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Modernisation of Education II: Education policy and programme, Innovation, EIT and MSCA
Innovation in education, EIT and MSCA

Conference Report
Future of the doctorate
Riga, 28-29 May 2015

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1. INTRODUCTION

The purpose of this report is to capture the wealth of good practices and the main elements of the discussions during a two-day conference on what makes today "**the modern doctorate**", and how it will need to evolve in the future.

The conference "Future of the doctorate" was organised by the European Commission (DG Education and Culture) at the Academy of Sciences in Riga on 28-29 May 2015, during the Latvian Presidency of the European Union.

The conference outputs will feed into the review and follow-up of the EC Modernisation Agenda for Higher Education published in 2011, upon which DG Education and Culture intends to consult later in 2015.

The conference was attended by nearly 250 policy makers, practitioners, researchers and other stakeholder organisations from 39 countries (26 EU Member States, 1 associated country and 12 others).

The programme was structured around plenary and parallel sessions that gave the opportunity to look at **different models and practices** of **doctoral training** around the world. Thematic sessions looked at **doctoral supervision**, **intersectoral collaboration**, the **employability of the doctorate** and **gender issues**. Practical examples, opportunities and challenges experienced by **joint doctorates** were discussed. A wide range of cases from the Marie Skłodowska-Curie **Innovative Training Networks (ITN**) were presented under three disciplinary clusters (the social sciences and humanities, the life sciences and geosciences and physics and engineering sciences).

The conference placed **innovation in doctoral training** in the broader context of the emerging **Open Science** and the implications for the way research will be carried out in the future.

This report has been structured to follow the conference programme (Annex 1).

2. EXECUTIVE SUMMARY

The **nature of doctoral training** has been **very much debated** in recent years at a time when the knowledge triangle of education, research and innovation is seen as the foundation for smart, sustainable and inclusive growth[1]. The doctorate is considered as one of the driving forces to generate economic growth and support positive developments in society, and in the knowledge economy.

Globally there is a **fairly good understanding** of the objectives of the **doctorate** to produce original research. Yet the **implementation of good practices** is very **uneven** across individual institutions and national systems, due to different contexts, cultural and socio-economic backgrounds.

In 2003 doctoral education[2] was added to the **Bologna Process**[3] as the third level of higher education. It was stressed that the doctoral candidate should be regarded as *a young professional* instead of a student. Doctoral training was said to be the level at which bridges could be built between the European Higher Education Area (EHEA) and the European Research Area (ERA).

In 2011 the EU endorsed the **EU Principles for Innovative Doctoral Training**[4] advocating that the **new doctorate** should combine excellence with **interdisciplinary research, international exposure and intersectoral engagement.** These principles are not adopted in the same way across individual universities and EU Member States.

From an individual journey carried out by an individual researcher, the doctoral exploration is increasingly taking place in a **doctoral school** that provides a structure in which ***research*** is carried out and ***training activities*** delivered by a **team of academic and administrative professionals,** instead of the individual academic in the Humboldtian university model. Training includes knowledge and intellectual abilities, technical skills, personal skills, leadership and management, and understanding of impact.

Beyond individual institutions, the PhD is offered in consortia of **multiple organisations**, from **academia and industry**, **across national borders**, in **Europe** and in the **world**. The **industrial doctorates** allow access to networks, expertise, and equipment. The different "languages" of academia and the private sector are learnt. The **joint doctorates** (in Erasmus Mundus, Marie Skłodowska-Curie and the KICs of the EIT) take the candidates into new transformational journeys to produce interdisciplinary research with a strong focus on business and innovation.

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[1] European Commission: Europe 2020 – A European Strategy for smart, sustainable and inclusive growth. European Commission, COM (3.3. 2010) (2010). http://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf, (Accessed: June 2015)

[2] Communiqué, Berlin: Realising the European Higher Education Area. Communiqué of the Conference of Ministers responsible for Higher Education in Berlin on 19 September 2003. (2003): http://www.ond.vlaanderen.be/hogeronderwijs/bologna/documents/mdc/berlin_communique1.pdf, (Accessed: June 2015)

[3] The Bologna Process has been launched in 1999 by the Ministers of Education and university leaders of 29 countries: http://www.ehea.info/, (Accessed: June 2015)

[4] European Commission: Principles for Innovative Doctoral Training, Brussels (2011): http://ec.europa.eu/euraxess/pdf/research_policies/Principles_for_Innovative_Doctoral_Training.pdf, (Accessed: June 2015)

There is **concern** that **short term agendas** have become so dominant to the detriment of the more long term approaches needed for research that requires longer timeframes. The three-year PhD required in EU research programmes and in many countries pose a number of difficulties to deliver the research in time, in particular when it is filled with the range of educational and skills components needed by the modern doctoral candidate to make him more employable.

Growing attention is given to **high quality supervision** of the doctoral candidates. Supervisors are increasingly trained. Supervisory committees are put in place to avoid that the candidate is too highly dependent on a single person.

Despite many charters and good practices, doctoral candidates are still often treated as students instead of young professionals carrying out research. As a result many of the PhD candidates not benefitting from EU schemes do **not receive a salary** but a scholarship and are not covered by social security, leaving them in a fragile financial situation which impacts on their performance. Yet it seems that the **situation is improving** in Europe, under the impulse of the EU Charter and Code for Researchers as well as through national financial schemes requiring that the PhD should be treated as an employee, either by the university or the company in which he/she is carrying out the research. All EU funding schemes require that the doctoral candidate receives a salary and is covered by social security.

Although women are still underrepresented in some doctoral programmes the situation is changing. The Researchers Report 2014 stated that "Between 2000 and 2011, the number of new women doctoral graduates (ISCED 6) per thousand population aged 25-34 has increased in all European countries. Between 2000 and 2011, Slovakia, Denmark, Latvia, Norway, UK and Italy reported the highest increase in the proportion of new women doctoral graduates. In Bulgaria, Hungary, Spain, France, Lithuania, Turkey and Cyprus, the number increased only slightly, yet these countries are starting from different baselines."[5]

Still more attention needs to be given to **gender balance** and the **gender dimension**. It is stimulated strongly in the Horizon2020 programme, where the gender dimension has been introduced for all EU research funded projects.

The emergence of **Open Science** and its future growth will transform globally the way research is performed. It will impact significantly on doctoral programme design. Different approaches are needed to prepare the candidates to opportunities in new research environments.

[5] European Commission. DG Research and Innovation. Researchers' Report 2014. Scorecards, Deloitte, p. 60-61: http://ec.europa.eu/euraxess/pdf/research_policies/Researchers%20Report%202014_FINAL%20REPORT.pdf, (Accessed: June 2015)

3. FUTURE OF THE DOCTORATE

3.1. Conference Purpose in the EU Context

The purpose of the conference was to **take stock and share experiences** on good practices for the **modern doctorate** and to **advocate for its further development** in a constantly changing world. Our complex society demands innovative solutions, knowledge leaders and creators to support sustainable economic growth and social progress.

Good practices and successful initiatives on doctoral training exist everywhere, yet their use varies significantly between individual countries, institutions, and inside institutions themselves. It is not unusual to see smaller universities demonstrate a stronger eagerness to adopt innovative approaches than is the case in the more traditional institutions.

The number of doctorates has increased significantly in Europe. Yet there is **growing concern** that outside academia candidates may not always possess the **right knowledge** and **skills for the labour market**. An entrepreneurial mindset may be lacking for graduates to act as agents of change and innovation in the private sector to transform knowledge into new products.

The European Commission is promoting new developments in doctoral training with **policy interventions** and **support to a range of initiatives.** These will continue in the coming years since doctoral training is seen as a key driver to stimulate change and research impact in Europe.

The **modernisation agenda** for higher education will be reviewed[6] in the coming months, probably starting with a consultation exercise later in 2015, addressing *inter alia* the issues surrounding the future of the doctorate.

At the Ministerial Conference and Fourth Bologna Policy Forum in Yerevan (Armenia) on 14 and 15 May 2015 the ministers of education emphasised the need to strengthen the links between the **European Higher Education Area** (EHEA) and the **European Research Area** (ERA), in particular at the doctoral level.[7]

During the seven-year timeframe of Horizon 2020, the **Marie Skłodowska-Curie actions** will support some 25 000 doctoral candidates. As such, the programme will have a strong structuring effect on doctoral training and a significant impact on skills acquisition and entrepreneurship. The programme encourages high levels of mobility between academia and

[6] The previous modernisation agendas date back to 2011 and 2006;
European Commission: Communication from the Commission to the Council and the European Parliament: Delivering on the Modernisation Agenda for Universities: Education, Research and Innovation *COM (2006)* 208 final, Brussels (2006):
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0208:FIN:en:PDF,
(Accessed: June 2015)
European Commission: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the regions: Supporting growth and jobs – an agenda for the modernisation of Europe's higher education systems, *COM (2011)* 567, Brussels (2011):
http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0567&from=EN,
(Accessed: June 2015)

[7] Yerevan Communiqué (Mai 2015):
http://bologna-yerevan2015.ehea.info/files/YerevanCommuniqueFinal.pdf, (Accessed: June 2015)

industry, supporting new approaches to doctoral training in highly specialised research domains.

Through the **Knowledge and Innovation Communities** (KICs), the **European Institute of Innovation and Technology** (EIT) is investing in new forms of research, innovation and education that foster cutting edge research in critical domains to support grand societal changes in the context of the EU2020 strategy.[8] Business creation and innovation and the acquisition of strong entrepreneurial skills are at the core of the KIC educational activities.[9]

Equally, the **Erasmus Mundus joint doctorates** have fostered significant innovation in teaching and learning and the delivery of transnational education around the globe.[10] In powerful consortia of diverse institutions pulling together their areas of excellence, international programmes have been offered to doctoral candidates to acquire cutting edge knowledge in the discipline, major opportunities to develop original research and broad skills in several institutions around the world.[11]

The **MSCA and EIT** will be subject to a **mid-term review in 2017**. The breadth and depth of different practices for doctoral training will be analysed in this context.

The Latvian context for doctoral education

The Latvian higher education system is made of 17 State and 14 private higher education institutions. For an overall student population of just under 90 000 students[12] studying in all types of higher education institutions at the tertiary level, doctoral candidates account for 2200 of the overall student population. Some 1600 doctoral candidates are subsidized by the State. The remainder of the doctoral candidates finance their own programme.

A modest innovator in the EU Innovation scoreboard[13], Latvia shows the common characteristics of a country that is **lacking an effective innovation ecosystem** made of a large and diverse number of public and private actors to support innovation. These include "entrepreneurs, investors, researchers, universities, venture capitalists, business developers

[8] European Commission: Europe 2020 – A European Strategy for smart, sustainable and inclusive growth. European Commission, COM (3.3. 2010) (2010). http://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf, (Accessed: June 2015)

[9] Blakemore, Michael, Burquel, Nadine, McDonald Neil: The educational activities of the Knowledge and Innovation Communities (KICs) of the European Institute of Innovation and Technology (EIT) – experiences, innovative practices and ways forward. Final Report. *Ecorys UK Ltd. and EFMD* (2013): http://ec.europa.eu/education/library/study/2013/eit-kics_en.pdf, (Accessed: June 2015)

[10] As from 2014-2020 programming period, joint doctorates are supported via the Marie Skłodowska-Curie programme.

[11] Blakemore, Michael and Burquel, Nadine: EMQA- Erasmus Mundus Quality Assessment 2012. Handbook of Excellence - Doctoral Programmes. (2012) http://eacea.ec.europa.eu/erasmus_mundus/tools/documents/repository/handbook_of_excellence_2012_doctoral_en.pdf, (Accessed: June 2015)

[12] Data from the website of the Central Statistical Bureau of Latvia: In the academic year 2014/2015 85,9 000 students are studying in higher education institutions of Latvia: http://www.csb.gov.lv/en/notikumi/number-students-higher-education-institutions-latvia-decreasing-40981.html, (Accessed: June 2015).

[13] European Innovation Scoreboards. Innovation Union Scoreboard 2015: http://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards/index_en.htm, (Accessed: June 2015)

and other service providers such as accountants, designers and providers of skills training and professional development".[14]

National funding for research is still relatively low and there is no strong market for innovative companies to grow. The relations between universities and companies are not sufficiently developed.

Latvia has developed a range of **support mechanisms for doctoral training**, among others through the use of EU **Structural Funds**. This has made it possible to offer better conditions to doctoral candidates. Their number has doubled in the last few years.

There is a need for doctoral candidates to be trained in such a way that they can contribute to economic growth and quick recovery. More opportunities for doctoral candidates to cooperate with industry would help in the process.

3.2. Different models of doctoral training across the world

A European model?

In the early 19th century **Wilhelm von Humboldt** conceived university education as a student-centred activity in which research was conducted under the professor's supervision. The German "**Bildung**"[15] **educational concept** focused on personal transformation with a "shaping of the mind" and a "shaping of the human being". It promoted the acquisition of personal and social skills. The education was not restricted to the acquisition of purely technical knowledge and skills. Academic freedom was an important element in the approach.

By the end of the 19th century the German Humboldtian model became predominant in Europe, the Americas, Japan and in many other parts of the world. This probably explains why globally the goal of a doctoral programme to produce original research is well understood in the same way. In addition it is supported by the significant international mobility of academics that contribute to this common understanding of the goal.

Yet there is **no international norm** on the ***duration*** and on the ***requirements***. There is today **no European model for doctoral training.** There are ***two main trends in Europe***, first the German/continental trend (with the doctoral training taking place after the Master) and the Anglo-Saxon tradition (with doctoral training placed Post-Bachelor after the Honours Degree). The critical issue is to determine whether the students are "research ready" to start a PhD.

The **practical implementation** of doctoral training has evolved considerably over the years and **differs greatly** between countries and individual institutions, due to a range of cultural, financial and socio-economic factors. In Europe, procedures on admission, supervision, monitoring research progress and the thesis assessment have been implemented in a large number of institutions.

The traditional orientation on **fundamental research** has been supplemented by a focus on **applied research**, with companies, and among others in the context of EU research projects.

[14] The KNOW-HUB Project: http://www.know-hub.eu/knowledge-base/videos/innovation-ecosystems-as-drivers-of-regional-innovation-validating-the-ecosystem.html, (Accessed: June 2015)
[15] German term refering to "education" and "training"

Political attention increased for doctoral education with its inclusion in the Bologna Process in 2003. In 2005 EUA[16] adopted the **Salzburg Principles** and revised these in 2010.[17] The Principles establish a framework for doctoral education in the Bologna Process based on research embedded in institutional strategies and the creation of structures to support doctoral training. The Council for Doctoral Education (CDE)[18] promotes exchanges of good practices to support the development of doctoral education and doctoral schools.

To **embed doctoral training** equally across all three key university missions, a large **number of challenges** remain. First there is ongoing ***tension between basic and applied research*** with governments demanding accountability, short term innovation and impact, between broad science and concentration of research and smart specialisation[19]. ***New forms of teaching and learning*** are developing, placing a strong focus on student-centred learning and using digital approaches. These also impact on doctoral training. The ***university third mission*** to provide services to society requires the collaboration between a broad range of non-academic partners to support local and global capacity for economic growth and innovation.

The Canadian example

Canadian higher education resembles European higher education in many ways with a mix of educational policies defined at the central State level and at decentralized levels.

The **typical Canadian PhD** takes 4 years after the Master. It involves coursework with field studies, skills development (languages) and professional skills development (teaching, statistics, presentation). It focuses on the writing of the PhD thesis. Its outlook will depend on the discipline and the level of connections to industry. The PhD is generally funded through research grants, projects or fellowships.

The PhD is disciplinary-based, yet there are opportunities to build **interdisciplinary features** to gain from diversity. Graduates in Canada can also apply for an interdisciplinary PhD programme as an entire separate programme.

The **strengths of the PhD** lie in the high quality of the universities and the strong focus placed on accountability ad transparency. The PhD is designed as a ***formal and structured***

[16] European University Association

[17] European University Association. (2010): Salzburg II Recommendations. European Universities' Achievements since 2005 in Implementing the Salzburg Principles. *Brussels*. http://www.eua.be/Libraries/Publications_homepage_list/Salzburg_II_Recommendations.sflb.ashx, (Accessed: June 2015)
Bologna Seminar Doctoral Programmes for the European Knowledge Society. Conclusions and Recommendations. *Salzburg* (2005): http://www.eua.be/eua/jsp/en/upload/Salzburg_Conclusions.1108990538850.pdf, (Accessed: June 2015)

[18] The EUA CDE has 235 members in 35 countries. It was created in 2008.

[19] The innovation policy concept "Smart specialisation" aims to boost regional innovation and economic development through specific support to research and innovation. Region-specific smart specialisation strategies build on the inherent strengths and advantages of a region.
See: European Commission: Smart Specialisation and Europe's growth agenda (2014): http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/smart_spec_growth_agenda.pdf, p.2 and 5, (Accessed: June 2015)

programme giving the candidates clear information before taking the decision to engage into a doctoral programme.

The ***relation with the supervisor*** and supervisor committee is very strong with clear guidelines formulated on expectations and levels of formal interactions with the doctoral candidate.

Through a range of training activities the candidate is offered ample opportunities to develop ***professional skills***, interact with peers and develop strong ***networks***. They are offered significant guidance before, during and after the programme.

Yet the Canadian PhD is **heavily depending on the funding situation**. The ideal situation is a fully funded programme for 3 to 4 years. Many candidates only obtain one or two-year funding "in the hope" and with "implicit indications" that more funding will be obtained at a later stage. When it is not the case candidates are left in a fragile financial situation which impacts on the completion of the doctorate.

The **supervision process** is not always taking place in the most effective way and there is a need to introduce ***more checks and balances***.

The growth of doctoral programmes in the past few years has resulted in a **difficulty** for doctorate holders **to find academic positions**. Such a situation is not restricted to Canada. In the past 10 years, North America rapidly increased its graduate student intake, yet less than 50% complete the doctorate. Canada graduates fewer PhD degrees than its competitors (such as US or Germany); still only one in four ends up with an academic position. *The Globe and Mail* (29 May 2013) reports on unemployment percentages among doctorates, i.e. *"Unemployment rates for doctoral grads remain in the low single-digits but there are legitimate questions about the extent to which the economy can continue to produce high-quality jobs for new PhDs – particularly with enrolment rising at some six per cent per year over the past decade, and average retirement ages edging upwards."*[20]

Learning from South Africa

The current socio-political context challenges the historical basis of the PhD. A strong focus is placed on innovation, the need to generate business and to respond to the priorities of policy-makers, the demands for accountability, economies of scale and immediate outputs. The demands for excellence are often made without any regards to local contexts, which leads to confrontations in many different parts of the world with a civil society increasingly eager about grand societal questions. The social media offer a wide range of new tools to support this engagement.

Doctoral training is very **context dependent.** Current trends must be placed in an analysis of national and regional environments to define the options that can be pursued in order to reach the goals that countries and organisations are looking to achieve.

Higher Education in South Africa follows the Anglo-Saxon degree structure with the three-year Bachelor (followed by the one-year Honours degree), or the four-year professional degree. The Master is obtained after one or two-years and the PhD after three or four years. Such a

[20] Herbert-Copley, Brent: Few academic jobs, but Canada's need for PhDs grows. *The Globe and Mail* 29.05.2013: http://www.theglobeandmail.com/news/national/education/few-academic-jobs-but-canadas-need-for-phds-grows/article12219592/, (Accessed: June 2015)

structure has become problematic in the current context in South Africa since it assumes an education "without interruptions" which is by far no longer the case due to a range of factors. **Enrolments are relatively low** in relation to the overall population. Yet despite these challenges, the number of publications increased significantly in South Africa.

Doctoral training focuses on research at an advanced level which culminates with the final thesis. The candidate has to demonstrate his/her capability to deliver original high level research. The doctoral training focuses entirely on a preparation for the **academic career**.

The country has established a number of **targets to increase the numbers** of PhD holders. It wants to have more than 100 doctoral graduates per million by 2030 (the figure currently stands at 36). It has estimated that it needs more than 5 000 doctoral graduates per year, mainly in Science and Technology.

A **number of surveys** have been carried out at the national level to track student progression and levels. Progression rates are very low and highly field and race dependent. Only 27% of Bachelor holders go to the Master (10% of them take 5 years to complete the Master) while only 15% of Master holders go to the Doctorate after 5 years. The average age of the PhD candidate is 33 years while graduation is usually at 41 years. Women are underrepresented. 61% of doctoral candidates are in (mainly university) employment during their PhD (full or part-time). This explains the long time taken to complete the PhD.

Doctoral candidates discontinue their PhD for financial reasons (25% of the cases among the black population compared to 6% among the white population), work obligations, or their interest in gaining work (instead of research) experience.

Questions emerge in the context of broader issues about **the type of science** that doctoral candidates should **pursue in the future** (either on frontier science or on "global consensus science"), on the **end delivery of the PhD** (a series of papers or a thesis), on so-called **emerging research areas** (at the intersection between economic and scientific interests, for example on new diseases), and **e-science** (remote access, large consortia, shifts to automated analysis, differences between data and information).

The current fairly generic model of doctoral training in South Africa needs to evolve to build on the complex interplay between a range of different factors and variables that are so critical for the development of South Africa and require urgent interventions.

3.3. Thematic clusters

3.3.1. Supervision and Quality Assurance

Doctoral training is a **journey "in the unknown"** that involves ***high risk and high investment***. It pushes the candidate to generate new knowledge beyond the traditional boundaries. It takes the candidate beyond his/her own personal limits, leading to personal and professional developments.

Such a transformational process requires **high quality supervision** with ***structured approaches*** and ***concrete tools*** that support the candidate in delivering according to expectations.

Doctoral training should be conceived as a dynamic process that provides a wealth of learning opportunities to shape the candidate's identity as a researcher and an individual.

There are many ways to carry out high quality supervision with innovative tools, instruments and good practices.

The **Nencki Institute in Warsaw** carries out experimental biomedical research. The selection of candidates is critical to test personal aspirations, levels of resistance to frustration and acceptance of failure as a way to progress. Over the years the candidate profiles have changed considerably to include candidates with a family, a high proportion of female researchers and mid-career applicants.

The ***mentoring scheme*** is a valuable approach to nurture "the right people" and assist them in developing their own research directions, acquiring a broad range of skills, learning to work independently and becoming highly creative.

Evaluation of progress is made through individual discussions, presentations at various levels of the organisation (in large or small meetings), active participation in laboratory meetings, assistance in paper writing and grant writing.

The **University of Edinburgh** is paying great attention to ensure that mutual expectations are met in the relation between the supervisor and the candidate.

The ***Thesis committee*** consists of a principal supervisor, a secondary supervisor, an "external person" and the Chair. The Committee meets at least once per year and overviews progress, ensuring that the candidate presents papers and is given the best training.

The ***Code of practice*** contains everything the candidate and the supervisor need to know from the doctorate initial welcome induction programme to research facilities and support services, problem solving (on matters of personal concerns, working relationships, research progress), academic appeals, plagiarism and provisions for international students.

Candidates are grouped in "***induction cohorts***", i.e. four periods in the year during which they are given information on good practices in the PhD.

The University uses the ***researcher development framework*** developed by ***VITAE***[21]***,*** the organisation in the United Kingdom that supports researchers through their professional and career development. The framework has four domains, i.e. knowledge and intellectual abilities, personal effectiveness, research governance and organisation and engagement, influence and impact.

In the UK more focus is increasingly placed on additional coursework and prescribed training for PhD, which creates a tension with the requirement to deliver the research in the maximum three-year period allowed under research grants.

At the **National University of Ireland in Galway** supervisors of doctoral candidates are supported through a structured training programme.

The initiative started with the creation of a ***support group for supervisors*** between all higher education institutions at the ***national level***. Supervisors expressed the needs for a training programme. Issues such as dispute resolution, managing a research group, fostering independence and thesis writing were identified as top priorities.

[21] VITAE – realising the potential of researchers: https://www.vitae.ac.uk/, (Accessed: June 2015)

Over time a ***training framework*** was defined at the level of NAIRTL[22]. The training programme was structured in five workshops and is now delivered in individual institutions. It is not compulsory yet strongly recommended. The programme focuses on the *supervisor in his institution* (policy, context, support) and the *doctoral candidate life cycle*, broken down in the four stages of the recruitment (framing the candidate and identifying training needs), making progress (expectations, roles and responsibilities), progress to completion (career support, examination), the viva voce and beyond.

Doctoral candidates need support to be recognised internationally during and after their PhD to create an international professional network, to publish in top journals and present in international conferences. At the **University of Geneva** the challenge of leading interdisciplinary teams is addressed by taking doctoral candidates out of their specific community and encourage them to exchange with other candidates from different backgrounds, to develop activities of mutual interest and work on common activities (such as books or fairs).

Aligning the (international) supervision in an interdisciplinary programme takes place when PhD candidates, despite working on specific disciplinary themes, have the opportunity to publish **papers in several disciplines** and as such constitute an interdisciplinary project.

At the **Faculty of education and health** of the **University of Greenwich** the profile of doctoral candidates is mainly mid-career professionals who have a strong curiosity in advancing their knowledge while at the same are concerned about potential failures.

The Faculty is eager to get "the right candidates" that will complete in time, given appropriate supervision. The VITAE framework and principles for career developments are used to develop the supervision process. The supervisory team is required to have clear understanding of its role to **assist the candidate** at the induction stage, with advice and training (all through the doctoral journey, in particular in more challenging times), and in developing "from a novice into a fully independent expert in his field".

3.3.2. Intersectoral collaboration in doctoral training

The provision of doctoral training is increasingly across geographical borders, organisations and different sectors. Doctoral candidates gain opportunities to enhance their opportunities to acquire specialised knowledge and skills "beyond academia" when they are exposed to industrial partners, their ways of working and infrastructures. The doctorates offered jointly by academic and industrial partners, on a bilateral or multilateral basis allow cross-disciplinary knowledge creation from a wide range of different perspectives.

The **Danish Technical University** has 110 industrial PhDs, out of a total of 1 492 PhDs.

In Denmark the Industrial PhD Programme is regulated in great detail by the University Act and a Ministerial order. The Industrial PhD is an **industrially focused research project** and a **PhD education** conducted jointly by a private sector company (a Danish company or its subsidiary), an industrial PhD candidate (Danish or foreign) and a university (Danish or foreign). The State subsidies are financially attractive for the company. The candidate and university gain significantly from the close cooperation with industry.

[22] National Academy for the Integration of Research, Teaching and Learning: http://www.nairtl.ie/, (Accessed: June 2015)

The Danish PhD programme lasts three years and consists of a **research project** (leading to a thesis), **course work** (30 ECTS points, 6 months), **research results dissemination** (3 months) and a **research stay** (3-6 months). Doctoral candidates are in universities (financed by the universities themselves, companies, research councils, or through EU programmes). **Industrial doctorates** are **employed** in the **companies.** The university provides the main advisor and the company a co-advisor.

The industrial doctoral candidate is required to take a Business course of 7.5 ECTS points and write a business report (describing the research project in the context of the company business profile). At least one member of the assessment committee is required to have private sector relevant research experience in the field.

The candidates for the Industrial PhD need to have as the minimum a Master degree (or equivalent). The private company must be in a position to support financially the Industrial PhD project for the entire three-year period, to provide a research qualified company supervisor, a professional working and research environment and embed the PhD candidate in the organisation. The project must have a clear scientific dimension and a defined area of application with business potential.

The **Fire Tools project** (2012-2016) is an initiative of Lund University and the Danish Institute of Fire and Security Technology, with 9 associated partners around the world (universities and private companies). It has fellows from 5 different countries.

The fellows receive **training** (coursework, thesis, academic research), opportunities for **experimenting** (industrial partners) and **lab work, applied research** (associate partners). The programme favours skill acquisition through seminars, courses at partner universities, team building events and other personal development activities.

The challenges lie in the accessibility of the scientific and technical advisors, working in teams (compared to individual work), IPR issues and the costs.

Yet, the programme offers mutual benefits for all partners. Fellows are bringing academic knowledge (e.g. from their courses, conferences, seminars) and can develop tools, methods, processes to optimize the work of businesses. Businesses provide a stimulating environment to work with experts in the field and to access to lab, equipment and networks. **Fellows and businesses gain recognition** through conferences, journal articles and project work.

The Doctoral School of EIT Digital (University of Bologna) provides skills for life "beyond academia", with an education on Innovation and Entrepreneurship towards Industrial leadership in the Digital industry. The PhD programme is delivered with a strong participation of industrial partners (more than 100 as a whole) and 18 partner universities located in different places in Europe.

During the doctoral programme the candidate has the opportunity to acquire **technical cross-disciplinary skills** and **soft skills**. These include understanding the business environment, customers and societal challenges, applying research and technology to drive ICT intensive innovation and business development, building partnerships and communicating, creating and maintaining professional networks.

The School offers training, summer schools, innovation and business courses, and business development experience with a link to the thesis.

Doctoral candidates are affiliated to Doctoral Training Centres (DTCs) across the ICT Lab KIC and obtain financial support for **innovation and entrepreneurship education**, **mobility abroad** and **6 months direct experience in an industrial setting**.

Companies gain from a pool of future ICT leaders and managers from which they can select directly. Universities gain from access to relevant funding sources (for education and research/innovation), direct links with possible employers (for their graduates), and networking (with other universities in Europe).

Founded in 1934 in Japan **FUJI Film** has today 80 000 employees (1 000 in its manufacturing operations in Europe), a turnover of $ 20 billion (7-8% is allocated to R&D).

The Marie Skłodowska-Curie actions have provided funding for 5 Post-docs and 14 PhDs. Fuji Film sees the main challenges of the 21 century "in the global village", in the stakeholders' interaction between policy-making, industry and the scientific community. In any research project the critical point is to define the right research question in order to set the direction. Collaboration patterns and synergies can then be explored to enhance the production of scientific knowledge and its translation into new products that will have a positive impact on society. The **construction of alliances** requires ***strong commitment*** from all partners to set precise targets, ***respect of the partners' identity*** and ***true mutual interest***.

In the Fujifilm BioInspire ITN project the therapeutic objective required the **integration of several disciplines** (e.g. medicine, cell biology, biomaterial). The collaboration with industry gives a rich research experience in the doctoral training, focusing on a clear scientific research direction and enabling the candidate **to acquire "two languages**" and cultures, i.e. the academic and the industrial language.

3.3.3. Employability of doctorate holders

Growing attention is paid to the employability of doctoral candidates. There are many examples of good practices from individual institutions, national organisations and funding schemes. During the doctoral training, candidates are increasingly offered wider opportunities to acquire different types of skills, join professional networks and access research platforms. Beyond the doctoral training, the tracking of doctorate holders from their early careers into career progression, in and outside academia, delivers valuable information for institutions to review their doctoral training provision.

VITAE supports the ***professional development of researchers*** in the UK through courses, training programmes, networking opportunities, and projects focusing on delivering evidence and impact.

Looking at researchers 'employability in terms of career ***motivations, first destinations, career pathways, impact, and individual career stories*** offers a wealth of information.

VITAE has produced a number of reports[23] that review careers in research (in or outside academia), what researchers want to do (personal aspirations, occupational intentions and the subsequent need for doctoral qualifications), and postgraduate research experiences.

[23] Mellor-Bourne, Robin, Jackson, Charles and Hodges, Vivien: What do researchers want to do? The career intentions of doctoral researchers. *VITAE, Cambridge,* (2012): https://www.abdn.ac.uk/careers/resources/documents/4374.pdf, (Accessed: June 2015)

The ***first destinations*** of doctorate holders is ***discipline related***, with a majority of graduates from the biomedical, biological and physical sciences going into research positions in higher education institutions, while PhD holders in the social sciences and humanities predominantly go into teaching and lecturing posts.

Three years after completion PhD holders are mainly employed in *"other common doctoral occupations"* outside academia (not classified as research or teaching roles, for example, working as health professionals, senior managers, engineering professionals and business and statistical professionals). *Teaching comes at the second position and in third position, PhD holders are employed in* research posts. In the UK, a majority of doctoral graduates are thus not working in academia three years after graduating. A limited 2% of PhD holders is unemployed. The value of the PhD is strongly acknowledged as having contributed to career satisfaction and progress.

PhD holders work in a ***variety of different sectors*** having a wide range of different titles and positions. The reason to leave a position is mainly to obtain more job security, better career prospects or a better work life balance.

In their transition to different organisations, PhD holders find it most challenging to change to different organisational cultures and status, to lose flexibility and be constrained by tight deadlines. They value the support of new colleagues, and gaining broader experience, using networks, careers advice and mentoring.

The **FWF**[24] is the **Austrian Science Fund,** an agency providing equal funding opportunities for fundamental research in all fields of science and the humanities. Its mission is to *"develop Austria's human resources for science and research in both qualitative and quantitative terms based on the principle of research-driven education".*[25]

Research proposals are assessed by international peer review teams on the basis of three guiding principles, i.e. the quality of the research (70% of the budget), the development of human resources (25% of the budget) and the approaches proposed to enhance interactive effects of science and research (5% of the budget).

The **European Charter for Researchers and Code of Conduct for the Recruitment of Researchers**[26] has been adopted by the FWF.

In 2004, the FWC implemented a doctoral programme, the **"Doktoratskolleg",** with the intention to improve the ***educational structures*** at the universities and provide them with a ***broader training basis*** for the doctorate programme. Quality assurance was at the core of the process with a strong focus on the selection of scientists (faculty) and students, the

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Bennett, Paul and Turner, Gosia: PRES 2013: Results from the Postgraduate Research Experience Survey. The Higher Education Academy: York (2013), (Accessed: June 2015) https://www.heacademy.ac.uk/sites/default/files/resources/PRES_2013_UK_report.pdf
Careers in Research Online Survey. 2013 UK aggregate results (2013): http://www.southampton.ac.uk/pdu/Research_Staff/ECR/documents/CROS%202013%20Analysis%20of%20UK%20aggregate%20results.pdf, (Accessed: June 2015)

[24] Austrian Science Fund (FWF): https://www.fwf.ac.at/en/, (Accessed: June 2015)

[25] https://www.fwf.ac.at/en/about-the-fwf/corporate-policy/, (Accessed: June 2015)

[26] European Charter for Researchers and Code of Conduct for the Recruitment of Researchers: http://ec.europa.eu/euraxess/index.cfm/rights/whatIsAResearcher, (Accessed: June 2015)

requirement for continuous improvement (with programme monitoring and evaluation). Small adaptations were made in 2008 to establish a standardized programme.
From a 12-year programme (divided into 3 times of 4 years) the „Doktoratskolleg" was reduced to 8 years in 2014. It covers a minimum of 5 and a maximum of 20 scientists ("Faculty Members"), with a proportion of 30 % women. The average annual budget amounts to € 700 000 for a maximum of 3 PhDs per Faculty Member and a maximum of 2 associated students.

The programme has enabled the creation of **internationally competitive and renowned training centres** for most talented young researchers, contributing to the improvement of doctoral training in Austria and the implementation of international standards for doctoral education. It has also supported the provision of *research-based education* through internationally competitive research *and* training programmes, and the exposure of PhDs to top quality research projects. In addition it has fostered **intense monitoring and supervision,** the development of structured doctoral training, **transparent procedures** (selection criteria, thesis assessment, etc.), and the international organisation of doctoral training.

The **Marie Skłodowska-Curie fellowships** have made it possible to take the doctoral candidates "to the next steps". **Personal testimonials** demonstrate the range of benefits.

AIST, the National Institute of Advance Industrial Sciences and Technology in Japan had 15 doctoral candidates from 14 partners in 8 countries who benefited from a fellowship. Personal experience was gained through publications, grants and awards. A clear understanding of tasks, hard work and a good supervisor (gaining from his/her experience to build confidence and go "in the right direction") enhances the chances of bringing the PhD to a successful conclusion.

The benefits of the fellowships also lie in the **access to international research platforms** and the **latest research in the field**, **high quality supervision** and **financial security**. The diversity and networking opportunities offered in international networks enhances learning opportunities to obtain a good position after graduation. Critical success factors are a good track record of publications, sound knowledge, advanced planning and open-mindness.

Doctoral training is about **nurturing professional ambitions and personal developments**, transforming the candidate into a curious, determined team player, emphatic and strategic individual. Beyond the technical specialisation, the development of transferable skills is critical for the development of young professionals.

The PhD should be seen as a **crossroads between culture, people, ideas, disciplines and management styles** in which the doctoral candidates are immersed. In some cases candidates may feel "confined" by their supervisors who coach them towards the intense production of papers (still seen a key success factor) and to the academic career. However PhD candidates need to work from the start towards their own career paths and set their own strategies.

For industries it is attractive to hire agile and adaptive individuals demonstrating a range of technical skills, soft skills and entrepreneurial mindsets. A first successful experience in industry (e.g. SMEs) also boosts employability.

3.4. Innovation in doctoral training

Individual universities are innovating in different ways and at different paces with doctoral training. Through their activities, several European university associations and other types of organisations and initiatives have compiled examples of good practices.
In 2010 and 2014 **LERU**[27] produced **two papers**[28] that compiled a range of practices and principles on doctoral education.

Every year through its **doctoral summer schools** LERU addresses a wide range of themes such as (in 2014) ***research integrity,*** plagiarism and fraud, access to transparent information in universities, principles of authorship and co-authorship, peer review, conflict of interest and data management. In previous years other topics were covered such as ***open science, open education and learning*** (including the issue of access, the definition of "***data***"), and ***doctoral school leadership***. In 2015 the school will focus on the ***knowledge economy*** and interactions with society, the media, government and science policy.

The view of LERU is that doctoral training must prepare doctoral researchers to adapt outside academia and become the drivers of their own professional developments. To achieve this doctoral candidates need a critical mass with a strong research environment in which they can thrive in research teams, with access to high quality research infrastructure.

For **EURODOC**[29] despite numerous declarations, researchers' charters and principles, "on the ground" and inside universities candidates are treated as students.

In many cases they are on a **stipend** with no social security coverage. They are not seen as professional researchers and therefore **not provided** with a **salary** and **social security** which impact on their (financial) ability to progress efficiently towards completion.

The **situation** of the doctoral candidate **seems to be improving** with a number of countries launching schemes under which the PhD becomes an employee (e.g. of a university or a company in the case of the industrial PhD). At the European level, **Marie Skłodowska-Curie fellowships** continue to offer attractive working and employment opportunities.

EUA reports that 85% of its members have now in place doctoral schools. Although main principles and guidance documents on doctoral training are converging, there are still differences across countries. The **EUA Council for Doctoral Education** sees the range of different approaches developed at different paces across its membership to enhance the doctorates' entrepreneurial aspects, shift **from individual to structural approaches to supervision**, different **understanding of interdisciplinarity** leading to different outcomes, multiple factors to support internationalisation strategies.

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[27] League of European Research Universities (21 research intensive universities in 10 countries)
[28] Bogle, David, et al.: Doctoral degrees beyond 2010: Training talented researchers for society. *League of European Research Universities* (2010): http://www.leru.org/files/publications/LERU_Doctoral_degrees_beyond_2010.pdf, (Accessed: June 2015)
Bogle. David, Maes Katrien: Good Practice Elements in Doctoral Training. Follow-on paper to Doctoral degrees beyond 2010: Training talented researchers for society. *League of European Research Universities* (2014): http://www.leru.org/files/publications/LERU_AP_15_Good_practice_elements_in_doctoral_training_2014.pdf, (Accessed: June 2015)
[29] The European Council of Doctoral Candidates and Junior Researchers (EURODOC). It has 32 member countries in Europe: http://eurodoc.net/, (Accessed: June 2015)

The pressure to deliver research and publish within **shorter timeframes** (three years) raises the question whether sufficient time is left for more risky research endeavours. Researchers should be better prepared for the many changes that they will be facing in their professional life in increasingly more complex environments. The growth of Open access and big data management will require a wide range of different approaches. They also raise new ethical issues that researchers will need to address.

The **UNIKE MARIE CURIE ITN** focuses on the challenges posed by universities' new role in a global knowledge economy, analysing more in depth the processes in Europe and the Asia Pacific Rim. The UNIKE network provides a rich example of **structured supervision and training activities** through a range of institutional training courses, fellow-led work groups, research, training and career planning, UNIKE mentors, secondments (for periods from 2 to 6 months), workshops and summer schools.

To illustrate changing approaches towards the doctoral training, the UK anthropology example was described. In the eighties, university departments in the UK spoke only about pure research ("*untouched by real life")* compared to applied research (that was "*polluted with practical action"*). In 1984 there were 100 unemployed PhD anthropologists. The doctoral training only provided a restricted set of skills added at the end of the programme.

The "Anthropology in action" organisation was set up to generate a conversation with practitioners about changes in society. As a result, a network of 300 anthropologists working in many different sectors in the United Kingdom came to life. A one-week vocational training week was designed, with a simulation of a project that the anthropologists were working on. The aim was to have the training mainstreamed in university departments. This did not happen due to other more pressing research priorities at the time, such as those related to the Research Assessment Exercise.

In both the UNIKE ITN and the Anthropology in Action experience, the challenges are similar, i.e. to feed back the training experience into the universities and **mainstream** these innovative training approaches in order to make them sustainable in the long term.

3.5. Open Science in doctoral training

The **Open Science** concept refers to the **systemic changes** that affect the entire research cycle and stakeholders. It is resulting from the demands for ***more open and data driven*** science and research. The changes will have multiple implications on the ways research is performed, evaluated and applied, the knowledge is shared and researchers collaborate.

The **environment for research** is **changing considerably** with the increase of research and researchers around the world, the growth of digital technologies, the active involvement of citizens and the demand for more accountable, responsive, transparent and productive science.

For society as a whole, the Open Science concept offers better value for money (by strengthening research productivity), more transparency and networked collaboration (responsiveness to societal challenges) and a sound science and society relationship (more trustworthy science for citizens and civil society organisations). Big and open data are estimated to add 1.9% of EU-28 GDP by 2020.

For research systems it increases efficiency with scientists sharing positive and negative results (reducing duplication of scientific work), faster knowledge transfer among scientists and scientific disciplines, more productive science (early identification of dead-ends and successes).

For **individual researchers** opportunities lie in the wider dissemination and sharing of results, involvement in more interdisciplinary research, increased visibility, participation in international researchers' networks and new career paths (e.g. data scientists, start-ups, science diplomacy).

Open Science could offer the opportunity to assess researchers on **other criteria than peer reviewed papers.** The impact assessment could go beyond the traditional outputs (journal articles), to alternative research outputs (blog posts, datasets and software). Making research data open could become an explicit criterion for career progression, and a data management plan becomes a must. New skills will be needed in the classical doctorate programmes.

Yet there is currently still a **limited awareness of Open Science**. Many barriers remain in terms of the lack of incentives for researchers, the resistance to change the traditional peer review system, the fear of error (i.e. writing about work in progress and risking errors), and intellectual property rights.

Debates in EU Member States predominantly focus on Open Access issues**.** Almost all Member States have set up legal and administrative conditions in support of Open Access to publications. Only one Member State has so far taken a comprehensive approach to Open Science, i.e. Finland has defined an "*Open Science and research roadmap for 2014-2017".*

The **Foster consortium**[30] encourages the integration of **Open Science** across **all stages of the research lifecycles,** from the research proposal to the data collection, testing, education and training activities, and publication. The Open Science **dimensions** include open (big) data, open access, open evaluation, open policies and open tools.

Open Science allows for co-creation by multiple stakeholders across organisations and sectors that have the potential to make a significant impact on societal needs. Yet for the moment Open Science is not aligned with the education provided in universities nor with researchers' career paths.

The Foster consortium offers a range of training programmes to review different types of Open Science dimensions and tools that enhance research proposals.

Future Ocean[31] is a network of 200 scientists with very different backgrounds who provide education and cooperate to discuss on issues related to the future of the ocean. The 150 (active) doctoral candidates have very diverse backgrounds (biology, economics, law).

A wide range of activities (courses, retreats, teambuilding, debates,) are offered to them, and to the 100 candidates that have already graduated. These help to nurture personal contacts.

[30] Facilitate Open Science Training for European Research (FOSTER): https://www.fosteropenscience.eu/, (Accessed: June 2015)

[31] Future Oceans – Kiel Marine Sciences. It's composed of - 7 faculties of Kiel University, the Kiel Institute for the World Economy, Muthesius Academy of Fine Arts and Design, GEOMAR| Helmholtz Centre for Ocean Research Kiel. http://www.futureocean.org/en/index.php, (Accessed: June 2015)

Open science is a **transversal theme across all activities**. Open events are organised with up to 1000 participants. Doctoral candidates work with open data and are offered many opportunities to interact with civil society that is interested in environmental questions.

3.6. Integrating the gender dimension in doctoral training

The **Marie Skłodowska-Curie Actions (MSCA) Alumni Association** and the Gender working group have produced a new publication "Role models for mobility of MCAA women scientists"[32] with a range of **good practices** to promote the gender balance and women in academic careers.

Traditionally, **gender issues** have been addressed in the hard sciences, whereas they were generally studied in the social sciences. The notion of sex refers to the biological difference between males and females, whereas gender is a socio-cultural construction.

Gender is now **integrated in Horizon 2020** at two levels, i.e. ***gender balance*** (in research teams and decision-making/management structures) and ***gender dimension*** (in the research content). Projects funded under Horizon 2020 are recommended to try to address these two dimensions from the beginning to the end of the project.

Integrating the gender dimension in a research project has the potential to bring substantial benefits in terms of the research quality and the market potential to develop new products adapted for each gender. There are many interesting examples on the integration of the gender dimension.

The **Gender Innovation website**[33] developed by the University of Stanford and to which the European Commission is associated has a wealth of good practice examples and case studies on how the gender dimension can be addressed in research.

The Commission MSCA Work programme and guide for applicants for 2016-2017 will include gender in the evaluation criteria of MSCA projects. Guidelines will be produced for a better preparation of the evaluators of MSCA proposals to assess gender issues.

The **EURODOC survey on doctoral candidates**[34] from 2008-2011 provides significant data to understand the range of issues that doctoral candidates are faced with through their doctoral journey. The survey focused on **personal situations**, **work and mobility** of PhD candidates.

Disparities between male and female are highlighted. Female PhD candidates and holders seem to have fewer career opportunities and be in more precarious situations.

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[32] Chmielowski, Riia M.: Role models for mobility of MCAA women scientists. *Marie Curie Alumni Association GEMS Working Group* (2015).
https://www.mariecuriealumni.eu/sites/default/files/ebook_mcaa_def_nologos_0.pdf,
(Accessed: June 2015)

[33] https://genderedinnovations.stanford.edu/, (Accessed: June 2015)

[34] Eurodoc Survey I: The First Eurodoc Survey on Doctoral Candidates in Twelve European Countries: Descriptive Report. Eurodoc (2011):
http://eurodoc.net/wp-content/uploads/2012/07/Eurodoc_survey_I_report_2011.pdf,
(Accessed: June 2015)

LERU produced a paper on gender dimension within research[35] that provides further data and analysis of the situations of doctoral candidates.

3.7. Joint doctorates: Lessons learnt

Many lessons can be learnt from the experience of the **transnational joint doctorates** that involve academic and non-academic partners in **Europe** and from **around the world**.

Collaborative doctorates and **joint (fully integrated) doctorates** differ in the degree of centralization between the partner institutions ("jointness") or decentralization, from the point of view of the programme design, recruitment, admission, and overall management. The strength of the partners' internationalisation strategy will have a great impact. Holders of international joint doctorates are highly valued by the labour market for their cutting-edge knowledge and the multiple exposures to different experiences, cultures and teaching and learning approaches leading to multi-skill developments.

The international **GEM[36] Erasmus Mundus Joint Doctorate** is offered by a global consortium of 10 institutions, out of which 4 European HEIs award the double degree. GEM partners offer a fully interdisciplinary research programme (political sciences, EU studies and law, international relations). Since the launch in 2010, GEM has selected 49 fellows in 5 cohorts. There is an 85% employment rate among the graduates. The programme demonstrates the growing range of opportunities for the social sciences to deliver knowledge and expertise in a wide range of sectors.

The critical success factors have been to cope with national diversities. This has been done by fostering **horizontal convergence** (transnational selection and evaluation practices; PhD School standards) and **vertical consistency** (different administrative practices due to different national regulations on tuition costs, employment contracts). Challenges remain in relation to sustained funding models for the social sciences.

Yet new opportunities for upward convergence can emerge through the EU Open Method of Coordination and the regular monitoring and **benchmarking of doctoral education in Europe**.[37] Deeper collaborations between European and non-European partners, further innovations and deeper interdisciplinary in the research design, and a more open and international ERA and EHEA can further enhance stronger convergence.

The **Erasmus Mundus SinChem[38] joint doctorate** is a consortium of 31 partners (HEIs, large chemical companies and a range of stakeholders'organisations) that focus on sustainable Industrial Chemistry.

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[35] Maes, K., Gvozdanovic, J., Buitendijk, S., Hallberg, I. R., & Mantilleri, B. (2012). Women, research and universities: excellence without gender bias. *LERU universities*. http://www.leru.org/files/general/LERU%20Paper_Women%20universities%20and%20research.pdf, (Accessed: June 2015).

[36] Globalisation, the EU and Multilateralism, Institut des Etudes Européennes, Université Libre de Bruxelles

[37] Open Method of Coordination: http://ec.europa.eu/culture/policy/strategic-framework/european-coop_en.htm. (Accessed: June 2015)

[38] SInChem - the Erasmus Mundus Doctoral Programme in Sustainable Industrial Chemistry

SinChem has clear **educational objectives** (provide research training with industrial relevance), **scientific objectives** (deliver high level science and facilitate the emergence of industrially relevant discoveries) and **socio-economic objectives** (finding new solutions for the chemical industry). These are achieved through the delivery of a lab-based interdisciplinary programme in which companies play a strong role (research long term direction, guidance and some training).

Joint doctorates require strong **collaborative and participatory approaches** between partners at various levels of the institutions. One of the main challenges for SinChem has been to deal with different national rules and immigration policies to meet the EU requirement that all doctoral candidates should be on an employment contract.

The international **European/International Joint PhD in Social Representations and Communication** focuses on social representation and communication. As a fully interdisciplinary programme it overcomes the traditional disciplinary boundaries (physics, chemistry, medicine, history, psychology, anthropology….). Started some 20 years ago it is an example that the joint degree is possible, and that initiatives are fully sustainable beyond EU project funding, through the full commitment of the partner universities to enable their full integration in institutions.

The field has **important applications for the public and private sectors** (cultural and health practices, ideology and politics, economics, the environment). It can also activate a conversation among social, human and natural scientists in a wide range of internationally recognized research programmes.

The joint doctoral programme has progressively expanded from the European to the international scene (i.e. North and Latin America, Asia). It has also opened to intersectoral collaboration (e.g. Elsevier is one of the strategic partners).

3.8. Experiences from discipline clusters

The **Marie Skłodowska-Curie ITN (Innovative Training Networks)** provides a wealth of examples of good practices to deliver doctoral training with emphasis on triple "i" mobility, transferable and entrepreneurial skills and exposure to employment sectors.

The remaining challenge is how to incorporate the triple "i" aspects in more traditional programmes and how to make them a reality throughout Europe.

3.8.1. Social sciences and Humanities

Interdisciplinary approaches create value, enhance the creativity of the doctoral candidates and discipline integration.

Yet the candidate's first connections remain with his own discipline and he/she faces specific discipline-dependent expectations as to the outcomes of the research. Besides, the largest proportion of research funding is discipline related, despite the policy discourse that interdisciplinary research is needed to "solve the complex problems of society". In addition career progression is related to research performance and publications within specific disciplines. Incentives are lacking for researchers to embrace more holistic interdisciplinary approaches on a much higher scale than is currently the case. Yet interesting examples are emerging of interdisciplinary networks within the social sciences and humanities that stimulate

research across and between several disciplines.

High quality supervision is crucial for the candidates to complete their research within the shorter three-year period required under Marie Curie. Recruiting the right candidates remains the key challenge.

LanPercept[39] – Language and perception

The network involves eight universities, one institution from the private sector and one institution from the industrial sector. The young researchers of the project come from different backgrounds. The project examines the interaction between language and perception. The training is characterized by basic research, applied research and the involvement of the industry and the private sector. Industrial partners offer the researchers secondments and project-specific collaboration and training, supervision and industrial guidance. One of the challenges of the project is related to the recruitment, i.e. to find the right fellow for a project. Another difficulty is that graduates are mostly qualified in only one discipline, which is often the case in traditional university programmes.

ITN CoHaB[40] - Diasporic Constructions of Home and Belonging

The ITN CoHab trains scholars in the field of diaspora studies. It involves five world-leading institutions from different countries and associate partners from the business and cultural sector. The training of the young researchers is interdisciplinary, international and inter-sectoral. It aims to establish the diaspora studies as a transdisciplinary research field (encompassing e.g. sociology, literary and cultural studies, political science, legal studies, anthropology, and human geography) and to strengthen the cooperation of world-leading institutions. A relevant aspect is the practical training. The researchers participate in two secondments – one secondment in an academic institution and one secondment in a non-academic institution of one of the associate partners.
One of the difficulties of the project is to negotiate different discipline–specific requirements, i.e. in relation to content matters and organisational issues. Time-intensive supervision and interdisciplinary prejudices are other challenges which have to be tackled.

EUROTAST[41] - Exploring the History, Archaeology & New Genetics of the Transatlantic Slave Trade

The EUROTAST ITN consists of ten academic partners, one industrial partner and international researchers. It is characterized by an interdisciplinary dimension within the doctoral training. The researchers are from different disciplines such as history, archaeology, social anthropology and population genetics. The interdisciplinarity is a tool to gain new insights in the history and the contemporary legacies of the transatlantic slave trade. Interdisciplinarity also offers the researchers training opportunities in other member institutions and networking opportunities during and after the project. Challenges of the interdisciplinary approach are, amongst others, different datasets, samples and time frames of experiments of the researchers.

3.8.2. Life sciences and Geosciences

All the four cases presented develop a transformational journey for doctoral training around a number of keywords, i.e. interactions, integration and networking.

[39] Language and Perception (LanPercept): https://www.ntnu.edu/lanpercept, (Accessed: June 2015)
[40] Diasporic Constructions of Home and Belonging (ITN CoHaB): http://www.itn-cohab.eu/, (Accessed: June 2015)
[41] Exploring the History, Archaeology & New Genetics of the Transatlantic Slave Trade (EUROTAST): http://eurotast.eu, (Accessed: June 2015)

The **ADVOCATE ITN[42] in Contaminated Land** develops multiple interactions between a wide range of academic and industrial partners. Doctoral candidates learn to speak "the language" of the other sector or the other discipline. The structured and integrated training programme defines what candidates should acquire in terms of knowledge and skills through a range of components delivered across the network.
Networking between fellows in interdisciplinary teams stimulate the acquisition of multidisciplinary skills through fieldwork, study visits (to facilities in other countries), results published in network publications and outreach activities. A whole range of experimental activities are offered such as in **MetTrans**.[43] Several academic and industrial partners are involved in this interdisciplinary project. The young researchers receive training in research and complementary skills. It addresses outstanding issues in the migration of metals in the environment.

Neptune ITN[44] is a multidisciplinary training network. The field of study is the evolution, development, neurobiology and ecology of marine invertebrates. The consortium consists of seven academic institutions and two industrial partners. The training comprises amongst others research, secondments, mentoring, career guidance, and offers the opportunity to acquire complementary skills. The project demonstrates how interdisciplinary is so important in their case since the field of "neurobiology of marine animal models" is so narrow. Only purely basic research is possible with no potential direct applications. Interdisciplinary training in advanced methods in biology, in complementary skills and exposure to non-academic partners will give a wide range of career options for the PhD holders.

This interdisciplinary dimension is also critical in the medical field in the **Mel-Plex ITN.**[45] The training network comprises 10 beneficiaries and 8 partner organisations from different countries. 15 PhD students are doing research in Translational Melanoma Cell Biology and Systems Biology.

The complexity of the disease means that traditional approaches are no longer sufficient. New knowledge needs to be brought in the research through the cooperation with other disciplines. Researchers need to be trained to navigate confidently between clinical, academic and private sector environments (intersectoral exposure). They need to gain interdisciplinary quantitative biomedical skills, computational research approaches, and have developed an innovative and creative mindset to progress research findings towards applications.

3.8.3. Physics and Engineering sciences

Two key words can characterize doctoral training i.e. the need for **flexibility** (research funding instruments in relation to individual circumstances of doctoral candidates, level of knowledge and skills) compared to the requirement for **high quality** and world-class excellence.

[42] Advancing Sustainable *In Situ* Remediation for Contaminaned Land and Groundwater (ADVOCATE): http://www.theadvocateproject.eu, (Accessed: June 2015)
[43] Metal Transport in the Environment (MetTrans): http://www.mettrans-itn.eu/, (Accessed: June 2015)
[44] Multidisciplinary training in evo-devo and neurobiology of marine animal models (Neptune): http://neptune-itn.eu/, (Accessed: June 2015)
[45] Exploiting MELanoma comPLEXity (Mel-Plex)

EDISON[46] **– European Doctorate in Image Sensors and Optical Nanotechnology (with Glasgow and Awaiba)**

The consortium of the European Doctorate EDISON involves the University of Oxford and Awaiba, a Portuguese company which develops CMOS image sensor as well as standard imaging products for the medical, automotive and industrial vision market. Associate partners are the University of Glasgow and NHS Beatson West of Scotland Cancer Centre, which has the largest clinical physics department in the United Kingdom. The young researchers are trained in the art and science of image sensor design and in nanofabrication.

SENSEIVER[47] **- Low-cost and energy-efficient LTCC sensor/IR-UWB transceiver solutions for sustainable healthy environment**

The consortium of this project consists of five academic/research institutions, two industrial partners and three associated partners. It provides training opportunities to young researchers in the field of new sensors, materials, transceivers and data acquisition systems. The training network includes interdisciplinary elements.

ABWET[48] **- Advanced Biological Waste-To-Energy Technologies**

This multidisciplinary and intersectoral ITN was previously an Erasmus Mundus Joint Doctorate. It aims to train environmental scientists and engineers in the field of advanced biological waste-to-energy technologies. Academic partners as well as industrial partners are involved in the project. The beneficiaries of the project are three European universities and the Institute for Water Education UNESCO-IHE. It has 7 academic partner organisations from 4 different countries and 10 non-academic partners from 10 different countries.

LCHPPHENONET[49] **- Advanced Particle Phenomenology in the LHC era**

The consortium of the ITN LCHPPHENONET consists of partners from different areas. 28 European Universities and Research Institutes, as well as the University of Buenos Aires and CERN and three partners from the industrial sector are involved in the project. Researchers are trained in a multidisciplinary environment in the field of particle physics. The students also have the possibility to gain professional experience through a secondment.

[46] European Doctorate in Image Sensors and Optical Nanotechnology (with Glasgow and Awaiba), (EDISON): http://www.eng.ox.ac.uk/edison, (Accessed: June 2015)

[47] Low-cost and energy-efficient LTCC sensor/IR-UWB transceiver solutions for sustainable healthy environment (SENSEIVER): http://www.senseiver.com/, (Accessed: June 2015)

[48] Advanced Biological Waste-To-Energy Technologies (ABWET): http://www.internationaldoctorate.unicas.it/abwet/, (Accessed: June 2015)

[49] Advanced Particle Phenomenology in the LHC era (LCHPPHENONET): http://www.lhcphenonet.eu/, (Accessed: June 2015)

4. CONCLUSIONS

There is a need to **accelerate** the **modernisation of the doctorate.** The doctorate is viewed as a strong mechanism to contribute to the development of the **global knowledge economy,** through the production of new knowledge, with or without direct business application. Yet the current doctorate needs to evolve further.

The **research and researcher** can **make an impact** through the commercialisation of research results, the development of new products and tools, and/or publications to advance knowledge in the field globally.

Delivering interdisciplinarity is a complex task since research funding and outputs tend to remain highly discipline-related. Besides publications are also linked to discipline clusters. Interdisciplinarity requires the delivery of doctoral training in larger and more complex research groups and structures that enable the cross-fertilisation of knowledge across the traditional faculty structure. The existence of such structures enhances the delivery of interdisciplinary programmes.

The modern doctorate must provide a **transformational journey** to the candidate that will enable him to produce **original research** of the highest quality. At the same time he/she should acquire a wide range **of transferable skills** that will make him/her **highly employable** on the labour market, not only in academia but also in a wide range of other types of organisations. The knowledge economy requires **a supply of highly qualified and flexible individuals** with an *entrepreneurial mindset*, capable of dealing with the **complex problems of society** and able *to go beyond current approaches* to propose innovative solutions. The modern doctorate must make ample provision for this.

Research integrity has become of paramount importance in today's research where plagiarism and fraud has been growing to alarming levels and need to be tackled.

From a novice, the doctoral programme transforms the candidate into an expert who can work independently to deliver outputs. The purely lonely individual journey of the doctoral candidate can no longer deliver the broad skills required today from the PhD holder. The doctoral journey must be embedded in a structure with a clear governance model, and in which a **critical mass** can be achieved with opportunities to **share knowledge among peers** and make use of **appropriate infrastructure**.

Doctoral programmes need to **nurture** doctoral candidates, providing **personal guidance**, **advice, training and structured supervision** that will stimulate *curiosity* and *intellectual development*. **Intersectoral approaches** will enhance the doctoral candidates' *access to expertise, opportunities and networks* beyond academia and subsequently their employability in or outside academia.

The **doctoral programmes operating** across sectors (academic and industrial) and geographical (transnational and international) spaces open up wider perspectives for the EU to deliver cutting edge leading research in and beyond the European space, in partnership with leading institutions in other parts of the world, contributing to global growth and innovation. From EU-funded projects these new forms of joint or industrial doctorates need to evolve toward becoming **embedded in the mainstream of the institutions' activities.**

It is difficult to predict the **number of PhDs** that will be needed in the future for the **knowledge economy,** yet some **forecasting** can be made, building on economic scenarios and taking into account local contexts.

Tracking the PhD holders in their career progression also allows to evaluate whether they have the right skills, the impact of support initiatives on graduate career progression and whether these need to be corrected or enhanced further. Tracking at country and institutional level remains a challenge yet it can and should be done.

Doctoral training should reflect the emergence of **Open Science** and prepare the candidates to operate in emerging research environments.

ANNEX 1

EUROPEAN COMMISSION
DIRECTORATE-GENERAL FOR EDUCATION AND CULTURE

Modernisation of Education II: Education policy and programme, Innovation, EIT and MSCA
Innovation in education, EIT and MSCA

Future of the doctorate

Riga, 28-29 May 2015

Programme

Day 1	
9:00 – 10:00	*Registration and welcome coffee*
10:00 – 10:30	Opening session - *Opening speech* – Adam Tyson, European Commission, DG EAC, Modernisation of Education II: Education policy and programme, Innovation, EIT and MSCA, Acting Director - *Opening speech* - Prof. Janis Vetra, Chairman of the Council Of Higher Education, Latvia
10:30 – 12:00	Plenary session Different models of doctoral training across the world Moderator: Adam Tyson, European Commission, DG EAC - Dr Thomas Jørgensen, European University Association, Council for Doctoral Education - Dr Amy Verdun, University of Victoria, Jean Monnet Chair Ad Personam, and the Director of the Jean Monnet Centre of Excellence, Canada - Dr Thomas Auf der Heyde, Department of Science and Technology, South Africa
12.00 – 13:30	*Lunch break*
13:30 – 15:30	Parallel sessions

Session A	Supervision and quality assurance Moderator and introduction: Dr Isolde Von Bülow, Marie Skłodowska-Curie Advisory Group - Dr Leszek Kaczmarek, Nencki Institute of Experimental Biology, Extrabrain ITN - Dr Jeremy Bradshaw, University of Edinburgh, LERU - Dr Lucy Byrnes, Dean of Graduate studies, NUI Galway - Prof. Nadia Thalmann, Multiscale Human ITN Coordinator, Director of MIRALab, University of Geneva and Director of IMI, NTU, Singapore - Dr Francia Kinchington, University of Greenwich
Session B	Intersectoral collaboration in doctoral training Moderator: Kamila Partyka, European Commission, DG EAC - Dr Jan Bouwstra, Senior researcher, FUJIFILM ITN Coordinator - Dr Maurizio Gabbrielli, EIT, ICT lab KICs, University of Bologna - Dr Fanny Guay, R&D Project Manager at DBI, ITN FIRE TOOLS - Prof. Mogens Rysholt Poulsen, Head of Department, DTU Nanotech, Technical University of Denmark
Session C	Employability of doctorate holders Moderator: Audrey Arfi, Research Executive Agency - Dr Janet Metcalfe, VITAE - Dr Birgit Woitech, Doctoral Programmes Management, FWF - the Austrian Science Fund - Dr. T. H. Shubhra Quazi, National Institute of Advanced Industrial Science and Technology (AIST), Japan, MCAA alumnus - Dr Maxime Durka, R&D Manager, Sioen Industries
15:30 – 16:00	*Coffee break*

16:00 – 17:00	Plenary session Moderator: Nadine Burquel, Director, Business School Services Unit, EFMD Rapporteurs' feedback from the parallel sessions
19:00	*Networking reception and dinner*

Day 2	
8:30 - 9:00	*Registration and welcome coffee*
9:00 -10:15	Plenary session "Innovation in doctoral training" Moderator and introduction: Denis Crowley, European Commission, DG EAC *Panelists:* - Prof. Talis Juhna, Vice-Rector for Research of the Riga Technical University - Dr Katrien Maes, KU Leuven, LERU Chief Policy Officer - Wolfgang Müller, Eurodoc Board member - Prof. Melita Kovačević, EUA Council for Doctoral Education - Prof. Susan Wright, Department of Education - Research Programme Education, Policy and Organisation in the Knowledge Economy, University of Aarhus, UNIKE ITN
10.15 -11.00	Plenary session Open Science in doctoral training Moderator and introduction: Irina Reyes, European Commission, DG RTD - Dr Ivo Grigorov, Technical University of Denmark, FOSTER project - Dr Nina Bergman, Kiel University, Projects implementing open science

11:00 – 11:15	*Coffee break*
11:15 - 12:45	Parallel sessions
Session A	Integrating the gender dimension in doctoral training *Moderator*: Dr Hilda Römer Christensen, University of Copenhagen, Member of the Horizon 2020 MSCA and Gender Advisory Groups - Dr Astrid Linder, Swedish National Road and Transport Research Institute, Member of the Gender Advisory Group - Dr Natalia Balcazar, MCAA, Member of the Gender Equality for Mobile Researchers in Science Working Group - Ludovic Garattini, Member of Eurodoc
Session B	Joint doctorates – lessons learnt Moderator: Paul Harris, European Commission, DG EAC - Prof. Mario Telo, ULB, Director of Research of the EUNRAGG/GEM Research Unit at the IEE-UL, Coordinator of EMJD GEM - Prof. Stefania Albonetti, Bologna University, Coordinator of EMJD SINCHEM - Prof. Annamaria Silvana de Rosa, University of Rome Sapienza, Coordinator of So.Re.Com. Joint-IDP ITN
12:45-13:00	Plenary session Moderator: Dr Giovanni Esposito, University of Cassino and Southern Lazio, EMJD and ITN coordinator Rapporteurs' feedback from the parallel sessions
13:00 – 14.00	*Lunch break*
14.00 – 15:30	Parallel sessions
Session A	Social sciences and Humanities Moderator: Kamila Partyka, European Commission, DG EAC - Prof. Mila Vulchanova, Norwegian University of Science and Technology, LANPERCEPT ITN - Prof. Matthew Collins, University of York, EUROTAST ITN

	- Dr Annika Merk, University of Münster, COHAB ITN
Session B	Life sciences and Geosciences Moderator: Audrey Arfi, Research Executive Agency - Dr Steven Thornton, University of Sheffield, ADVOCATE ITN - Dr Donald Porcelli, Oxford University, METTRANS ITN - Dr Andreas Hejnol, University of Bergen, NEPTUNE ITN - Dr Isabela Aparicio Erriu, Royal College of Surgeons Ireland, and Dr Thomas Sauter, University of Luxembourg, MEL-PLEX ITN
Session C	Physics and Engineering sciences Moderator: Alan Craig, Research Executive Agency - Dr Choubey Bhaskar, University of Oxford, EDISON GA ITN - Dr Goran Stojanovic, University of Novi Sad, SENSEIVER ITN - Dr Giovanni Esposito, University of Cassino and Southern Lazio, ABWET ITN - Dr. Germán Rodrigo, Instituto de Física Corpuscular IFIC, Consejo Superior de Investigaciones Científicas CSIC, LHCPHENONET ITN
15:30-16:00	*Coffee break*
16:00-17:00	Closing session Rapporteurs' feedback from the parallel sessions *Closing remarks:* Nadine Burquel, Director, Business School Services Unit, EFMD Denis Crowley, European Commission, DG EAC, Head of Unit Innovation in education, EIT and MSCA
17:00	*Networking reception*