

A discipline approach to the Bologna reforms: the case of physics

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Abstract

The physics discipline has been quite active in student mobility even before the start of the Bologna process. Indeed a successful '*European Mobility Scheme for Physics Students*' (EMSPS) was established already in 1992 in the frame of the Erasmus programme with the support of the EPS. Hence the more than 100 participating institutions gained quite good insight into the structure of the physics studies when organizing the student exchanges.

A thematic evaluation conference in 1995 gave the start to a sustainable network, *European Physics Education Network* (EUPEN) of more than 100 physics departments in more than 30 countries to co-operate from 1996 till now in different projects [EUPEN (1996/2003), STEPS (*Stakeholders Tune European Physics Studies*) (2005/2008) and STEPS-TWO (2008/2011)] taking along the aims and goals of the Bologna declaration.

Close collaboration with the '*Tuning Educational Structures in Europe*' initiatives subject specific competences were developed and '*Reference Points for the Design and Delivery of Degree Programmes in Physics*' were obtained.

A recent (2008) investigation by EPS, executed with the help of INCHER, *Universität Kassel* (DE), '*The implementation of the Bologna Process into Physics Studies in Europe*' gave the status of the degree structure in the physics bachelor programmes in more than 150 institutions in some 24 Bologna signatory countries. This project will be continued looking at the masters programmes in 2009 and at the doctorate studies in 2010.

Recently a document was drafted '*Specification Description for European Physics Bachelor Studies*' describing the characteristics of the physics bachelor study programmes in a European dimension.

Results of the preliminary outcomes will be presented in the frame of the follow-up on master studies in 2009 and beyond 2010.

Very recently physics joined a project for a *Sectoral Qualification Framework* in the Natural Sciences, where the ISCED levels 2 till 6 for physics would be developed in a European dimension.

1. Introduction

The 'Bologna Process' started officially after the *Bologna Declaration* [Bo99] signed in 1999 in Bologna by ministers in charge of higher education from 29 European countries. However, this movement would not have gained the needed momentum, if already from 1987 the ERASMUS programme was not established with its implications. Indeed this operational framework for the European Commission's initiatives in higher education placed great importance on mobility and furthering career prospects through learning and inspired a lot the Bologna Process. The physics discipline has been quite active in this student mobility (almost from the start) and has been supportive to the creation of a European Higher Education Area (EHEA) based on international co-operation and academic exchange.

2. Prelude/Prologue

Indeed already in 1992 a successful '*European Mobility Scheme for Physics Students*' (EMSPS) was established. Prof. E. Heer (*Université de Genève*, CH) previously obtained experience with a student mobility initiative in the Swiss federation among the different language groups. He gave the real impulse to start the activity. Financial support for the project was found in the frame of the ERASMUS programme with the administrative support of the *European Physical Society* (EPS) [He93a, He93b]. By this project the partners in the physics departments of the more than 100 participating institutions gained quite good insight into the structure of the physics studies when organizing the student exchanges. Moreover the scheme was not only relying on support for the - at the time - EC and EFTA partners *via* an ICP (Inter-University Co-operation Project) [co-ordinated by *Universiteit Gent*, H. Ferdinande (BE)] but also *via* a set of five MJEPs (Mobility Joint European Project) from the TEMPUS programme for central and eastern European countries [co-ordinated by *Leibniz Universität Hannover*, P. Sauer (DE)], covering the partners in Hungary, Poland, Lithuania, Latvia and Romania.

A successful thematic evaluation conference [Fe95] in the frame of the SOCRATES programme was held in Gent (BE) in 1995. Representatives of 24 western, central and eastern European countries reported on the physics studies and training in their countries, giving the status of the degree programmes, the needs for co-operation and the implementation of those aims in a European perspective. Four themes were identified (curriculum development, intensive programmes, mobility and educational resources) and are still the main topics in the present Lifelong Learning Programme of the E.C. This meeting concluded to the creation of a permanent forum and gave the start to the formation of a sustainable network, the *European Physics Education Network* (EUPEN)

In 1996 this consortium of more than 100 physics departments in more than 30 countries was successful in receiving a three years' grant for an academic network project in the frame of the E.C.'s SOCRATES programme. Five working groups were formed (chair & secretary): (i) the student experience [L. Donà dalle Rose (IT) & G. Jones (UK)], (ii) curricula structure and development [J. Dore (UK) & J.-Cl. Rivoal (FR)], (iii) organization of physics studies [E. Cunningham (IE) & A. Konsta (GR)], (iv) career aspects of physics education [Fr. Brut (FR) & J.-P. Hansen (NO)] and (v) research in physics teaching [M. Vicentini (IT) & R. Pinto (ES)]. During the three annual assemblies, better known as EGF or EUPEN General Fora the following main topics [Fe05] were discussed: (i) the 'first-degree' curricula [mostly equivalent to (sometimes integrated) master degree courses], (ii) the Bologna Declaration and (iii) the doctoral studies, as well as the skills & knowledge of ICT in the curricula.

The comparative study of these topics was realised by a set of several questionnaires to the partners. Although the reports could not be regarded as statistically robust, they confirm that quite similar teaching/learning outcomes could be achieved through quite different organisation of studies, teaching methodologies, learning habits and evaluation procedures. The project was able to establish a close link with the students *via* the *International Association of Physics Students*

(IAPS), who were represented at and took integral part in our meetings and even made a presentation [Nigel Harris (UK)] at the first EGF97, held in Brugge (BE). From the start also a link with the *American Association of Physics Teachers* (AAPT) was laid.

A (quasi) monthly e-zine, EUPEN ON-LINE, informed during more than ten years (1996/2008) the contact persons at the partner institutions about European physics education news (Did you read?, Events, Books, and Physics Education Conferences and Summer Schools).

3. The 'Bologna' period

During the academic year 1999/2000 the results of the previous project were disseminated in three EUPEN regional fora, held in Lille (FR), Poznan' (PL) and Barcelona (ES). In the *EUA Trends I* report [EU99] - under the heading "*Subject-based evaluation at European level*" - our network was mentioned as: "... Such European networks have an important role to play and should be supported by institutions and governments in their efforts: to gather, publish and disseminate information on study possibilities in Europe in each field of specialisation (as some Thematic Networks established under the Socrates programme have already done, e.g. for the field of Physics); ..."

A second phase for the EUPEN consortium happened during the three years' contract with the DG EAC of the E.C. in the period 2000/2003. The tradition of annual EGFs was continued. In this phase almost 150 physics departments from more than 30 "SOCRATES countries" worked in five working groups (chairperson): (i) quality assessment and assurance & TEEP2002 (see further) [G. Jones (UK)], (ii) first- and second-cycle degree in the context of 'Bologna' & TUNING (see further) [L. Donà dalle Rose (IT)], (iii) networking opportunities for specialisation in physics [E. Cunningham (IE)], (iv) trends of enrolment and destination of students & comparing exams in Europe [H. Latal (AT)], and (v) multimedia in physics teaching & learning [MP09] [H.-J. Jodl (DE)]. The proceedings of all those fora were published as a series of seven books: '*Inquiries into European Higher Education in Physics*' [Fe05]

From the start in 2000 a close collaboration was established with the '*Tuning Educational Structures in Europe*' ('TUNING' for short) [TU09a] initiatives. E.g. the author was member of the management committee under the chairmanship of the joint co-ordinators, J. González (ES) and R. Wagenaar (NL). The name for the project *Tuning* was chosen to reflect the idea that universities do not look for uniformity in their degree programmes or any set of unified, prescriptive or definitive European curricula but simply for points of reference, convergence and common understanding. The TN EUPEN co-operated in synergy as the Subject Area Group (SAG) in physics [chair L. Donà dalle Rose (IT)], together with the other groups in the disciplines of chemistry, mathematics, geology, business, history and educational sciences, while European studies and nursing joined the project at a later stage. Apart from the collaborating efforts (e.g. inquiries among a large number of diversified 'stakeholders', i.e. staff, students and employers) executed in common, the physics group developed the study on the physics & astronomy (subject) specific competences. The resulting document, '*Reference Points for the Design and Delivery of Degree Programmes in Physics*' [TU09b], (i) provides the academic communities a transparent guide for planning or re-planning physics degree courses, (ii) presents the main aspects of a physics curriculum and its related opportunities to potential or already enrolled students, and (iii) helps employers and different stakeholders to understand the competences of the physicists they hire. The brochure was validated by a panel of nine physics experts in a joint conference of the physics experts with the physics SAG group.

EUPEN was also partner in the "*Trans-national European Evaluation Project*" (TEEP 2002 for short) [Th04]. This E.C. supported pilot project, executed by the "*European Network of Quality Assurance in Higher Education*" (ENQA), investigated the operational implications of a European trans-national quality evaluation in three disciplines: physics (five volunteering universities from five different countries), history and veterinary sciences. The project was hampered by the fact that, both across the programmes and across the disciplines, there existed

large differences in the perception of the competence concepts, mainly because the 'Tuning' project was not well widespread enough over Europe's HEIs. The pilot project proved that better understanding on the meaning of the quality concept should be reached between the group of academics and/or peers on one side and the group of quality evaluators from the agencies on the other side. Progress in this field has been recently obtained in the project Quality Assurance for the HE Change Agenda (QAHECA) [EU09].

The co-operation with the students also extended in the inverse sense, this paper's author being invited at their annual *International Conference of Physics Students* (ICPS2002) held in Budapest (HU). Because the Bologna Process was hardly visible at that time in most countries, the students were not terribly interested in this subject.

The '*Stakeholders Tune European Physics Studies*' (STEPS) initiative by the '*European Physics Education Network*' (EUPEN) was the name of the Thematic Network (TN) Project in physics, funded in the frame of the SOCRATES programme by the E.C.'s Directorate General, Education and Culture (DG EAC) during the period 2005/2008. STEPS counted 161 physics departments from 37 countries as 'partners' and 10 regional, national or European associations as 'associated partners'. The objectives were: (i) enhancing the training of physicists by helping universities to improve their degree course through considering the views of all stakeholders, (ii) helping university physics departments to adapt to the changes required by the Bologna Process and to adopt the *Tuning* methodology, and (iii) developing and supporting projects to encourage school pupils to take an interest in physics and hence to improve the future supply of physicists and teachers. The initiative had five working groups (chairperson): (i) *Tuning* and the Eurobachelor® [F. Cornet (ES)], (ii) research & education [I. Sosnowska (PL)/G.V. Pallottino (IT)], (iii) learning methodologies [S. Feiner-Valkier (NL)], (iv) quality assurance & doctorate [U. Titulaer (AT)], and teacher training/school-university gap [M.-C. do Carmo (PT)]. For detailed conclusions we refer to the website.

The EUPEN network has also been an active partner in the Archipelago of Thematic networks in the fields of Sciences and Technology (TechnoTN). [Te09] The TechnoTN initiative has been bringing together the experts working in the related fields through their respective TN and offering them a unique opportunity to share and exchange views, case studies and experiences, and from there, to enable them all to disseminate the results of the event through their TNs partners and scientific circles.

At the end of the STEPS project the physics students were so well organised that they started their own *European Physics Students Initiative* (EPSI) [Bi07] who collaborated with EUPEN; they even learned how to submit proposals - unfortunately still non-granted - for their own purposes.

The STEPS initiative is continuing in the STEPS-TWO network (supported by a 2008/2011 grant from the EAC Executive Agency) [Tu08], taking along the aims and goals of the Bologna declaration. The academic network is co-ordinated by the *Universitatea din București* [L. Țugulea (RO)] and contracted by the *Universiteit Antwerpen* [J. Naudts (BE)]. The scheme will support the university physics departments in their strategic institutional development following the structural changes by the Bologna process, with greater European vision to overcome some of the local and national obstacles. It will continue to use the partnership and expertise of the EUPEN (*European Physics Education Network*) consortium, in order to provide universities with a support in implementing reforms in physics education and to respond to lifelong learning priorities. There are three lines of action developing policy recommendations and offering solutions for concrete strategies (chairperson): (i) curricula after Bologna and Lifelong learning [U. Titulaer (AT)], (ii) modern teaching methods in physics education and student centred learning [S. Feiner-Valkier (NL)], and (iii) physics teacher education and the European dimension [E. Vitoratos (GR)]. The most recent EGF2009 Forum, focusing on the first topic, was held from 10 till 13 September in Vilnius (LT) and tried to answer the question "*what after Bologna?*" by offering a set of Benchmarks for the physics programmes, posted on the project's website.

Recently the *European Physical Society* (EPS) received a three years' grant (2008/2011) to investigate '*The implementation of the Bologna Process into Physics Studies in Europe*'. During the year 2008 the study [Ke09] was executed by Prof. B. Kehm with the help of the *International Centre for Higher Education Research* (INCHER) of the *Universität Kassel* (DE). It gives the status of the degree structure in the physics bachelor programmes in more than 150 institutions in some 24 Bologna signatory countries. It was concluded that there already some convergence in the two-cycle structure and the use of comparable credit points for the curricula. More heterogeneity appeared in the definition of student workload, in the pedagogical approaches, and in the forms of assessment. Most physics bachelor programmes attach more importance on a smooth transition to master than to prepare the graduates for labour market. This EPS project will be continued looking at the masters' programmes in 2009 and at the doctorate studies level in 2010.

Very recently this paper's author was invited again at the students' ICPS2009 [IC09] in Split (HR). Quite surprisingly the interest in the Bologna reforms by the students was now overwhelming, so that even an afternoon was filled up by a round table discussion on this topic only.

4. The future

Recently and parallel with the INCHER study in the same EPS project, a document was drafted '*Specification Description for European Physics Bachelor Studies*' [EP09] describing the characteristics of the physics (and astronomy) bachelor study programmes in a European dimension. It is expected that a series of brochures will be produced covering the Bachelor or first-cycle or EQF level 6, the Master or second-cycle or EQF level 7 (at the end of 2009) and the Doctorate or third-cycle level or EQF level 8 (in 2010). These brochures will represent general expectations about the standards for the award of qualifications at the given level and articulate the attributes and capabilities - *i.e.* the learning outcomes - that those possessing such qualifications should be able to demonstrate. The Bachelor document has already gone through a long and complex validation procedure and is expected to be finalised very soon.

Very recently a group of physics departments and (secondary) schools joined a project overarching the sector of natural sciences, searching to establish a *Sectoral Qualification Framework* in the Natural Sciences, where the study programmes from the ISCED levels 2 till 6 or EQF levels 3 till 8 for - among others - the discipline of physics will be developed in a European dimension. The project will pay attention to the relation between secondary education (general and VET) and higher education by developing clear reference points and favouring transparency in the transition from secondary to higher education.

In a global perspective the EUPEN scheme will try to co-operate with similar bodies acting in other parts of the world (*e.g.* Asian Pacific Physics Education Network, Arab Physics Education Network, Council of Inter-American Physics Education Conferences, and American Association of Physics Teachers).

Also the EPS (*European Physical Society*) and the AAPPS (*Association of the Asia-Pacific Physical Societies*) are happy to announce that the first Asia-Europe Physics Summit "*Physics towards Science Innovations*" will be held in Tsukuba (JP) 24/26 March 2010.

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