)	71	29	100
Lithuania (N=3)	33	67	100
Macedonia (N=1)	100	0	100
Netherlands (N=2)	0	100	100
Poland (N=8)	75	25	100
Slovakia (N=2)	0	100	100
Slovenia (N=1)	0	100	100
Spain (N=5)	40	60	100
Sweden (N=5)	0	100	100
Switzerland (N=3)	0	100	100
UK/Ireland (N=19)	100	0	100
Ukraine (N=1)	100	0	100
Total (%)	41	59	100
Total (N)	48	70	118

Question 5.3: Is teaching offered in a foreign language in your Master programme(s) in Physics?

Altogether 50 percent of the respondents stated that they don't observe any changes regarding teaching in a foreign language, 32 percent said that teaching in a foreign language increased but was not related to the Bologna Process, and only 18 percent saw a link between an increase in teaching Physics in a foreign language and the Bologna Process (see Figure 9).

The majority of respondents stated that teaching is offered in English (71 %), followed by German (17 %), French (14 %), Spanish and Italian (7 % each).

▼ Figure 9: Teaching in a Foreign Language



► **Conclusion:**

- **Many respondents see changes in student mobility in recent years – but mainly not related to the Bologna Process.**
- **Increase in mobility linked to Bologna only for Master students (outgoing and incoming) and for Bachelor (incoming).**
- **Mobility as a required component in Physics Master programmes is high (33 %).**
- **Incoming and outgoing mobility in Master Physics programmes is in most countries well-balanced.**
- **Apart from UK and Ireland teaching in a foreign language has increased in recent years – but this is mainly not linked to the Bologna Process. English is most common (71 %).**

4.6 Assessment, Examinations, and the Concept of Learning Outcomes

Assessment of student performance shows a wide variety of forms (multiple replies were possible) reaching from written tests (93 percent of the responses to the survey) to oral examinations (79 %), project presentations (77 %), and homework papers (67 %). Less frequent but used as well are multiple choice questions (23 %), interview with the teacher (21 %), and other forms of assessment (14 %) (see Table 10).

Typically student performance is assessed after each module or unit of teaching and learning (91 percent of respondents stated this). When asked if they asses subject knowledge only or also transferable skills, 44 percent of the respondents said that only subject knowledge is examined and 56 percent stated that subject knowledge as well as transferable skills are included in the assessment.

In their assessment (multiple replies were possible) almost 90 percent of respondents use absolute marking, *i.e.* the degree of fulfilment of established criteria, while relative marking (performance of a student in relation to the group of fellow students) is used by 11 percent of our respondents. Still, 20 percent just use pass or fail (possibly a pass with distinction) and 16 percent mark the individually acquired knowledge and competences during a module or class (see Table 11).

75 percent of our respondents also stated that student performance during the programme is included into the calculation of the final mark or the final classification for the degree. Only 25 of the respondents stated that this is not the case. Countries in which the

▼ Table 10: Assessment Types
(percent and count/multiple reply by university)

	%	count
Written tests	93	(112)
Multiple choice questions	23	(28)
Homework papers	67	(80)
Interview with teacher	21	(25)
Oral examination	79	(95)
Project presentation	77	(92)
Other forms of assessment	14	(17)

Question 6.6: What types of assessment are being used during the course of study?

▼ Table 11: Types of Marking (percent and count/multiple reply by university)

	%	count
Just pass/fail/passed with distinction or honours	20	(24)
Relative marking (performance of individual student in relation to group)	11	(13)
Absolute marking (degree of fulfilment of established criteria)	89	(107)
Individually acquired knowledge/competencies during a module/class	16	(19)
Other forms	3	(3)

Question 6.7: What forms of marking are used in your Master Physics Programme?

latter frequently occurs are predominantly located in the central and eastern European region. This indicates that in these countries the examination system is still rather traditional, taking into account only the performance of the student during a final written or oral test.

As the final examination for the award of a Master degree in Physics still plays an important role in basically all countries, we asked what types of assessment are used in the process. About two thirds of the respondents stated that it is a thesis plus defence, however, a quarter each also included an oral examination and project presentations (see Table 12).

The curriculum analysis has shown that in the two-year Master programmes typically the last six months of the second year are devoted to the Master thesis. The first year or the first one and a half years are devoted to deepen subject specialisations often coupled with general Physics courses.

The reform agenda of the Bologna Process also includes a shift from teaching to learning which has an impact on the forms of assessment, namely the assessment of student learning outcomes which are composed of subject specific knowledge and competencies and of more general and transferable skills and competencies. Only few curricula are explicit on the forms and objects of assessment involved in a given programme of study. This might be due to the fact that there are separate documents, one specifying the curriculum, another one specifying the examination regulations. However, in a few curricula that were submitted in the framework of this project we find exemplary formulations. Here are two examples:

For a taught Master of Physics programme in the UK specifications are formulated with respect to:

- the formal aim of the programme (*e.g.* to prepare students for research or work in industry);
- the student achievement objectives (*e.g.* the level of understanding, the skills, the capacity to work effectively, *etc.*);
- knowledge and understanding (detailing levels of subject specific knowledge);
- intellectual skills (what a student can do in terms of critical thinking and analysis at the end of a programme);
- practical skills (what a student can do in terms of practical competencies at the end of a programme);

▼ Table 12: Master Physics Final Steps (percent and count/multiple reply by university)

	%	count
Written thesis	32	(38)
Written thesis plus defence	63	(76)
Written test(s)	18	(21)
Oral examination	26	(31)
Demonstration of an experiment, mathematical formula (or similar)	3	(3)
Project presentation	23	(27)
Other, please indicate	7	(8)

Question 6.2: What are the final steps for the award of a Master degree in Physics in your institution?

- transferable skills (*e.g.* problem-solving, investigating, communicating, analytical skills, IT skills, personal skills).

The curriculum of a Belgian university outlines four general types of learning goals for students in a Physics Master programme:

- final competencies (discipline-related, scientific, intellectual, teamwork and communication, societal, job-specific);
- objectives (general objectives for the entire programme, minor-specific objectives);
- learning outcomes;
- course-specific competencies.

In many countries, however, the concept of learning outcomes and the question how to assess them remains quite unclear and will require some more time of experimentation and change.

► Conclusion:

Assessment and Examination:

- **Absolute marking is dominant (89 %) compared to relative marking (11 %).**
- **Assessment happens in 91 percent of the cases after each module or unit of teaching and learning, thus reducing the weight of the final examination.**

4.7 Employability, Key or Transferable Skills

The issue of employability and transmission of key skills is closely related with the demand to prepare more highly qualified students for non-academic jobs. The Physics validation Panel

▼ Table 13: Employer Cooperation (percent and count by university and by country)

	Yes, in all of them (%)	Yes, in some of them (%)	No (%)	Total (%)
Albania (N=1)	100	0	0	100
Austria (N=3)	100	0	0	100
Belarus (N=1)	100	0	0	100
Belgium (N=3)	33	0	67	100
Croatia (N=1)	100	0	0	100
Czech Republic (N=5)	60	20	20	100
Denmark (N=3)	67	0	33	100
Finland (N=7)	57	14	29	100
France (N=5)	80	0	20	100
Germany (N=28)	25	18	57	100
Hungary (N=5)	0	40	60	100
Italy (N=7)	57	14	29	100
Lithuania (N=3)	100	0	0	100
Macedonia (N=1)	0	100	0	100
Netherlands (N=2)	0	0	100	100
Poland (N=7)	29	57	14	100
Slovakia (N=2)	100	0	0	100
Slovenia (N=1)	100	0	0	100
Spain (N=5)	40	20	40	100
Sweden (N=6)	33	17	50	100
Switzerland (N=3)	100	0	0	100
UK/Ireland (N=21)	43	14	43	100
Ukraine (N=1)	100	0	0	100
Total (%)	46	17	37	100
Total (N)	56	20	45	121

Question 5.6: Did you cooperate with employers in the design/development of the curriculum in your Master programme(s) in Physics?

▼ Table 14: Transferable Skills Acquisition (percent and count by university type)

	Yes, in all programmes	Yes, in some programmes	No	Total
University	71 % (N=75)	8 % (N=8)	22 % (N=23)	100 % (N=106)
Technical University	90 % (N=9)	0	10 % (N=1)	100 % (N=10)
Total	72 % (N=84)	7 % (N=8)	21 % (N=24)	100 % (N=116)

Question 8.1: Is the acquisition of transferable skills part of the Master curriculum in Physics?

Report (quoted in the *Tuning* Project 2007, p. 21) stated: *"Physics provides an extraordinarily rich package of transferable skills, probably more than any other subject."* And the *Tuning* Project itself mentions the fact that because of the high importance of mathematical and experimental skills, students in Physics develop generic competences *"which endow the graduates with a flexible mind, able to approach and model increasingly complex systems, even outside the realm of the physical world"* (*Tuning* Project 2007, p. 21).

▼ Table 15: Transferable Skills Acquisition (percent and count by university and by country)

	Yes, in all programmes (%)	Yes, in some programmes (%)	No (%)	Total (%)
Albania (N=1)	100	0	0	100
Austria (N=3)	100	0	0	100
Belarus (N=1)	100	0	0	100
Belgium (N=3)	67	0	33	100
Croatia (N=1)	100	0	0	100
Czech Republic (N=4)	50	0	50	100
Denmark (N=3)	100	0	0	100
Finland (N=7)	71	0	29	100
France (N=5)*	60	20	20	100
Germany (N=28)	82	4	14	100
Hungary (N=5)	80	0	20	100
Italy (N=7)	71	14	14	100
Lithuania (N=3)	67	33	0	100
Macedonia (N=1)	0	0	100	100
Netherlands (N=2)	50	0	50	100
Poland (N=7)	43	14	43	100
Slovakia (N=2)	100	0	0	100
Slovenia (N=1)	100	0	0	100
Spain (N=4)	75	0	25	100
Sweden (N=5)	60	20	20	100
Switzerland (N=3)	67	0	33	100
UK/Ireland (N=20)	75	10	15	100
Ukraine (N=1)	0	0	100	100
Total (%)	73	7	21	100
Total (N)	85	8	24	117

Question 8.1: Is the acquisition of transferable skills part of the Master curriculum in Physics?

* Due to a comment of the representative of the national Physical Society, in France all Master programmes include the acquisition of transferable skills. The column "Yes, in all programmes" in Table 15 should therefore indicate 100 percent.

The *Tuning* Project also provides a broad list of typical or possible occupations for Physicists (see p. 27-29) both for graduates with a Bachelor degree and with a Master degree. In some of the curricula we have analysed, such a broad approach to potential job opportunities is reflected. Typically the generic or transferable skills which students of Physics acquire in their programmes include problem-solving, communication, presentation, creativity and originality.

In our questionnaire we asked programme coordinators whether cooperation was sought with employers in the design and development of Master level curricula in Physics. Here 46 percent of our respondents stated that cooperation with employers was sought for all the Physics programmes offered by their institution, 17 percent stated that this was the case for some of the curricula and 37 percent said that this was not the case. High proportions of respondents who stated that they did not cooperate with employers can be found in the Netherlands (100 %), Belgium (67 %), Hungary (60 %), Germany (57 %), and Sweden (50 %) (see Table 13).

An interesting distinction turned up in this complex of questions, namely that between universities and technical universities. Indeed, 71 percent of the respondents from universities stated that the acquisition of transferable skills is part of their Master

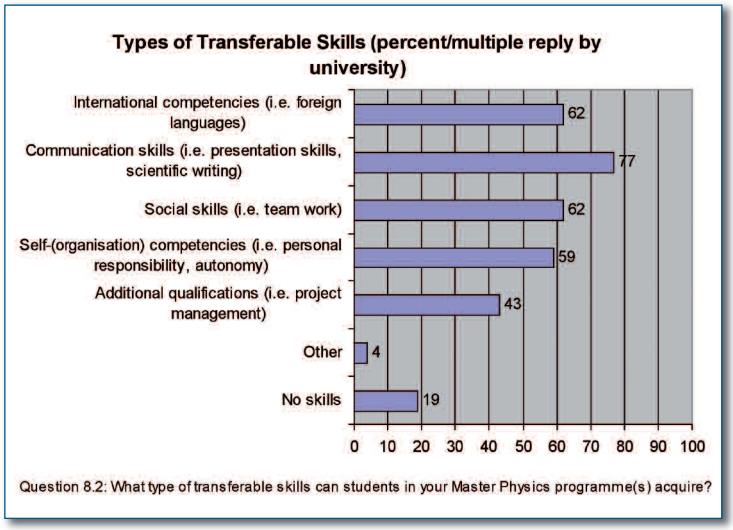
curriculum in Physics; eight percent stated that this was the case for some of the curricula and 22 percent said that transferable skills were not part of their curriculum. Despite the fact that the number of respondents from technical universities was not so high, the figures show a different trend: *i.e.* 90 percent of the respondents from technical universities stated that transferable skills were part of their Physics curricula in all programmes and only 10 percent stated that this was not the case (see Table 14).

Looking at the distribution according to country, in Macedonia and Ukraine (one respondent each only) transferable skills are not part of the programmes but also some of the respondents from other countries stated this: 50 percent from the Czech Republic and from the Netherlands and 43 percent from Poland (see Table 15).

We provided a list of types of transferable skills and asked whether they were part of the Physics curriculum (multiple replies were possible). Almost all of them were ticked by more than half of the respondents, the highest proportion being received for communication skills (77 %), followed by social skills (62 %) and international competences (62 %), self-organisation competences (59 %) and additional qualifications like project management (43 %) (see Figure 10).

Mostly the acquisition of transferable skills is integrated into the Physics curricula (61 %) but some respondents also stated that there is a mixture of integration and provision in separate special courses (32 %).

▼ **Figure 10: Transferable Skills**



While respondents from technical university mostly did not see any changes in the provision of transferable skills, those that did see them did not relate them to the Bologna Process. This is a bit different for universities: 60 percent of the respondents saw a rise in the acquisition of transferable skills and 23 percent linked this to the Bologna Process (see Table 16).

► Conclusion:

- **The acquisition of transferable skills is supposed to smooth transition into employment and is receiving more attention. This attention, however, is mainly not linked to the Bologna Process.**
- **In a number of countries also employers are involved in the development of Physics curricula.**

▼ **Table 16: Changes in Transferable Skills Acquisition (percent and count by university type)**

	University	Technical University	Total
No, there aren't any changes	40 % (N=34)	75 % (N=6)	43 % (N=40)
Yes, the number and extent of transferable skills has risen, but this is not linked to the Bologna Process	37 % (N=32)	25 % (N=2)	36 % (N= 34)
Yes, the number and extent of transferable skills has risen and this is clearly linked to the Bologna Process	23 % (N=20)	0	21% (N=20)
Total	100% (N=86)	100% (N=8)	100% (N=94)

Question 8.4: Do you observe any changes regarding the acquisition of transferable skills in the Physics Master programme(s) at your institution in recent years, and if yes, are they linked to the Bologna process?

4.8 Transitions

Like Bachelor programmes, Master programmes are framed by two transition phases. The first stage is the selection and admission onto the programme, the second stage is the transition into the labour market or onto a doctoral programme after successful completion of the degree. This is essentially the continental European model.

In the UK, there are two models for Masters programmes. The first is essentially the same as that common across continental Europe. Here, students enter Masters programmes following completion of their Bachelor degrees and on completion, they either enter the job market or progress to doctoral studies. In this model, the Masters programmes are typically one year long, comprising the equivalent of 90 ECTS, and are usually focused on a narrow aspect of physics; a good example would be a Masters programme in Medical Physics. They are considered to be postgraduate degrees, a classification that is important for funding.

The second model, which applies to a restricted range of disciplines, including Physics, Chemistry and Engineering, is where a student undertakes a four-year integrated Masters programme (five-year in Scotland). Graduates may then enter the job market or enter doctoral studies. While this is increasingly the most common route to the PhD for Physics, it is still possible to progress directly from BSc to PhD.

Another system which differs from the main European model can be found in France. Here the selection for the Master degree does not take place after the Bachelor degree (Bachelor graduates normally have open access to the same field at Master level), but after the first year of the Master programme. This is not due to a specific law but to capacities in the universities (a restricted number of places for the second year). Consequently, entry into the second year of the Master programme is accompanied by selection procedures like an interview or a letter of intent. Graduates that don't continue the Master programme in the second year and leave university with an intermediate degree after the first year of the Master programme should be able to find employment because in the traditional system before Bologna there has been exactly the same selection system (after the first year of advanced studies) and employers are well informed about the relevant competence levels of such graduates.

In our online questionnaire we asked about the requirements for access into a Master Physics programme. We differentiated between second-cycle and integrated Master programmes. With regard to second-cycle programmes, about two thirds of our respondents stated that there are special requirements for access, namely the grade point average from the Bachelor degree (63 %), an interview (34 %), a written test (6 %) and various other requirements (32 %) (multiple replies were possible here).

Integrated Master programmes typically have no written test and the grade point average of the school leaving certificate is important (73 %) (see Table 17, multiple replies were possible here).

Typically the curricula state for most of the Master Physics programmes analysed that they prepare for research careers as well as for professional careers in the non-academic labour markets.

In our online survey we asked the respondents to estimate transition rates, both into the labour market and into a doctoral programme of Master graduates and of traditional graduates. With regard to the new Master graduates the results have to be interpreted with cautiousness because in many

▼ **Table 17: Entrance Requirements for Integrated Master Programmes (percent and count/multiple reply by university)**

	%	count
Written test	0	(0)
Interview	8	(3)
Grade point average	73	(27)
Other	35	(13)

Question 3.11: Do you have entrance requirements for the Master phase?

countries the number of Master graduates is still low and thus does not provide an adequate picture of the transition process.

Interestingly, when comparing transition rates of Master graduates and of traditional graduates into the labour market (see Figure 11), the figures are quite similar, while the comparison of transition rates of Master graduates and of traditional graduates into a doctoral programme shows a more varied picture (see Figure 12). (UK and Ireland were not taken into consideration because a comparison between Master graduates and traditional graduates does not make sense here). As mentioned before, these findings should not be over-interpreted due to the fact that in many countries the higher education system is still in a phase of transition from the old to the new degrees.

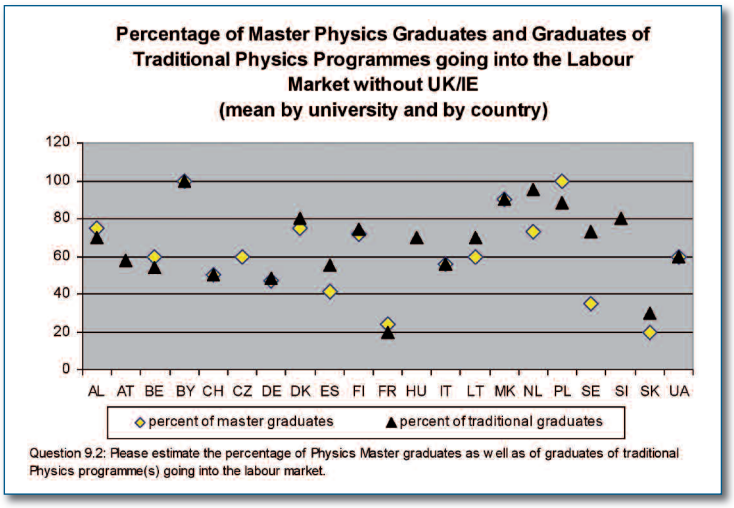
The more interesting finding is maybe the highly diverse picture from country to country when taking into consideration only traditional graduates (where one can assume that the figures are more or less valid): We can observe differences between 30 percent of Physics graduates (in Slovakia) and of almost 100 percent (in the Netherlands) going into the labour market (see Figure 11). But again a comment from the representative of the national Physical Society in France was very useful in order to make us careful with the interpretation of this data as well: As mentioned above, in France there are three types of Master programmes (concerning the second year): research-oriented, professionally-oriented and more general programmes.

Since most of the respondents to our questionnaire are coordinators of research oriented programmes, this explains why there is a rather high percentage of graduates (traditional and new ones) going into a doctoral programme (see Figure 12) and a rather low percentage of graduates (traditional and new ones) going into the labour market (see Figure 11) compared to other European countries. This bias in the population of respondents might exist in the group of respondents of other (big) countries as well.

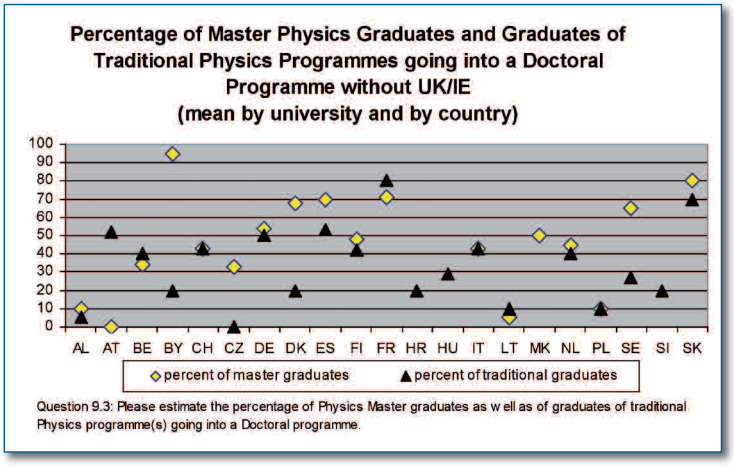
► Conclusion:

- **A European mainstream is emerging, requiring the successful completion of a Master degree for selection into a doctoral phase.**
- **Transition rates into the labour market (of traditional graduates) vary a lot from country to country – but this might be also a question of a bias in the population of respondents.**
- **Comparing Master graduates with traditional graduates, we have the paradox situation that transition rates into the labour market are quite similar while transition rates into a doctoral programme vary to a quite high extent. Studies at a later date (when Master Physics programmes will have produced a higher number of graduates) will probably show a better picture of the transition process.**

▼ Figure 11: Transition into the Labour Market



▼ Figure 12: Transition into a doctoral programme or phase



4.9 Quality Assurance, Accreditation, Evaluation

The curricula themselves include hardly any information about the quality assessment and assurance system which is applied in a given country or a given university. We know, however, that in most European countries national regulation is in place with regard to continuous or periodic quality assessment (evaluation of teaching) and that most European countries have established accreditation agencies for the new programmes.

Looking at the institutional level, 92 percent of our respondents said that quality assurance was implemented in their institution and programme. However, again this was not the case in all universities of a given country. A high proportion of respondents stating that quality assurance is not implemented in their institution/programme came from Switzerland, Italy, and Finland (see Table 18).

▼ Table 18: Implementation of Quality Assurance in the Institution (percent and count by university and by country)

	Yes (%)	No (%)	Total (%)
Albania (N=1)	100	0	100
Austria (N=3)	100	0	100
Belarus (N=1)	100	0	100
Belgium (N=3)	100	0	100
Croatia (N=1)	100	0	100
Czech Republic (N=4)	75	25	100
Denmark (N=3)	100	0	100
Finland (N=7)	71	29	100
France (N=5)	80	20	100
Germany (N=27)	100	0	100
Hungary (N=5)	80	20	100
Italy (N=7)	71	29	100
Lithuania (N=3)	100	0	100
Macedonia (N=1)	100	0	100
Netherlands (N=2)	100	0	100
Poland (N=8)	88	13	100
Slovakia (N=2)	100	0	100
Slovenia (N=1)	100	0	100
Spain (N=5)	100	0	100
Sweden (N=6)	100	0	100
Switzerland (N=3)	33	67	100
UK/Ireland (N=20)	100	0	100
Ukraine (N=1)	100	0	100
Total (%)	92	8	100
Total (N)	109	10	119

Question 7.2: Is quality assurance implemented in your institution/programme(s)?

We further asked whether various types of quality assurance activities are related or not related to the Bologna Process or whether they were not applied at all. The following trends can be observed (see Figure 13):

- Those quality assurance activities that a high proportion of respondents see related to the Bologna Process are predominantly periodic accreditations and re-accreditations of study/degree programmes (47 %);
- A number of quality assurance activities are widespread but dominantly not seen as related to the Bologna Process: system of approval of programmes/curricula (49 %), evaluation of courses by student questionnaire (72 %), and evaluation of programmes by external evaluators (42 %).
- Quality assurance activities which have not been introduced yet are: inclusion of external examiners (56 %), monitoring of teaching material and preparation of teachers (47 %), and obligatory participation of teachers in pedagogical/didactic courses (62 %).

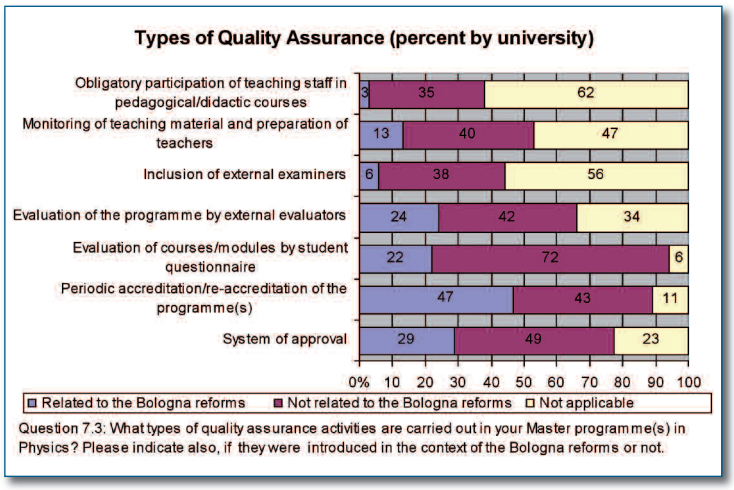
► **Conclusion:** **Quality management has been on the agenda in most countries already before the Bologna Declaration. By now a broad range of quality assessment and improvement instruments have been introduced. Programme accreditation is the only instrument which is closely related to the Bologna Process.**

5. Conclusions: Physics Studies in Europe Today. The Master Level

With regard to the general picture of the implementation of Bologna Process into Physics studies in Europe at the Master level we can summarise our findings as follows.

1. There is some degree of harmonisation at the macro level (two-cycle structure, ECTS) but a high amount of heterogeneity at the institutional and the programme level. This has implications for the question whether recognition should be based on similarity (standards) or on equivalence.
2. The proportion of universities which have not yet introduced the second cycle (Master level) or offer traditional one-cycle programmes alongside of new Bachelor and Master programmes is still quite high.
3. The number of Master level programmes has multiplied. Most traditional programmes were not simply changed into one Bachelor and one Master programme but a relatively high number of specialised (22 %) and/or interdisciplinary (22 %) programmes were newly established at the Master level.
4. The majority of new second-cycle programmes has a duration of two years (after a three-year Bachelor programme), except in the UK where four-year integrated Master programmes or one year 'stand alone' Master programmes are still more common.
5. The use of ECTS is widely established. The calculation is frequently based on student workload (one ECTS credit point equals 25 to 30 hours of student workload combined of classroom teaching plus self-study).
6. Modularisation continues to be a more or less elusive concept despite of efforts to understand and implement it. Time units and coherence of content differ widely.
7. The provision of a Diploma Supplement upon graduation is becoming more widespread (70 %) and it is mostly issued automatically.
8. We found a relatively high number of examples of integrated mobility (33 percent of the institutions included in the survey stated that they have such programmes). Optional mobility is included in an even higher proportion of programmes. Also the international composition of the student body is rather high in some countries. In general, enrolment of international students has increased in all Master programmes as well as teaching in a foreign language (mostly English).
9. Assessment of student performance varies widely but performance of the student throughout the course of study is increasingly included in the final grade (75 %), thus reducing the weight of the final examination.

▼ **Figure 13: Quality Assurance**



10. Transferable skills to prepare for entrance into the labour market have a high importance in Master level Physics programmes and are either conveyed separately or as an integrated part of the Physics curriculum. Communication skills, international competencies, and social skills were given the highest importance.
11. Typically, Master level Physics programmes prepare for both an academic or research career and a professional career in the non-academic labour market. In continental Europe completion of a Master degree is required before graduates are considered for entering doctoral studies.
12. Quality assurance is high on the agenda in most countries. A broad range of assessment instruments has been introduced. In addition, most countries have established (external) accreditation procedures for the new study programmes in the framework of the Bologna Process.

6. Acknowledgements

This report deals with the master level of university physics education in Europe after the Bologna reforms. The two studies presented by EPS - on the Bachelor and now on the Master level - are the first systematic analysis of the European-wide impact of the reforms in one specific academic field of the natural sciences. With these two studies and reports, the

EPS analysis of physics education is complete. EPS is proud that this project has been awarded by the European DiVa partnership as an example of good practices for dissemination and valorisation of educational projects in Europe.

EPS wants to acknowledge the financial support by the Commission for this project. It would not have been possible without the readiness of many national Member Societies of the EPS who have joined and supported it. Each participating Member Society has identified a project contact with interest in and commitment to the educational needs of our profession.

This group – the steering committee – has worked together intensively now for three years. A major part of the contact's work was to identify the national universities and physics departments and to collaborate with them during this study. The actual information and experience, which had to be collected and made available is with the universities. We are all very grateful to those deans and professors in physics who helped us and provided the necessary information. It is clear to all of us that we were requesting a lot from you specifically as we had to sent our questionnaires during semesters when the university system is already maximally strained. Therefore, we want to sincerely thank you.

Our thanks include the members of the steering committee for their important role as bridges to their national universities.

We also want to use this opportunity to thank INCHER which did the actual analysis of the material, specifically the authors of this report, Prof. B. M. Kehm and Mrs. B. Alesi. INCHER has a high reputation in higher education research, specifically in the implementation issues of the Bologna process. This wide experience was vital for the success of this study.

Finally EPS would like to thank its own key members who have scientifically accompanied these studies - Professor H. Ferdinande and Professor U. Titulaer. Both have been deeply involved in European physics education over many years, notably their leading roles in the EUPEN, STEPS/STEPS T W O & TUNING processes. It is remarkable that on the background of these studies and others including the two EPS studies presented here two EPS papers on "A European Specification for Physics Bachelor Studies" and the equivalent for the master studies could be written.

The next and final step of this project, still supported by the Commission, is the analysis of the "doctoral candidate" period in physics. This is now somewhat different because it deals with the analysis of a still important step in the career of a physicist after his/her formal education has been completed. Also "A European Specification for Physics Doctoral Studies" is envisaged. This part of the study should be completed mid-2011.

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NOTES

NOTES

APPENDIX 1: QUESTIONNAIRE

Part I: General Questions

1. Personal Details

1.1 What is your status in the Department/Faculty?
Dean/Director/Head of Studies.
Professor/lecturer/reader.
Junior teacher/researcher.
Member of administrative staff.
Other, please indicate:

1.2 What is your function in relation to the Physics Programme(s)?
(Multiple replies possible)
Programme coordinator.
Teacher (professor/lecturer/reader).
Administrative staff.
Other, please indicate:

2. Institutional Details

2.1 Please provide the name of the country in which your institution is located:

.....

2.2 How old is your institution counting from date of establishment?
..... years.

2.3 Please indicate the type of your institution:
University.
Technical University.
Other, please indicate:

2.4 In what subject groups does your institution provide study/degree programmes?
(Multiple replies possible)
Natural Sciences.
Engineering.
Humanities.
Social Sciences.
Arts (incl. Design and Architecture).
Medicine.
Law.
Agriculture.
Other, please indicate:

2.5 Please indicate the size of your institution in terms of numbers of students and numbers of academic staff:

..... students (incl. doctoral students).
..... academic staff (teaching and research).

2.6 Please indicate the size of your Physics Department/Faculty in terms of numbers of students and academic staff:

..... students (without doctoral students/candidates).
..... academic staff (teaching and research).
..... doctoral students/candidates (*i.e.* persons accepted for getting a doctoral degree).

2.7 Please state the name (in English translation) of the Physics programmes (and degrees) offered at your institution, BEFORE changing to the new model of Bachelor and Master (in the following we will refer to these as "TRADITIONAL PROGRAMMES"). Please include also the scheduled duration in years and the total number of students enrolled (If applicable, also name traditional degree programmes currently still running parallel to Bachelor and Master programmes).

Name of programme	Scheduled duration (years)	Total no. of stud.

2.8 What is the amount of tuition fees for one academic year in your Master Physics programme(s). (Please indicate in Euro)

..... Euro
Not applicable, no tuition fees.

Part II: Second-cycle or Master Programmes in Physics

3. Implementation of the tiered structure

3.1 When did you or will you introduce Master degree programme(s) in Physics in your institution? (Multiple replies possible)

INTEGRATED Master Physics programmes are the traditional degree programmes in my institution.
SECOND CYCLE Master Physics programmes are the traditional degree programmes in my institution.
Before the year 2000; please indicate in which year: .....

In the year 2000	In the year 2001	In the year 2002	In the year 2003 .....
In the year 2004	In the year 2005	In the year 2006	In the year 2007 .....
In the year 2008	In the year 2009	In the year 2010	

Introduction of Master degree programme(s) in Physics is envisaged for the year: .....

3.2 How many Master programmes in Physics do you currently offer at your institution?
Number .....

3.3 Please state the name of the Master programme(s) (and degrees) in Physics currently offered at your institution (please in English translation), the scheduled duration in years, the number of Credit Points to be earned and the total number of students enrolled:

Name of programme	Scheduled duration (years)	Number of credit points	Total no. of students

3.4 Please indicate which of your Master programmes in Physics are research oriented and which are professionally oriented?

Name of programme	Research	Professionally oriented

3.5 What is the character of your Master Physics programme(s) (and degrees)?

Name of programme	Standard Physics	Specialised [13]	Interdiciplinary plenary [14] (incl. Engineering)

[13] Please note that with a specialized programme we don´t mean a curriculum with certain specializations but a programme with a quite narrow focus, *e.g.* a Master in Plasma and Vacuum Technology.
[14] An interdisciplinary programme is a programme which includes knowledge from different disciplines and is often provided jointly by different study departments/faculties, see *e.g.* programmes in Nanotechnology which include Physics, Chemistry, Electrical Engineering and Mechanical Engineering.

3.6 If you offer (an) interdisciplinary Master programme(s), please indicate with what other subjects/ subject groups Physics is or can be combined. (Multiple replies possible)

Other natural sciences, please indicate:
Engineering Sciences.
Medical Sciences.
Humanities.
Social Sciences.
Economics.
Other, please indicate:

3.7 Please indicate, which of your Master programmes in Physics are to be attended immediately after the Bachelor degree (often called "consecutive programmes") and which are to be attended after spending some time on the labour market after the Bachelor degree (often called "continuing education programmes").

Name of programme	Consecutive programme	Continuing education programme

3.8 How many of your Master programme(s) in Physics are:

Full-time programme(s)? ..... Number of programmes: .....
Part-time programme(s)? ..... Number of programmes: .....
Our programme(s) can be attended either part-time or full-time.

3.9 How many of your Master programme(s) in Physics are offered:

In classical presence delivery mode? ..... Number of programmes: .....
In e-learning, distance learning mode? ..... Number of programmes: .....
In blended learning mode? ..... Number of programmes: .....

3.10 Please estimate the composition of the students enrolled in your Master Physics programme(s) (only for those which are not Integrated Master programmes):

..... percent of Bachelor graduates from YOUR INSTITUTION enrolled in your Master Physics programme(s).
..... percent of Bachelor graduates from OTHER INSTITUTIONS IN YOUR COUNTRY enrolled in your Master Physics programme(s).
..... percent of Bachelor graduates from INSTITUTIONS IN OTHER COUNTRIES enrolled in your Master Physics programmes.
..... Not known yet.

3.11 Do you have entrance requirements for the Master phase?

No.

Yes, please indicate for SECOND CYCLE and for INTEGRATED Master programmes separately:

	Second cycle programmes	Integrated programmes
Written test		
Interview		
Grade point average		
Other, please indicate:		

3.12 What system of accreditation/approval of Master study programmes is in place? (Multiple replies possible)

National/regional accreditation system.

Accreditation by institutional bodies.

Approval by Ministry.

Approval by institutional bodies.

Other, please indicate:

3.13 Is/Are your Master Physics Programme(s) approved/accredited?

Yes (all of them).

Yes, some of them. Please indicate the number of the programmes: .....

No.

3.14 .....How long does it actually take on average for Master students in Physics (incl. final examinations) to complete their studies at your institution?

Completion during the scheduled duration.

Half a year longer than the scheduled duration.

One year longer than the scheduled duration.

One and a half years longer than the scheduled duration.

Two years longer than the scheduled duration.

Longer than two years than the scheduled duration.

No information available (yet).

4. Implementation of Complementary Measures

4.1 Do you apply ECTS Credit Points in the framework of your Master Programme(s) in Physics for all students?

Yes (in all of them). Please go to question 4.4

Yes, in some of them. Please indicate the number of the programmes: .....

No, for ERASMUS students only.

No, we don't apply ECTS Credit Points.

4.2 Do you apply other forms of Credit Points?

Yes. No. Please go to question 4.6

4.3 Are these Credit Points compatible with ECTS?

Yes, please indicate conversion: ..... 1 ..... ECTS = ... Credit Points No

4.4 How are the Credit Points calculated?

On the basis of contact hours and independent study = student workload concept.

Only on the basis of contact hours. **Please go to question 4.6**

4.5 How many hours of student workload are required to earn one Credit Point?

10 hours ..... 15 hours ..... 20 hours ..... 25 hours ..... 30 hours .....

Other, please indicate: .....

4.6 Have you modularised your Master Physics Programme(s) (a module being a self-contained unit of study)?

Yes (all of them).

Yes, some of them. Please indicate the number of the programmes: .....

No. **Please go to question 4.9**

4.7 Please describe in a few words, what a module consist of as a rule in your Physics department (*e.g.* what different teaching formats does it include, does it include also independent study, is the module completed by an examination or homework paper?)

.....

.....

4.8 What is the size of a module as a rule? (Multiple replies possible)

(If modules have different sizes, please indicate by separating figures with a slash)

Number of hours of student workload, please indicate: .....

Number of ECTS Credit Points, please indicate: .....

Number of other Credit Points (if applicable): .....

Number of teaching hours in class, please indicate: .....

Others, please indicate: .....

4.9 Do you provide graduates in Physics with a Diploma Supplement?

No, but the introduction of the Diploma Supplement is envisaged for the year: .....

No, the introduction of the Diploma Supplement hasn't been discusses yet.

Yes: Automatically. Under request.

Bachelor graduates are provided with a Diploma Supplement.

Master graduates are provided with a Diploma Supplement.

4.10 Do you have (a) joint or double degree Master programme(s) in Physics? [15]

No.

Yes, double degree programme(s) How many? .....

Yes, joint degree programme(s) How many? .....

4.11 Besides joint or double degree programme(s), are phases of study abroad part of the curriculum in your Master programme(s) in Physics?

No.

Yes (in all programmes).

Yes, in some programmes. Please indicate the number of the programmes .....

[15] A double degree programme is programme offered jointly by two institutions located in different countries; a joint degree programme is a programme offered jointly by more than two institutions from different countries.

4.12 At what point in time do students go abroad?

Between the Bachelor and the Master.
1st year of the Master.
2nd year of the Master.
Other (for SECOND CYCLE Master programmes), please indicate: .....
Other (for INTEGRATED Master programmes), please indicate: .....
Any point in time.

4.13 For how long do students go abroad on average?

1-2 months. 3-5 months. longer than 5 months.

4.14 Please indicate the percentage of Physics Master students from your institution who use such opportunities to go abroad:

percent on average (in SECOND CYCLE Master programmes) .....
percent on average (in INTEGRATED Master programmes) .....
no information available yet.

4.15 Please indicate the percentage of international students enrolling in your Master programme(s) in Physics.

..... percent on average (in SECOND CYCLE Master programmes)
..... percent on average (in INTEGRATED Master programmes)
..... no information available yet

4.16 Are there other opportunities for mobility (internship abroad, work or lab work abroad)?

Yes, please indicate which ones:
No.

4.17 Do you observe any changes regarding student mobility in the Physics Master programme(s) at your institution in recent years, and if yes, are they linked to the Bologna process?

No, there aren't any changes.
Yes, there are changes regarding student mobility, but they are not linked to the Bologna process.
Yes, we observe changes which are clearly linked to the Bologna process:

.....
.....
.....

The number of students in our BACHELOR Physics programme(s) going abroad is Higher Lower
compared to the number of students in our traditional programmes going abroad.
The number of students in our MASTER Physics programme(s) going abroad is Higher Lower
compared to the number of students in our traditional programmes going abroad.
The number of international students in our BACHELOR Physics programme(s) is Higher Lower
compared to the number of international students in our traditional programmes.
The number of international students in our MASTER Physics programme(s) is Higher Lower
compared to the number of international students in our traditional programmes.

4.18 Are there additional incentives to increase student mobility in your country/institution?

No
Yes, please indicate what is the nature of the incentives:

5. Curriculum

5.1 Do your modules/course descriptions include expected learning outcomes?

Yes (all of them).
Yes, some of them. Please indicate the number of the programmes: .....
No.

5.2 What is the respective percentage of compulsory *vs.* elective modules/courses in your Master Physics programme(s) (excluding the thesis)?

Name of programme	Compulsories	Electives

5.3 Is teaching offered in a foreign language in your Master programme(s) in Physics?

No.
Yes. In how many programmes?

5.4 Please indicate the foreign language or languages and rank them according to the frequency of use (with Rank 1 being the highest):

English	Rank:
French	Rank:
German	Rank:
Italian	Rank:
Spanish	Rank:
Other foreign language(s), please indicate:	Rank:

5.5 Do you observe any changes regarding teaching in a foreign language in the Physics Master programme(s) at your institution in recent years, and if yes, are they linked to the Bologna process?

No, there aren't any changes.
Yes, teaching in a foreign language has increased but this is not linked to the Bologna process.
Yes, teaching in a foreign language (or the increase of it) is clearly linked to the Bologna process.

5.6 Did you cooperate with employers in the design/development of the cur-riculum in your Master programme(s) in Physics?

Yes (in all of them).
Yes, in some of them. Please indicate the number of the programmes: .....
No.

6. Assessment and Examinations

6.1 How are the Credit Points (CP) distributed in your Master Physics cur-riculum over the various types of performance (please provide number of CP for each programme)?

Name of programme	CP for theoretical modules/ courses/ other units of time	CP for lab work/ practicals	CP for Master thesis/ project work and defence	CP for other forms of performance, please indicate	Total CP	Not applic.

6.2 What are the final steps for the award of a Master degree in Physics in your institution? (Multiple replies possible)

Written thesis. Written thesis plus defence.
Written test(s). Oral examination.
Demonstration of an experiment, mathematical formula (or similar). Project presentation.
Other, please indicate:

6.3 Do you assess student performance after each module or unit of teaching/learning?

Yes. No.

6.4 Are the marks a student has received during the course of study included when calculating the final mark/the final classification of the degree (please indicate percentages)?

Yes:

..... Percent from theoretical modules/courses/other units.
..... Percent from lab work/practical exercises.
..... Percent from thesis and defence (if applicable).
..... Percent from final oral examination.
..... Percent from final written examination/test(s).
..... Percent from other form(s) of assessment, please indicate:

No.

6.5 Do you assess subject knowledge only or also transferable skills? [16]

Subject knowledge only Also transferable skills

[16] The term "transferable skills" is frequently used synonymous with the following terms: soft skills, generic skills, key competences, key qualifications. It denotes a combination of cognitive, motivational, moral, and social skills needed to fulfil tasks, solve problems, cope with demands, and cooperate in teams.

6.6 What types of assessment are being used during the course of study? (Multiple replies possible)

Written tests .....
Multiple choice questions .....
Homework papers .....
Interview with teacher .....
Oral examination .....
Project presentation .....
Other forms of assessment, please indicate:

6.7 What forms of marking are used in your Master Physics programme(s)? (Multiple replies possible)

Just pass/fail/passed with distinction or honours.
Relative marking (performance of individual student in relation to the group).
Absolute marking (degree of fulfilment of established criteria).
Individually acquired knowledge/competencies during a module/class.
Other forms, please indicate:

7. Quality Assurance

7.1 Is quality assurance regulated by national law in your country?

Yes. No.

7.2 Is quality assurance implemented in your institution/programme(s)?

Yes. No. Please go to question 4.9

7.3 What types of quality assurance activities are carried out in your Master programme(s) in Physics? Please indicate also, if they were introduced in the context of the Bologna reforms or not. (Multiple replies possible)

	Related to the Bologna reforms	Not related to the Bologna reforms	Not applicable
System of approval			
Periodic accreditation/ re-accreditation of the programme(s)			
Evaluation of courses/ modules by student questionnaire			
Evaluation of the programme by external evaluators			
Inclusion of external examiners			
Monitoring of teaching material and preparation of teachers			
Obligatory participation of teaching staff in pedagogical/didactic courses			
Other, please indicate			

8. Employability and Transferable Skills

8.1 Is the acquisition of transferable skills part of the Master curriculum in Physics?
Yes (in all programmes).
Yes, in some programmes. Please indicate the number of the programmes: .....
No. **Please go to question 8.3**

8.2 What type of transferable skills can students in your Master Physics programme(s) acquire? (Multiple replies possible)
International competencies (*i.e.* foreign languages).
Communication skills (*i.e.* presentation skills, scientific writing).
Social skills (*i.e.* team work).
Cognitive competencies (dealing with complexity).
Self-(organisation) competencies (*i.e.* personal responsibility, autonomy).
Additional qualifications (*i.e.* project management).
Other, please indicate:

8.3 Is the acquisition of transferable skills integrated into the Master Physics curriculum or is it separated from it (*e.g.* in special courses)?
Integrated
Separated in special courses
Mixed

8.4 Do you observe any changes regarding the acquisition of transferable skills in the Physics Master programme(s) at your institution in recent years, and if yes, are they linked to the Bologna process?
No, there aren't any changes.
Yes, the number and extent of transferable skills has risen, but this is not linked to the Bologna process.
Yes, the number and extent of transferable skills has risen and this is clearly linked to the Bologna process.

8.5 What activities/services does your institution offer to ease transition of Physics Master graduates into the labour market? (Multiple replies possible)
Career services and advice.
Organisation of interviews with potential employers.
Internships during the course of study.
Lectures by alumni or potential employers about labour market and career opportunities.
Training for job applications and job interviews.
Information brochures about potential job areas.
Other activities/services, please indicate:
No particular activities/services on offer.

9. Completion and Transition Rates

9.1 Please estimate completion rates in your Master programme(s) in Physics as well as completion rates in your traditional Physics programmes:
..... percent of students complete their Master programme(s) Not known
..... percent of students complete their (traditional) programme(s) Not known

9.2 Please estimate the percentage of Physics Master graduates as well as of graduates of traditional Physics programme(s) going into the labour market:

..... percent of Physics Master graduates going into the labour market Not known

..... percent of graduates of traditional Physics programme(s) going into the labour market Not known

9.3 Please estimate the percentage of Physics Master graduates as well as of graduates of traditional Physics programme(s) going into a Doctoral programme:

..... percent of Physics Master graduates Not known

..... percent of graduates of traditional Physics programme(s) Not known

THANK YOU FOR YOUR COOPERATION.

NOTES

APPENDIX 2: Country Specificities

Albania:

Organization of and regulations for higher education in Albania:
The organization of and regulations for higher education programmes in Albania are set up at the national level and all higher education institutions, both public and private must follow these legal requirements. Having a common framework, clearly defined in the guidelines, codes and regulations at the highest institutional level providing detailed rules for recruitment, supervision, examinations, evaluation and defense of the thesis are a highly beneficial and innovative approach.
Higher education in Albania is organised in three cycles: first cycle, second cycle and third cycle:

1. First-cycle study programmes

- The overall goal of training in study programmes of the first cycle is to enable students to focus on a broad subject area and on the most fundamental and general principles of science.
- Duration of a first-cycle study programme is three academic years in which 180 ECTS must be earned. One ECTS is the equivalent of 25 hours of student workload combining contact hours and self-study in various proportions.
- Students who successfully complete a first-cycle study programme are awarded a "Bachelor" degree.

2. Second-cycle study programmes

- Study programmes of the second cycle provide to students holding a Bachelor degree deeper theoretical and practical information much of which is at, or informed by, the forefront of the discipline, field of study or area of professional practice and also basic training in research on the topics of their specialty; Graduates of second-cycle study programmes should be capable of demonstrating originality in their application of that knowledge and in addressing problems. In relation to future employment, Master graduates will be expected to possess the skills needed to exercise independent learning and to develop new skills to a high level.
- Duration of a second-cycle study programme is two academic years in which 120 ECTS must be earned.
- Graduates of second-cycle study programmes must pass one of the internationally known tests in English;
- Students who successfully complete a second-cycle study programme in Physics are awarded a "Master of Sciences" degree.

3. Study programmes "Professional Master"

- Study programmes "Professional Master" provide to students who hold at least a Bachelor degree a focused professional education.
- The duration of a study programmes "Professional Master" is 1.5 academic years in which 60-90 ECTS must be earned.
- Graduates of study programmes "Professional Master" must pass one of the internationally known tests in English.
- Students who successfully complete a study programme "Professional Master" are awarded the degree "Professional Master" in the specific field of study.
- Graduates holding a "Professional Master" degree can be admitted to a study programme of second cycle which awards a "Master of Science" degree. Strategies, rules and regulations are the responsibility of faculties or departments.

4. Third-cycle study programmes

4.1 Study programmes of doctorate

- Doctoral programmes should provide high quality disciplinary research enabling students to focus on a particular subject area or field of study in greater depth.
- Candidates holding a "Master of Science" degree can be admitted to a doctoral study programme.
- Duration of doctoral study programmes is at least 3 academic years including also 60 ECTS for the theoretical (taught) part of the programme. The institutions of higher education can specify other supplementary admission criteria. Strategies, rules, regulations and quality standards of research are the responsibility of faculties or departments. Students failing to pass the determined standards will not be allowed to continue doctorate studies. Students who fail will get a certificate documenting all academic and research achievements.

- Students who successfully complete a doctoral study programme are awarded a "Doctor (Dr)" degree.

4.2 Institutions of higher education can offer study programmes of second cycle and study programs of third cycle only in those fields of study in which the institution meets the national quality standards.

5. Other issues:

- Study programmes of first, second and third cycle are university study programmes.
- Institutions of higher education can offer also non-university professional study programmes. The amount of credits to be earned must be at least 120 ECTS. The normal duration of these programmes is two academic years. Students who successfully complete the above study programmes are awarded a "Professional Diploma" in the specific field of study. ECTS credits accumulated during the study programme can be transferred to a study program of first cycle. Rules and regulations are the responsibility of faculties or departments.
- All graduates of study programmes of first and second cycle receive a Diploma Supplement automatically and free of charge.
- Candidates applying for admission to a study programme of the third cycle must hold a "Master of Science" degree or equivalent and also meet specific admission requirements determined by the institution of higher education
- Opening, closing or reorganisation of a study programme of first, second or third cycle in a public institution of higher education is proposed by the institution of higher education and decided by the Minister of Education and Science. Prior to his decision, the Minister of Education and Science asks the opinion of the "Council of Accreditation of Institutions of Higher Education".

6. Opening, closing or reorganisation

Of a study programme of first, second or third cycle in a public institution of higher education is proposed by the institution of higher education and decided by the Minister of Education and Science. Prior to his decision, the Minister of Education and Science asks the opinion of the "Council of Accreditation of Institutions of Higher Education".

Austria:

In Austria, all physics departments introduced a 3-year Bachelor and 2-year Master programmes in 2006 or 2007. By law, students registered in the old integrated master programmes have the choice to either transfer to the new programmes or to complete the old ones as long as their studies are in the prescribed period of study time for the programme or are only moderately delayed. Virtually all those students who had a choice chose to stay in the old programmes. However, students transferring to a university after the introduction of the new system must register in the new programmes. Thus, there are a few students who have completed a Bologna type Master programme, but they form a highly atypical group. Teacher training programmes are still integrated master programmes; a transition to the Bologna structure is envisaged, but there is as yet no political agreement on the precise form.

In regular universities, the degree MSc is awarded, but technical universities are allowed to award the old degree "Diplom-Ingenieur(in)" instead, and in (technical) physics all have done so, at least as an option for the graduates.

Austrian universities have a high degree of autonomy in designing their curricula and study regulations. There is no obligation to modularise the curricula. The ECTS system, with 1 CP corresponding to a workload of 25 hours, is mandatory. Universities are essentially free to design their own quality control system; there is no obligatory programme accreditation. Draft curricula have to be sent to various stakeholders for comment before they are issued in their final form.

The following elements are regulated by law:

- Master: In the natural and technical sciences 120 credits must be earned for a Master degree.
- Diploma Supplement: Upon request each student must be supplied with a Diploma Supplement. According to a survey carried out by the Ministry a Diploma Supplement is provided automatically by most institutions (by all universities).

France:

This short report by Nathalie Lebrun (representative of the French Physical Society) gives an overview of the state of the art concerning the implementation of the Bologna Process in Physics studies at master level in France. The second part is dedicated to recommendations. Statistics on Physics masters are scarce and scattered. Consequently, this report can only show some trends.

State of the Art

As pointed out in the Bachelor report [17], all French universities are evaluated every four years and get a four-year contract from the Ministry for Higher Education and Research (MESR) through which the MESR ensures that the Bologna process is well implemented. A group of national Bologna promoters supports the universities in the implementation of the Bologna process reforms [18] in France. Since September 2006, all universities adopted the LMD scheme (licence, French name of the bachelor; master; doctorat, French name of doctorate) which is a reflection of the European award structure based on Ba/Ma/Dr. The decrees from April 2002 [19] relating to licence and master degrees had set up monitoring committees. In 2008, the monitoring committee on master programmes published a report concerning the implementation and impact of the Bologna process. [20]

The evaluation of the masters at national level

The assessment is done by the evaluation agency AERES [21]. The evaluation criteria for Master programmes [22] are different from those for the licence.
The criteria for the licence are:

- Teaching plan: Assessment of the consistency and balance of the teaching plan as well as of the progressiveness of the acquisition of skills and knowledge;
- Teaching aids for success: Assessment of the variety and effectiveness of teaching aids set up by the teaching staff and the institution;
- Integration into the job market and continuing chosen studies: Assessment of initiatives for preparing to continue studies, for gaining experience of the workplace and for following up what becomes of graduates;
- Running the Bachelor cycle: Assessment of the members and activities of the teaching team as well as the way in which the team improves the management of its programme by analysing and considering the different information gathered, including the evaluation of lessons by students.

The criteria for the Master programmes are:

- Extent to which the Master is associated with research: special attention has to be paid to the renowned research teams on which the master degrees call, the potential which can be called on in terms of professors and researchers, taking into account accreditations to supervise research, research and doctoral supervision grants, etc;
- Organisation of the teaching programmes: students should have the opportunity to specialize in a particular field over time, resulting either in integration into the job market or an admission into doctoral training;
- Extent to which the Master programme helps students to prepare for the job market: link between degrees and professions, partnerships with businesses (in designing the degree, participating in teaching, offering placements), follow-up of vocational integration – a report of the fate of students since the Master was created must be supplied and analyzed;
- International partnership arrangements: type and relevance of international partnerships set up, number of students concerned.

[17] European Physical Society (ed.) (2009): The Implementation of the Bologna Process Reforms into Physics Programmes in Europe. EPS Publication. Authored by: Kehm, B. M. and Eckhardt, A.: Mulhouse: European Physical Society.
[18] See the web site for more details on the activities of these experts www.europe-education-formation.fr/bologne.php.
[19] Arrêté du 23 avril 2002 relatif aux études universitaires conduisant au grade de licence ; Arrêté du 25 avril 2002 relatif au diplôme national de master.
[20] « Bilan et évolution du cursus de master », Jean-Michel Jolion, Head of the monitoring committee on Masters www.cpu.fr/uploads/media/Rapport_Jolion_sur_Master.pdf.
[21] Agence d'Évaluation de la Recherche et de l'Enseignement Supérieur.
[22] See www.aeres-evaluation.fr.

The impact of the Bologna Reform on the provision of Master programmes

After the implementation of the Bologna reforms, the provision of Master programmes proliferated and became inflationary, confused, and intransparent. At first, more than 10 science domains were created for the Master programmes in science leading to 1100 different titles and 7000 specialities (3800 research oriented and 3200 professionally oriented programmes). Before the implementation of the Bologna reforms, there were only 2600 DEA [23], equivalent to the research oriented Master level. These statistics concern all scientific domains. In order to make the provision of Master programmes more transparent, the MESR decided to create a unique scientific domain named Sciences, Technologies, Health including around 100 titles of Master programmes in science. Each of them has several specialities. At that stage, 35 of 87 universities offered Master programmes in Physics. 54 percent of these programmes are research oriented and 21% are professionally oriented. 25 percent are both research and professionally oriented. In the long term, the universities are encouraged to offer Master programmes the outcomes of which are both academically and professionally oriented.

The specificity of the French higher education structure at universities

Before the implementation of the Bologna Reform, the French structure was based on a three cycle structure (according to the time needed to complete the studies required after the Baccalauréat) that offered exit points each year after the end of the second year of studies:

- *First cycle:* duration of 2 years after the Baccalauréat leading to the academic degree DEUG where students were trained for more specialized studies in the second cycle.
- *Second cycle:* duration of 2 years after the DEUG [24]. The academic degree licence was conferred after the first year of the second cycle and was the first year of specialization. The academic degree maîtrise was conferred after the second year. The national denomination of these degrees referred to a discipline, for example Physics. In parallel, a professionally oriented degree was created in 1971 inside universities entitled MST [25]. Later (in 1994), other professionally oriented degrees were delivered by the IUP [26] at first and second cycle level with their own specific degrees: DEUP [27] (same level as DEUG), licence d'IUP (same level as licence) and maîtrise d'IUP or maîtrise d'ingénieur-maître (same level as maîtrise). These professional degrees expressed the willingness of the universities to move towards more professional studies in order to correspond better with the needs of the economy and to respond to students' demands. The number of students enrolled in these courses was relatively small compared to the number of those enrolled in the academic programmes. In general, national legislation specifies the length and required credit points for a Master degree.
- *Third cycle:* duration of 1 year after the maîtrise or more (in case of doctorate). The professionally oriented diploma DESS [28] led after to the labour market after one year. The academically oriented diploma DEA6 was the prerequisite for the preparation of a doctoral thesis. The doctorate was awarded after three or four years spent on in-depth research after the DEA.

The Bologna reform dramatically changed the structure of higher education in French universities. The first cycle now lasts three years instead of two years leading to the licence, and the second cycle lasts two years leading to the master. Licence and Master are maintained as national degrees. This new degree structure did not really change the access conditions to courses leading to the existing diplomas. Holders of a licence have open access in the same field at master level. After the first year of a Master programme, selective procedures follow the same process as before the Bologna reform. The number of students is limited for the second year of the master because of limited financial resources and the number of opportunities

[23] Diplôme d'Études Approfondies.
[24] Diplôme d'Études Universitaires Générales.
[25] Maîtrise Science et Techniques.
[26] Instituts Universitaires Professionnalisés.
[27] Diplôme d'Études Universitaires Professionnalisées.
[28] Diplôme d'Études Supérieures Spécialisées.

on the labour market. Consequently, the entry into the second year of a Master programme is subject to the opinion of the head of training. In Physics this selection is more crucial in universities where the number of candidates is higher than the number of opportunities on the labour market.

The first year of the Physics master programmes is generally dedicated to standard physics with some optional courses in more specialized domains. Then the second year only contains courses related to the specialization of the Master programme. For both academically and professionally oriented Master programmes the speciality is generally introduced during the first year. The training in laboratory or in industry is most of the time the only distinction between professional and research oriented Master programmes.

Since the introduction of the Ba/Ma/Dr system there is a strong increase of the number of students entering the second year of Master programmes. Despite a decline in the number of students holding a licence, the number of incoming students in first year of the Master is constant. This reflects an external inflow which is essentially international. Some data on Physics Master programmes is available in Jolion's report.

The international level of masters

Since 2005, the MESR encourages international cooperation for master and doctoral programmes. The offer is based on the research done in laboratories including their networks that traditionally generate international scientific collaborations through joint research contracts and recruitment of researchers and students. Laboratories are part of a tradition of international openness and also have the means to continue and strengthen the policy of international openness. Conversely, institutions which offer training relying less on research (licence level) cannot benefit from international networks of research laboratories and those of teachers and researchers. Their openness is exclusively based on international exchange programmes with European or foreign institutions of the same level.

Currently five universities coordinate Erasmus Mundus Master programmes in Physics (EEM-Nano for Grenoble 1, EUROPHOTONICS for Aix-Marseille 3, FUSION-EP for Nancy 1, SPACEMASTER for Toulouse 3, OPSCITECH for Paris 11). Two other Erasmus Mundus Master programmes are piloted by ENS [29] schools (Monabiphot for ENS Cachan, ATOSIM for ENS Lyon). In addition, five international Master programmes in form of double or joint degree programmes also exist (collaboration between two or more countries as for example Spain and Germany).

The different types of Master programmes in Physics

32 percent of the French Master programmes are *standard Physics*: material science, light, condensed matter, optics, plasma, theoretical physics, complex systems, quantum physics, astrophysics, cosmology, photonics, fundamental physics, modelling, subatomic, non linear phenomena, atomic and molecular physics, surface, interface, universe, fusion, etc.

15 percent of the Master programmes are *specialized Physics*: nuclear materials, laser, complex materials, nano-sciences, accoustics, physics of materials, nanophysics, structure of materials, nanomaterials, ionizing radiation, molecular reactivity, etc.

19 percent of the Master programmes are *interdisciplinary*: biology, environment, mechanics, fluid mechanics, chemistry, energy, hydrodynamics, space, atmosphere, climate, cultural heritage, planetology, informatics, electronics, oceanography, etc.

34 percent of the Master programmes are *technological*: advanced materials, detection, electronics, optical instruments, technology of fusion, nuclear engineering, nanotechnology, sensors, quantum devices, energy, instruments in astrophysics and space, environment controls, process, nanotechnology, particle accelerator, medical imaging, control vision, magnetic systems, ultrasound devices, laser, nano-devices, space technology, microelectronic devices, remote sensing, etc.

[29] ENS means École Nationale Supérieure which are not part of the Bologna Process.

Lifelong learning

All Master programmes include consecutive and continuing education. A prior learning accreditation called VAE [30] (validation of acquired experiences) which takes into account professional experiences is available. It constitutes an individual right open to all to obtain a whole or part of a degree or an accreditation by the VAE alone without a course of studies. The VAE is a means of access to accreditation in the same way as initial training, apprenticeships or ongoing vocational training. The modular organisation of Master programmes combined with the accreditation of prior experience (VAE) allows participation in these higher education programmes by students from more varied backgrounds. This flexibility in the provision for diverse groups of learners was possible thanks to the principle of modularity and of the wider application of the ECTS.

Legislation governing the arrangements for the implementation of ECTS

As already mentioned above, the duration of the Master programmes is 2 years with a selection at the end of the first year. Each year 60 ECTS can be acquired, thus 120 ECTS are required to obtain the Master degree [4]. There is no legislation governing the correspondence between ECTS and the student workload hours but in general it is 25 to 30 hours per one ECTS credit point. Teaching activities include lectures, seminars, projects in laboratories or in industry, practical sessions, examinations. In most Master programmes the total number of hours a student is expected to invest into one academic year is about 1600 including both teaching hours and homework. This leads to 25-30 hours for one ECTS credit point. More than 75 percent of institutions and programmes are using ECTS for both transfer and accumulation purposes

The organisation of a Master programme (modules, teaching, examination, transferable skills)

Master programmes are organised into four semesters, each containing several modules. Due to a number of constraints (budget, calendar, administrative organisation, etc) a student who fails a module in the first semester of the academic year is obliged to go into the next semester. The student has a second chance to pass the failed examination(s) of the first semester during the second semester of the academic year.

Mostly each module is linked to a scientific subdomain related to the speciality of the Master degree and includes different types of learning (lectures, seminars, self-training, exercise sessions, laboratory projects) and an examination (regular and/or final assessment). In contrast to the Bachelor, the practical activities mainly concern laboratory projects and trainings in companies. These practical sessions are mandatory and are mostly concentrated during the fourth semester. They constitute in general one or two modules and ECTS credit points are given. These modules also include a final examination (written report and oral examination on the work done).

The Bologna process did not change the types of transferable skills to be acquired during Master level studies. Typically these are foreign languages, communication skills, social skills, self-organisation competencies, and project management.

Diploma Supplement

There is national legislation requiring the provision of a Diploma Supplement [31]. A partial and gradual introduction of the Diploma Supplement (DS) is observed. In France, the DS is organised centrally through the RNCP [32]. There is no national monitoring currently. The provision of a DS is automatic and free of charge. It is available in the language of instruction and when required in other official languages of the European Union depending on the wishes of the students and the choices offered by the institution.

[30] Validation des Acquis d'Expériences.
[31] Circulaire n°2006-202 du 8-12-2006 sur les modalités d'élaboration et de délivrance des diplômes dans le cadre du LMD.
[32] Répertoire National des Certifications Professionnelles.

Employability

As for the Bachelor level, regular surveys of the employment of young graduates having obtained the Master degree are undertaken by the CEREQ [33]. The employability rate strongly depends on the speciality of the master degree. Students in professionally oriented master programmes integrate issues and problems of the professional life in companies into their studies and Master thesis. Students in research oriented Master programmes prepare a thesis in a public laboratory (university or public research institution) or inside a private company. Most of the holders of a professional Master degree have a permanent job after about 3-4 months of an unemployment period. In general, the salary is slightly lower than that of the holders of a degree from engineering schools. Each university is now obliged to publish the statistics about the employment of master degrees holders. In general, these data are available on university websites.

No difference has been observed regarding the transition rate to the labour market before and after the Bologna Reform. The employability rate strongly depends on the economic situation of the country. Since 2007, students have also the possibility to undertake their practical training in foreign companies. Nevertheless, this possibility does not increase the employability rate of French Master degree holders outside France.

The number of students in professionally oriented Master programmes is limited and strongly depends on the career opportunities. Consequently, the number of students is higher in research oriented Master programmes and pursuing a doctoral programme.

National qualification network, learning outcomes, competences

The MESR sets up a National Directory of Vocational Skills, *i.e.* a framework for qualifications. All research and professional oriented Master programmes now have to be registered in this framework and a formula is attached to the Diploma Supplement which highlights learning outcomes, especially in terms of skills. It also sets out the field of activities and specialities, as well as the level of qualification. For the professionally oriented Master programmes, the employment rate over the past three years is also included. To be registered in the framework of qualifications, degrees must have received the approval of the CNCP [34]. The self-certification of compatibility with the EHEA framework started but it is not yet completed.

Mobility

A national Council for the development of international mobility of students has been created in October 2003 with the objective to define strategies for the development of international student mobility and for improving the attractiveness of French higher education. A first report was published in 2004 [35] just during the implementation of the Bologna reforms in France.

The number of foreign students enrolled in institutions of higher education in France strongly increased in the last decade. The proportion of international students in French universities increased from 8.5 percent in 1998 to 14.7 percent in 2005. Most of the foreign students were concentrated at the third level (DESS, DEA, and Doctorate). 3.3 percent of the foreign student population is involved in science studies [36].

After several years of strong development of both, incoming and outgoing mobility, the incoming mobility has sharply declined since 2000. With a 9 percent increase in the overall student population from 2000 to 2006, the international mobility of French students also has declined over the same period (by 25%) [37].

[33] Qualifications study and research centre.
[34] National Commission for Professional Qualification.
[35] www.education.gouv.fr/cid2147/stategies-de-developpement-de-la-mobilite-internationale-des-etudiants-et-attractivite-de-l-enseignement-superieur-francais.html.
[36] Fabre J., Guillerm M., MEN-DEPP, Note d'information n° 07.02, janvier 07.
[37] Les notes de Campus France, n°14, juillet 2008.

Nevertheless, France is still a destination reference. In 2006, the country hosted 12 percent of all foreign students in OECD countries [38]. The Master programmes give rise to numerous international exchanges. The percentage of foreign students in Master courses was 17 percent in 2006 [39].

Outgoing mobility increased again after 2007. This was correlated with the new opportunities for students to go through an industry training in a foreign country. As pointed out in Jolion's report, there was an effect of the Bologna reforms on international mobility. Outgoing mobility has shifted to the start of the first year of a Master programme instead of happening at the beginning of the second year as it was administered in the former degree system. However, this discrepancy is not sufficiently pronounced because many students do not want to risk the multiple selections (initial selection for entry into the Master programme and a second one after 60 credits even if they are validated).

The statistics indicated above comprise all fields of study, specific data on Physics master programmes are not available.

In most of the Physics Master programmes, training abroad is not mandatory. For many students the costs of a stay abroad is a barrier for mobility. Other obstacles are the lack of information about and support mechanisms for mobility opportunities across European countries and the complexity of administrative procedures. The positive relationship between mobility during the training and employment or career development, demonstrated in all studies, is unknown to many students. Some students refuse to go abroad except to Germany, Spain and the United Kingdom due to lack of language abilities. The period of study abroad gives rise to issues of recognition because a French university can decide not to take into account credits earned abroad if the courses are not validated in the degree programme of the university [40].

Teaching in a foreign language

The French education code [41] stipulates that the language of teaching, examinations and competitions, as well as theses and dissertations in public and private institutions must be French, except if there is a necessity of regional or foreign teaching languages and cultures, or if teachers are associate professors or guests.

Quality assurance

As already mentioned above, each Master programme is evaluated by experts from the evaluation agency AERES2. All Master programmes are periodically re-accredited every four years. Most of the external experts are coming from France. However, the evaluation agency is appealing increasingly to international experts. Each university also includes self-evaluation by, for example, organising evaluation of modules/courses of programmes in form of student questionnaires. Results are communicated to AERES. The experts of AERES write reports which are then delivered to the MESR. AERES has no power to make decisions. The reports of AERES are taken into account by the MESR in the negotiation process with the university.

Recommendations:

- The combination of professional and research oriented Master programmes would promote convergence within the European higher education system. The adoption of a unique degree is a means to achieve these changes. However, a unique degree does not mean a unique pedagogical teaching method. The diversity and specificity of professional careers (research is a professional purpose) must be articulated.
- The need to harmonise the titles of the Master programmes should reflect the discipline as well as the thematic area. Moreover, the registration goal of training should lead to the framework of qualification designers to specify the skills training provided for each course in addition to all the knowledge acquired and skills implemented related to the career opportunities.

[38] Data from OECD 2005.
[39] Harfi M. & Mathieu C., Mobilité internationale et attractivité des étudiants et des chercheurs, Horizons stratégiques, n°1, juillet 2006.
[40] "La mobilité étudiante sortante en France – Note pour le conseil d'orientation", Campus France (Octobre 2008).
[41] Article L.121-3, alinéa 2 of the educational code.

- Courses taught in the English language have to be developed. All or part of a course should be delivered in a foreign language in order to facilitate the admission of foreign students and to develop foreign language skills of French students. When all or part of a course is delivered in a foreign language, students must have the choice to be assessed in French or in the foreign language. The Master degree should be awarded only after validation of the knowledge of at least one foreign language based on the Common European Framework of Reference for Languages (B2 level). The MESR must be pro-active to validate the foreign language competencies by providing the necessary resources (funding, human capital, etc).
- Universities need to inspire students to study abroad. The benefits of mobility and its impact in terms of human capital must be explained to the French students. Direct contacts with students already mobile must be increased. Students need better information about the benefits of mobility and the options offered by the university.
- To finance the stay abroad, financial aid based on social criteria should be given to all students with few resources who apply for a stay abroad.
- The development of international mobility should be facilitated by an increase of Master programmes comprising an efficient organisation of mobility during the study. Barriers against mobility related to the accreditation of diplomas will be partially deferred if training courses will be built into the partnership with institutions of several foreign countries based on multiple modalities. The development of double degree programmes ensuring the quality of training should be encouraged because it leads to the award of two degrees accepted by the countries involved.
- Vertical mobility offers opportunities to attract the best students from other national or foreign institutions which is not yet realized by most institutions. Much remains to be done in this area, for example the establishment of Master programmes addressing a specific student clientele at national or international level.
- The LMD (Ba/Ma/Dr) system has already helped to foster numerous bilateral agreements between countries. This should be continued in the future ensuring their effective and speedy implementation. The bilateral approach is also appropriate to promote mobility outside Europe.
- The differences between the academic calendars in Europe are a major obstacle to mobility. This requires attention and action. A European agreement that would determine a period for the end of the first semester or the beginning of the second could be a first step towards improvement.
- The introduction of the Diploma Supplement is well advanced in most universities but two major challenges remain: the technical implementation (software, data exchange between universities and central administration, etc) and the formulation of the content that has been studies (name of training and courses, objectives of the Master programme, knowledge, competencies, transferable skills, etc).

Germany:

The German situation on the implementation of the Bologna structures in physics is well analysed by separate studies of the German Physical Society. A still up-to-date overview is given in Europhysics News, volume 39, number 4, 2008, page 13 under the title "Physics on Course to Bologna" written by Prof. G.U. Nienhaus, DPG. More detailed background material is pointed out in the references.

Hungary:

Concerning the master degree the legislation in Hungary, law CXXXIX/2005 accepted by the parliament in 2005 specifies the following:

- A minimum of 60 credits and a maximum of 120 credits should be earned, the length is minimum 2 semesters and maximum 4 semesters. In Physics Master programmes are accredited to be 4 semesters at all universities.
- All universities should provide a Diploma Supplement. Its content is also regulated.
- A credit is equivalent to 30 hours of student workload (including contact hours and study at home).

Netherlands:

- The duration of courses of study is regulated by the government in the so called CROHO (Central Regulations for Courses in Higher Education) on the basis of the Higher Education Act [42].
- All Master programmes in Physics at the research universities in the Netherlands have a duration of two years. There exist some teacher training courses in Physics at Universities of Professional Education (Hogeskolen) that have a duration of 90 ECTS. There also exist some Master-after-Master courses of one year duration, also for obtaining a teacher's licence.
- The use of credit points in the Netherlands is regulated in the Higher Education Act (article 7.4) which states that all programmes and all course units in higher education are expressed in credit points, that one year of study corresponds to 60 credit points and that 60 credit points correspond to 1680 hours of study: *i.e.* 1 credit point is 28 hours.

Slovakia:

There is national legislation specifying:
- the length of study and credits required to obtain a Master degree;
- the number of hours to earn one credit point (25 to 30 hours);
- the criteria according to which a Diploma Supplement is provided to graduates.

Slovenia:

The following issues are regulated by national law (Higher Education Act) [43]:
- length of study and credits required to obtain a Master degree (2 years, 120 CP);
- the provision of a Diploma Supplement.

The Council for Higher Education has regulated the number of hours of student work load to earn one credit point [44].

Spain:

Regulated by national law are the following two issues:
- 1 ECTS credit point is equivalent to 25 – 30 hours of student workload for all valid Spanish degrees;
- all universities have to provide the Diploma Supplement. The problem is that the universities are not prepared to provide a Diploma Supplement to all students. So it is only provided to those students who ask for it.

Sweden:

Physics programmes in Sweden used to be 4-year integrated Master programmes but according to national regulations all general programmes shall now be organised according to the three cycle Bologna structure beginning from 1 July 2007. However, the national regulation demands that some vocational degrees shall be integrated Master programmes. The national regulation is found in the Higher Education Ordinance which regulates several parts of the Bologna reform such as the credit system, the length of the Master examination and the Diploma Supplement.

The extent of all courses and study programmes shall be denoted by credits, with full-time study during a normal academic year of 40 weeks corresponding to 60 credits which makes the credit point system one to one compatible with ECTS. However, there is no clear definition what is meant by "full-time studies". Most teachers regard this to be 40 hours per week for a normal student. This includes both contact hours with the teacher and independent studies. The number of contact hours per credit point varies a lot between different courses and universities.

A Master of Science with a specialisation in Physics is awarded after the student has completed courses required to gain 120 credits of which at least 60 credits are for specialised studies in Physics. In addition the

[42] http://apps.ib-groep.nl/MCROHO/pages/zoeken.jsf.
[43] http://zakonodaja.gov.si/rpsi/r02/predpis_ZAKO172.html.
[44] www.mvzt.gov.si/fileadmin/mvzt.gov.si/pageuploads/doc/dokumenti_visokosolstvo/zakonodaja_VS/01d-Merila_ECTS.doc.

previous award of a Bachelor's degree is required. The Ordinance also stipulates that a Diploma Supplement that describes the study programme and its place in the educational system shall accompany certificates for first and second cycle qualifications.

Due to the late introduction of the Bologna structure in Sweden the universities have still limited experience with the new structure which makes the estimates in this report of changes in various statistical numbers after the introduction of the Bologna structure rather uncertain.

At the time of data collection for this report no student in Sweden had yet completed the Bachelor degree in the new system which results in some unexpected data. Sweden stands out in the report as having the highest proportion of international students in the new Master programmes (100%). This was a temporary effect since no Swedish students were at that time eligible for a Master programme but now the first Swedish students with Bachelor degrees have started to appear. At the time of the study there were Swedish students in their final years of the old integrated Master programmes but these are not included in the report.

Some Swedish universities say in this report that they have modularised programmes while others say that they do not use modularisation. This split picture is probably explained by the fact that the term ”modularisation” is seldom used in Sweden and the respondents to the questionnaire could have different understandings of the concept.

United Kingdom:

Until the 1990s, it was the normal route for everyone in England, Wales and Northern Ireland to have a 3-year Bachelor degree in Physics as with most other subjects. There were a few longer programmes, such as Medicine and Architecture, but essentially all the main sciences had degrees requiring three years of study. Graduates from these courses most certainly did become physicists, possibly progressing to a PhD, taking a one year Master of Science degree or by starting a job in a private company – there was no other route. The vast majority of current academics in the UK followed this route and obtained their PhD six years after entry to university. In Scotland, all first degree courses were and are one year longer because entry is at a lower level.

In the early 1990s, four year, integrated Master degrees were introduced, usually called MPhys or MSci. The reason for their introduction was that universities were putting more and more material into their degree programmes, so it was felt that there should be more time to give the students a better chance to understand the subject matter and also to allow time for developing soft skills, such as communication skills and teamwork. Since then, it is certainly the case that the majority of professional physicists have the four year degrees but there is still a substantial number who obtained the three year degree. It is still possible, though much less common, to enter a PhD programme directly from a Bachelor of Science. It is also important to note that the majority of the other courses at universities, *i.e.* all the arts and humanities and the biological sciences, do not have the integrated Master programmes and progression to PhD is directly from the Bachelor degree. Engineering, Chemistry and Mathematics are similar to Physics. The one year, stand alone MSc courses, usually covering a particular topic within physics or its application, are still popular and run alongside the integrated Master programmes. A key point is that the funding arrangements are different for the MSc stand alone courses and the integrated Masters.

For more than 10 years, the UK has been familiar with a regime of quality assurance based upon guidelines issued by the Quality Assurance Agency (QAA). In its early days, along with other subjects, physics departments were subjected to external visits and rated on a 24 point scale on the quality of their provision. Since then, the monitoring has been lighter and largely the responsibility of the institution. In parallel, the Institute of Physics accredits degree programmes and essentially every physics degree in the UK is accredited in this way. Despite this national framework and the almost universal adoption of a credit

system, there is no common model for the translation of hours of work into credits. A typical arrangement would be equivalent to 20 hours of student activity to 1 credit in the ECTS. There is no national legislation specifying the length and credits required to obtain a Masters degree. However, this information is specified by the Quality Assurance Agency who is the body that is responsible for auditing the quality assurance within universities. This information is detailed in two documents [45].

Although compliance with these frameworks is not enshrined in law, in practice all universities do comply. The number of hours to earn one UK CATS point (0.5 ECTS) is usually taken to be 10 hours. This again is not a legal requirement; it is a generally accepted norm that has arisen through evolutionary convergence. Following developments elsewhere in Europe, some universities have introduced two year, Euromaster courses. Some institutions are also considering 3 + 2 integrated Master programmes but there is considerable disagreement on this issue.

There is no legislation dictating that a Diploma Supplement has to be supplied or provided. However, provision of an academic transcript to students is common practice in the UK and this supplies much of the information that would be part of the Diploma Supplement. Read in conjunction with programme specifications (QAA requirement) these documents exceed the requirements of the Diploma Supplement [46].

[45] www.qaa.ac.uk/england/credit/creditframework.pdf (for England, Wales and Northern Ireland) and www.qaa.ac.uk/academicinfrastructure/FHEQ/SCQF/default.asp (for Scotland)
[46] Additional information can be found in this document
www.qaa.ac.uk/academicinfrastructure/progressfiles/guidelines/progfile2001.pdf

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