

Topic 4: Global Labour Market developments (economic dimension)

Forces and Forms of Doctoral Education 2019 Conference

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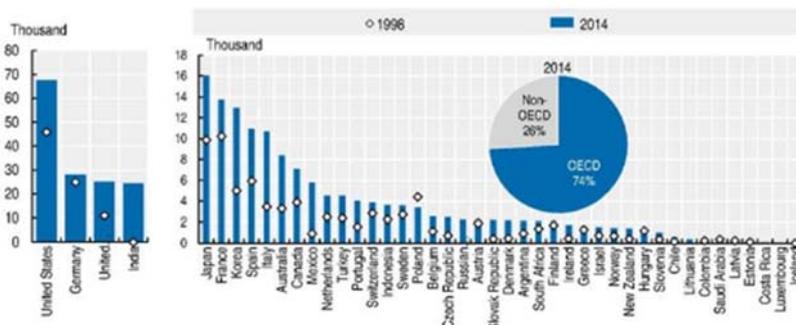
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Global labour market developments (economic dimension)

- Skills development: Which might be common doctoral skills? How do we ensure doctoral graduates are 'fit for purpose' for the global labour market for researchers in and beyond academia? In what way could new developments such as open science and interdisciplinarity be integrated in doctoral education curricula?
- Professional doctorates: To what extent has the 'explosion' of professional doctorates changed the nature of the doctorate? Where are the limits of doctoral education, i.e. when is a doctorate no longer a doctorate?
- Careers of doctorate holders: What do we know of doctorate holders' careers? How could knowledge of their trajectories be used for planning doctoral education policies and programmes?

1. Introduction

Numbers of doctoral graduates have swelled in recent years, particularly in the developed world (Fig 1 from OECD(2016)). There has been a considerable increase in funds for doctoral study, particularly in STEM subjects. Many Governments aim to increase the numbers of researchers as a means of driving innovation leading to greater social and economic development and greater prosperity. There seems to be no shortage of talented candidates keen to undertake a doctorate although the SERU survey shows a decrease in the USA in the share of graduates from R1 universities (doctoral universities with very high research activity) who would like to obtain a doctorate degree. There is a need also to train researchers to reach out to society and involve all in co-creating their research questions and projects. Undoubtedly this wider role of doctoral education has led to some challenges.



Note: World estimates include countries for which data are available, i.e. 35 OECD countries, Argentina, Colombia, Costa Rica, India, Kazakhstan, the Russian Federation, Saudi Arabia and South Africa. Mexican value for 1996 corresponds to 1999 value.

Source: Based on OECD (2016c), Education At a Glance 2016, OECD Indicators, <http://dx.doi.org/10.1787/eag-2016-en>.

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An important change needed is to clarify the mind set of candidates and employers to see doctoral graduates as drivers of innovation, rather than just their traditional role as a pipeline to academic careers:

EU Commission, THE ECONOMIC RATIONALE FOR PUBLIC R&I FUNDING AND ITS IMPACT. Policy Brief Series. March 2017: “One of the elements that directly channels into economic growth is the skills development by training researchers. It is a crucial mechanism for the transfer of knowledge from public research to companies, especially when this knowledge is embodied in the researcher that carries out the specific research. More precisely, one of the wider economic benefits from publicly-funded basic research is associated with scientists' migration into the commercial sector of the innovation system. The benefits are notably associated, not only with applying the latest theoretical knowledge accruing from scientific research, but rather, scientists transfer elements of problem-solving strategies that are fundamental in basic research (Meyer-Krahmer and Schmooch (1998), Pavitt (1998), Salter and Martin (2001) or Georghiou (2015) Zellner, 2003). “

This has been happening in some countries for many years but not so in others and even where it has the perception of some employers has not necessarily changed.

While budgets have increased in many countries, with this comes higher expectations and a greater scrutiny from the funders and from society more generally. With this can also come greater volatility of funding as money is more closely tied to targets and expected outcomes. Funds can also be varied to achieve more explicitly political wishes which may not align with the primary purpose of doctoral education. The more we can explicitly highlight and demonstrate the value of doctoral education and the role graduates play the more likely there will be secure and stable funding.

Political developments around the world are resulting in rejection of evidenced based policy which seems to indicate a need for more and better trained researchers to assemble and critique the evidence. However the reputation of doctoral study has been tarnished in some countries where there is evidence that doctoral degrees can be bought. In Russia for example there is evidence of plagiarism but without resulting in any action. It is unclear how widespread this is around the globe but clearly it has the potential to damage the reputation of all doctorates

In this chapter we explore trends in the global labour market for doctoral graduates. There have been significant changes in doctoral education in preparing candidates for a wider range of careers. But are these the right changes and is it sufficient? What should the distinct skillset be for doctoral graduates so that they may fulfil this role? And is the skillset the same across the developed and developing world? Are there new forms of doctoral education that might supplement and enhance graduates in this role? Should this be distinct from the historic PhD leading to an academic career? How can we better persuade society and employers especially small employers of the value of doctoral education?

Following a brief literature survey, this chapter explores developments in the labour market and its implications, consideration of the skillset that should be developed, the potential role of professional doctorates, and a discussion of the environment that is conducive to high quality doctoral education.

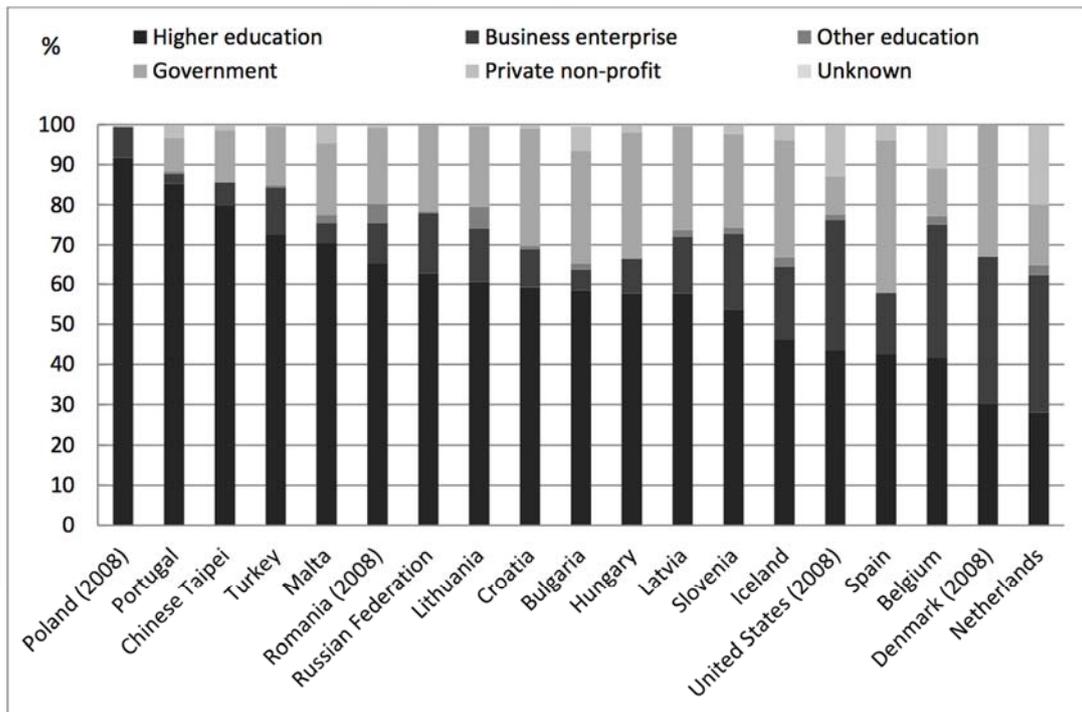
2. Labour Market Trends.

The career outcomes of PhDs across multiple countries have notably been documented through a joint data collection initiative in 2010 by the OECD, the UNESCO Institute for Statistics and Eurostat. The data from Careers of Doctorate Holders (CDH) spans 25 countries and references 2008/2009 survey data. The CDH includes countries, such as Belgium, Bulgaria, Croatia, Denmark, Finland, Germany, Hungary, Israel, Latvia, Lithuania, Malta, the United States, and Turkey. Auriol, Misu, and Freeman (2013) analysed the labour market outcomes of doctorate holders using CDH. Overall, they found that employment rates continue to be high among doctorates, and that PhD holders experience a labor market premium compared to others with high qualifications. Consistent with previous trends, PhDs tend to work in the academic/education sector, although there is evidence of employment in other sectors. Following higher education, the second most prevalent employment sector is business or government. Fig. 2 below summarizes the labour market outcomes of PhDs across different countries, highlighting that the majority of PhDs work in higher education (Auriol, Misu & Freeman, 2013, p.19).

Temporary positions (postdoctoral positions) at academic institutions are becoming more prevalent worldwide, particularly in Portugal, Germany, and the Netherlands. PhDs who graduated within five years of the survey were more likely to hold temporary contracts compared to those who graduated more than five years from the survey. Across the CDH countries, over 50% of PhDs are in research-related positions. Portugal and Poland, in particular, have higher proportions of their PhDs working in research. As can be expected, the job market outcomes vary by PhD discipline. Whereas PhDs in the sciences and engineering are more likely to hold research-related occupations, PhDs in the social sciences are less likely to do so. However, the work activities of those holding non-research occupations are still generally related to their doctoral education.

In the United States, as well as many countries around the world, little is known regarding long-term career trajectories and outcomes of PhD holders. The limited knowledge in the longitudinal career trajectories of PhDs stems from challenges associated with uniform and longitudinal data collection (i.e. difficulty and costs with tracking individuals over time), as well as changes in workforce norms where careers are now less likely to progress linearly and where employment in foreign countries is increasingly becoming more common. However, there are several ongoing efforts to collect longitudinal data in the United States—the Council of Graduate Schools is administering surveys across institutions, the American Association of Universities Data Exchange encourages the use of a common set of questions, and the National Science Foundation has revised the Survey of Earned Doctorates to collect longitudinal data from PhD holders. While many of these efforts are still ongoing, several longitudinal studies have been completed by the Centre for Research and Innovation in Graduate Education (CIRGE) (e.g., Nerad & Cerny, 1999; Nerad, et al., 2007, Nerad, 2009), the Andrew W. Mellon Foundation (Ehrenberg, et al., 2010; Main, Prenovitz & Ehrenberg, 2019), and the Wisconsin Centre for Education Research (e.g., Connolly, 2016).

Figure 11. Doctorate holders, by sector of employment, 2009
As a percentage of employed doctorate holders



Notes:

- *Data for Belgium, Hungary, the Netherlands and Spain refer to graduation years 1990 onwards.
- *For the Russian Federation, data relate only to those doctoral graduates employed as researchers and teachers.
- *For Spain, there is limited coverage of doctorate holders for the years 2007 to 2009.
- *Data for Turkey exclude foreign citizens.
- *Data for the United States exclude doctorate holders who received degree abroad and who received a doctorate in humanities.

Source: OECD, based on OECD/UNESCO Institute for Statistics/Eurostat data collection on careers of doctorate holders 2010.

Fig. 2. Doctorate holders by sector of employment (2009) from OECD (Auriol, Misu & Freeman, 2013, p.19).

3. The doctorate for the labour markets within and beyond academia

In the previous section we outlined some of the literature and data that has been published about global labour market trends. Some people and institutions still consider that the main destination of PhD graduates is an academic career while many do not in fact pursue this path on completing their doctorate. In the UK around 50% take up jobs beyond academia immediately after their doctorate [VITAEWhatdoPhDs], in Germany the figure is 65%, in Austria 80% [OECD2], and in France 37% but after 5 years only 53% remain in academic research [ADOC]. In the USA the NSF reports that around 50% of their scholars stay in academia on graduation from 1996-2011 and in 2016 it dropped to 44%. The Royal Society reported in 2010 that in the U.K. only 3.5% of PhD graduates end up in permanent academic positions [RoySoc]. Even from the prestigious Marie Skłodowska Curie scheme around 30% end up in permanent academic employment. However comprehensive data collection is not done in most countries or if they do it is often only a few months after graduation which is not representative.

NSF undertakes regular surveys of graduate destinations of doctoral recipients in the USA [Nsf.gov, 2019]. Around 70 US Universities track career pathways of most of

their doctoral alumni. Some preliminary data is available. The Council for Graduate Schools is encouraging more programmes to increase awareness and exposure to career paths beyond academia. They are considering the effects of partnering with industry and particularly exploring early career industry experiences in engineering. In contrast to other programmes engineering doctoral graduates do mostly go to industry. However there are significant differences in outcomes across different institutions depending particularly on the research ranking of University. New work recently commissioned is studying the profiles of PhD graduates who end up in leadership positions in academia and industry and how their preparation helped their career progress. CIRGE has data for the Social Sciences in the USA (<https://www.education.uw.edu/cirge/phd-career-path-tracking/>).

The decline in the number of permanent academic positions per researcher at universities and increasing dependency of researchers on temporary and short-term, third-party funding is well documented (<https://www.nature.com/articles/d41586-019-00219-5>), job insecurity (<https://artemiosv.info/permadocs-illusion-eternity/>), the 'lost generation' of postdocs (<https://www.nature.com/articles/d41586-018-05745-2>)), with a growing number of postdocs and few places in academia (<https://www.nature.com/news/the-future-of-the-postdoc-1.17253>). This means that early career researchers are confronted with a limited number of job opportunities in academia, while indeed the number of doctoral candidates and postdoctoral researchers is steadily increasing (<http://www.esf.org/blog/post/the-post-doc-problem/>) job insecurity, continuous temporary contracts on third party funding (<https://artemiosv.info/permadocs-illusion-eternity/>) and a 'lost generation of postdocs' (<https://www.nature.com/articles/d41586-018-05745-2>).

The recent EURODOC-MCAA declaration on sustainable careers strongly recommends more systematic career tracking [EurodocDeclaration]. In the USA, with recent recruit from the UK, the Next Generation Life Sciences Coalition (<https://nglscoalition.org/>) commits its members to tracking career destinations of both PhD graduates and postdocs. The problems are well documented by Daniels et al. [NextGenLS] 1.88 million researchers were employed in the EU28 (2016,

https://ec.europa.eu/eurostat/statistics-explained/index.php/R_%26_D_personnel). The site contains the data comparing business, higher education, government.

In Europe Universities are less well developed in their doctoral alumni tracking. The MORE3 study on researchers' mobility and careers provides data and with continuing follow up studies planned (<https://www.more3.eu/indicator-tool/>). The European Commission has collected data for its Marie Skłodowska Curie Association MSCA Fellows [MSCAEval]. The drive in the EU has been to encourage careers beyond academia in order to help drive innovation in the economy. The EU continues to track labour force numbers (see Eurostat https://ec.europa.eu/eurostat/statistics-explained/index.php/R_%26_D_personnel). The extent to which this does improve competitiveness is an open question. In the UK VITAE has produced a number of reports in a series 'What do PhDs do' [VITAEWhatdoPhDs]. In Italy the AlmaLaurea IV Indagine (2019) (*Condizione occupazionale dei Dottori di ricerca - Employment status of doctoral graduates* [AlmaLaureaInvestigation1, AlmaLaureaInvestigation2]) carried out on 5.500 PhD

doctors who in 2017 obtained the PhD degree in one of the 32 Italian Universities who are members of the consortium Alma Laurea and who have been contacted in 2018 one year after the PhD graduation. The survey on the employment status of doctoral graduates, started in 2008 on an experimental basis has been definitively up and running since 2015. The 2019 Survey returns a broad and detailed photo of the type of work carried out, the profession, the remuneration of employees and their satisfaction with the work carried out, on the branch and sector in which they work, on the use of skills in the work performed acquired at university. There is a need to collect this data and to maintain national/European/Global databases for reliable data. A recent study has also explored Academic Pathways Across Europe [APAC]. APAC is an online platform aimed to facilitate academic recruitments across countries and to help academics willing to move between institutions and academic systems. There may be lessons to be learned from the more extensive experience in the USA.

There is less information about doctoral destinations in the developing world where such tracking is even less well developed. In developing countries most are preparing their doctoral graduates for academic teaching careers because of a shortage of research skills in Universities. In Brazil the evaluation of doctoral programmes by funding agencies tracks outcomes of the programmes they fund. CAPES has destination information which confirms that very few go to the private sector. Mexico currently directs its system to develop candidates for faculty careers (either to continue as professors or to become new professors) but less well for other careers (i.e., industry, private sector). Many developing countries are growing and strengthening their Higher Education provision and so are in need of more recruits with research training for academic positions. This is very much in contrast to the developed world where academic recruitment is static and in some cases decreasing due to shrinking undergraduate cohorts, the removal of the compulsory retirement age and an increase in the use of adjuncts and temporary academic contracts.

It is common in the Natural and Life Sciences for researchers to undertake several postdoctoral posts before they obtain a permanent or tenured academic position (and increasingly even for even temporary positions). Main is researching the effect of the increasing need for postdoctoral experience for engineering academic positions, which was not so much the case in the past, and considering the opportunity cost of this trend. There is also a trend in the USA to encourage industry professionals to come back to academia. This requires education of search committees about the very different nature of publication records. In many European countries (notably Germany) recruitment from industry to academic engineering positions is common. However increasing emphasis on research performance is reducing this trend, most notably in the UK where research evaluation (Research Excellence Framework) discourages recruitment of practitioners to permanent academic posts.

The global market is increasingly structured into two levels: a 'top' tier which is international with a larger sector which is predominantly national. The gradSERU survey [SERU] tells us that students generally rank the quality and quantity of information about career opportunities outside universities as poor.

The data that is collected generally includes people coming from abroad for doctorates but there are many problems with the data. It is often far from comprehensive and the data is often collected too soon after graduation which leads to misleading conclusions about longer term trends. It is not clear how best to capture data on labour market outcomes since it is now very international. Better data will give insights into benefits which will give traction.

In order to persuade Governments to collect the data the sector needs a more compelling case for the need. Why should governments collect the data? Given the increasing emphasis on innovation and the role that doctoral graduates should have it will be useful to collect the data in order to guide investment in research talent to determine how to optimise its effect on competitiveness. However a stronger case needs to be made to ensure resources are available for this. Of course it is also important for Universities and their planning processes and to keep in close contact with alumni for fundraising and seeking their in kind support for career education. It is often thought that doctoral alumni are typically not so generous so they less of a focus for alumni offices but recent evidence in the USA shows that this is not the case and they are just as generous. There may be lessons from USA. A key issue is the need for longer term longitudinal surveys in order to really track their experience. Who might do this? Universities must have a stake but is it adequate for a country to rely on this with the inevitable heterogeneity in coverage, quality and detail that this would bring?

Finally, our current understanding of careers is based on the current economic system but this is changing. Long term stable career trajectories are probably not the future – what is the future of work within and beyond academia? Do we adequately prepare doctoral graduates who will primarily be involved in teaching with limited research opportunities? Will instability be the norm? Many doctoral graduates in fact value flexibility. Many are looking for stability and clarity about where the future is leading them. Graduate aspirations are mixed.

4. Skills Development for the doctoral labour market across the world

A doctoral programme's unique point is to develop 'creative critical autonomous intellectual risk takers' [LERU 2010]. The unique element of a doctorate is to develop original independent thinking in the candidate and this is the main criterion by which most thesis defences are judged – on the basis of the candidate and their ideas as evidenced by the defence, the thesis and in some cases publications.

It is also important that candidates understand the uncertainty inherent in research projects and that they are encouraged to take intellectual risks as part of their journey to finding an original contribution. This element of risk taking is vital for training the thinkers and researchers for future unknown significant challenges facing the world but is perhaps the element that has been reduced as there is a feeling that it is less risky to opt for intellectually safer projects. However this is also true of many parts of the research world where the intense competition for funds and the tightening of peer review and expectations of guaranteed outcomes have resulted in

safer projects. It is vital that the PhD retains this element of intellectual risk taking. In the European Research Council (ERC) Qualitative Evaluation in May 2018 found “A strong positive correlation was found between the high-risk/high-gain feature and the overall grade of projects. The evaluation concluded that only 10% of the projects were not considered originally high-risk/high-gain. These results support the ERC policy of funding high-risk/high-gain research.”

With this comes a set of skills that are of value in academic research jobs, also in research jobs beyond academia, but also all jobs which require creative thought based on careful and rigorous analysis of conflicting evidence. A list of skills developed during a doctorate is given in the appendix. These skills are developed largely through undertaking supervised research while being supported and supplemented by formal training. A key skill for researchers is embracing uncertainty. For whatever future role it is important to help graduates articulate this unique skill set to potential employers. Doctoral graduates must take responsibility for choosing and developing their skills, with support from their advisors, and be able to articulate their particular strengths and experience. Universities too need to articulate more strongly and widely the skills that researchers develop through their training and research. Universities are not getting this message out clearly enough.

While once a candidate would rely on their supervisor/advisor for all their training, this greater focus on the skills, which they develop both for the undertaking of their project but also for future careers, has led to the development of frameworks and to training programmes provided by Universities and collaborating institutions and companies.

Researchers Career Development (RCD) needs to tackle many aspects: identifying researchers and employers needs in order to train researchers accordingly, raising awareness among the different stakeholders, providing with the necessary frameworks to facilitate joint efforts towards better trained researchers, agreeing on the responsibilities, etc. The EC’s research portal EURAXESS provides a career development and career orientation tool to help guide skills development and competence profiles for PhDs <https://euraxess.ec.europa.eu/career-development>. The EURAXESS initiative is currently exploring how the network can support career development at different levels through different EURAXESS projects. The first results include a set of recommendations for different stakeholders on how to foster RCD, some case studies where different European institutions share their approaches to RCD, and a few tips on how to measure the impact of the RCD strategies. The UK community, co-ordinated by VITAE, developed a researcher skills taxonomy called the Researcher Development Framework [RDF]. These skills are needed in all parts of the world although each individual may seek to develop particular strengths according to their needs and aspirations.

When few doctorates were sought and awarded most focused on topics without much external scrutiny. With the significant increases in investment there is now a greater emphasis on providing skills for the economy (often still with complete freedom with regards to the topic but where funds are provided by Government Agencies there is more prescription of the scope of the project even if not the specifics). Modern economies are seeking intellectual leadership and risk taking

together with people who can drive the topics and agendas that this leadership indicates and justifies. The precise need for such skills will of course be context dependent, depending on discipline and country needs. It is recognised that R&D spending drives innovation but labour markets are not static and it is important to create dynamism in the economy rather than just more research jobs.

There are some new skills that we particularly wish to highlight that are vital for doctoral graduates to take their place in the workforce within or beyond academia.

While once the doctorate was very much an isolated experience, it is important for researchers inside and beyond academia to know how to collaborate – it is widely recognised that in future discoveries are unlikely to come in isolation. This applies just as much in academia as beyond – in making progress on society's grand challenges, in working together in collegiate environments, and in developing and delivering new curricula and new teaching methods which rely increasingly on problem solving approaches and 'flipped' classrooms.

A new set of skills that is becoming prominent is in the use and manipulation of data, and in understanding the complexities and weaknesses of sophisticated algorithms. Once the preserve of science and engineering it is becoming clear that all researchers, and indeed professionals, whatever their disciplinary background will require these skills. The recent U.S. National Academies report [NatAcadskills] lays out some of the additional data skills doctoral students will need. This is now being explored at UG level and will result in major changes to education. New PhDs programmes and their formal training programmes will need to place much more emphasis on programming skills, regardless of discipline. It is increasingly vital that PhD candidates in all disciplines have the capacity to work with big datasets. 'Systems thinking' – the ability to understand and analyse whole systems and the way they interact - is an important element.

Communication to the wider world has become increasingly important for academic researchers as they fight for profile and impact especially internationally. Since talent is increasingly mobile it is important to at least allow for but also understand different cultures and ways of working. The researchers need to be able to translate research ideas and outcomes into a broader context and explain context. Also important is social media as a platform, particularly given the high levels of misinformation bred by its immediacy. Many doctoral candidates are more skilled in social media than their advisors.

To make the most of their skills and to demonstrate their unique skillset, doctoral candidates will need to work in an environment where there is less distinction between inside and outside Universities. Although not all doctoral candidates should necessarily be expected to reach out to all three of industry, schools and society, in Europe outreach by doctoral candidates is considered to be a 'horizontal duty' of all as part of Responsible Research & Innovation <https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation>. This is as part of the general Commission Open Science policy <https://ec.europa.eu/research/openscience/index.cfm?pg=home>. Increasingly there are links with schools but most institutions lack sufficient time and resources to reach

out very far, geographically or in terms of numbers. Bringing the excitement of new discoveries to schoolchildren and teachers, perhaps via appropriate 'low budget publications' as well as through direct contact helps raise the credibility and recognition of research and researchers. But what skills are needed for this and are they being developed routinely? For this candidates would need to be able to translate concepts and practices into language that very young people can understand. Bringing researchers into contact with the places with poverty, crime etc. will help to educate, reduce mis-information, and break down barriers that lead to social dislocation. Breaking out of the poverty cycle is very difficult. Citizen Science, where researchers engage with society in co-creation of research and its execution, will require a new set of skills. Should public service should be part of the doctoral degree requirements?

Open Science (sometimes known as Open Scholarship) is changing the landscape within Europe and beyond through supporting open access and open data for greater openness and transparency of published results, The Recommendation on access to and preservation of scientific information <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32018H0790> (April 2018), reflects developments in areas such as research data management (FAIR data), Text and Data Mining (TDM) and technical standards that enable re-use incentive schemes. It reflects ongoing developments at the EU level of the European Open Science Cloud, and the increased capacity of data analytics of today and its role in research. Importantly, the recommendation also clearly identifies as two separate points the issue of reward systems for researchers to share data and commit to other open science practices on the one hand, and skills and competences of researchers and staff from research institutions. The development of Open Scholarship, necessary to demonstrate transparency in research and to help enhance trust in the research world, will require training a new range of programming skills, data archiving, and data management skills. What is the role of institutional support for Open Scholarship? This is being debated around the world [ECOpenSci, LERUOpen].

We aim to train our researchers to be original, to be able to support and defend their original ideas and also to use these ideas to drive innovation. Innovation is a key part of enhancing prosperity in modern developed societies. Extremely rapid development of automation will see changes made that result in much quicker innovation cycles. So what is the difference between research and innovation? Innovation ('the application of better solutions that meet new requirements, unarticulated needs, or existing market or social needs') requires taking ideas into practice for the benefit of society. Is it easier to advance someone else's research question as opposed to come up with a research question that has not been addressed before? What are the skills required to take one's ideas forward as opposed to ideas of others and are they different? We need to try to instil all these in our 'researchers as innovators'. Not all will succeed. On top of this there is an increasing need to develop entrepreneurial and business skills that support innovation. Programmes funded through the European Institute of Technology (EIT) particularly emphasise entrepreneurship and innovation skills (<https://eit.europa.eu/our-activities/education/skills-future-initiative>).

Many of these ideas are being adopted in the developing world. Many developing countries need to think more of developing the skills in their researchers to help improve their economies and social conditions. However it is an open question as to whether the skill sets are the same in different stages of development. Currently countries don't measure the extent to which skills are developed and do not have the instruments to measure and benchmark skills development. Interdisciplinarity is also a major challenge for many developing countries especially when disciplines are not strong.

Research 'talent' mostly wishes to be allowed to work independently with greater international mobility. There is a recognition of the key role of public funding in driving innovative practices in academia which is mostly rather conservative. Innovation within the academy is largely driven by major funding schemes eg NSF, the MSCA (Marie Skłodowska-Curie Actions) programme, German Excellence Initiative, other national programmes in the EU. MSCA through its bottom up approach contributes towards tackling societal challenges: 63% of the budget was awarded to sustainable development, 23% to climate change and 6% to biodiversity. [MSCAEval]. There is strong evidence that MSCA fellows are producing excellent research and indeed in many cases are outperforming other established researchers in their field. The features that differentiate specific Universities as being more successful in their social mission is the existence of offices which encourage outreach, Knowledge Transfer, and innovation. This should also include Arts & Humanities and Social Science research and innovative ideas although this is rarer. In general we are seeing a mixed situation – innovation is in some cases coming from within Universities often from young researchers. Since they embody the future and have so much at stake how best should we empower ECRs?

Given these changes to the system and the extra requirements of doctoral candidates are we expecting too much? Given the pressure to deliver a successful doctoral project outcome and the uncertainty that underpins this we can only expect introductions to some of these skills while a few are taken to a more sophisticated level. We need to consider more clearly what skills should specifically be taken to a higher level at a postdoctoral stage so that this clearly adds to the training and employment prospects of an early career researcher. Given that many postdoctoral researchers also will not pursue academic careers it is important that this stage clearly adds new skills that will be useful in the workplace, in academia and beyond (<http://blogs.nature.com/naturejobs/2018/06/27/how-could-universities-and-funders-improve-the-situation-for-postdoctoral-scientists/#/>). The recent EURODOC-MCAA Declaration on Sustainable Research Careers (<https://zenodo.org/record/3082245#.XRzDe0xuKUm>) shows that researchers are increasingly vocal on the need for change. A postdoctoral stage that only gives narrow technical skills and some papers will increasingly be seen as pointless for those not seeking an academic career. This would be damaging to a research system that relies on postdoctoral researchers for delivery of research programmes. Communicating about the competences and transferable skills of the researchers to future employers is crucial. Equally important is to do this in the language and terminology of the future employers. Several universities are collaborating with HR staff from companies and other non-academic sector entities to develop competence profiles for their young researchers as part of their career guidance.

It is more difficult to promote change in political systems which are regulated more centrally particularly where we seek to obtain a meaningful and flexible skills development and disciplinary development with cross-disciplinary work. Where regulation is light and institutional autonomy strong some confident institutions can lead.

5. The potential of professional and industrial doctorates

Professional Doctorates are typically three year (full time or equivalent duration part time) doctorates with some advanced courses, a portfolio on introducing new practices in a professional environment, and a research project (much shorter than the PhD) anchored in professional practice. They are growing in certain areas where the doctorate can be done while in professional practice. They still follow doctoral principles of originality and rigour but are clearly linked to professional practice. All in the US are in health related disciplines which can lead to a professional license. In Europe most common are Education, Clinical Psychology and other health related disciplines with growing interest in the Doctor of Business Administration. Developments in the EU for industrial doctorates have been particularly driven by Denmark. Professional Doctorates are very new in Brazil with certification through CAPES only allowed last year.

There are a number of benefits with professional doctorates: that candidates can do it more easily alongside an active job, the research is more directly driven by societal needs, and typically they are shorter with a more defined timescale. There is a risk of expectation management – that employers expect the same as a PhD which it is not - and a need to prevent inflation of titles. Universities are the custodians of quality of all degrees and need to be clear about the expected outcomes to potential and current employers. They could be seen as a way of extending links with society. There is a desire for real relevance in research degrees but with high standards.

Professional doctorate candidates are often practitioners with significant administrative workloads. Perhaps the aim of these awards is not necessarily for the pursuit of knowledge but rather for advancement in professional, and in some cases managerial, roles. In the USA they are expensive for students as often there is no institutional or federal financial aid and students invest in these costs almost always directly out of pocket. In the UK some clinical doctorates are funded by the National Health Service as part of professional development, for example in Clinical Psychology. Mostly professional doctorate candidates come with more professional experience than those directly from Masters programmes and PhD applicants. They tend to be older and come with years of work experience, a greater level of skills development, although not necessarily of research skills, so the programmes are inevitably of a different nature.

There has long been a tradition of 'industrial' doctorates but these are typically a PhD but undertaken within an industrial context but judged in the same way as a traditional PhD. They are done in Denmark, UK, France and Germany. 62% of MSCA fellows benefit from some form of cross-sectoral mobility or exposure of benefit to their research or their career development largely through secondments and research staff exchanges outside academia. Industry is increasingly interested because of a desire to increase research and links with Universities to help keep

ahead of competitors. The objective of the MSCA European Industrial Doctorates is to involve the non-academic sector in doctoral training, especially enterprises. European Industrial Doctorates help PhD candidates step outside academia and develop skills in industry and business. This type of network is provided by at least one academic partner and partners from the business world. Individuals are enrolled in a doctoral programme at the academic partner and are jointly supervised by the academic and non-academic partners. The EC reviewed their European Industrial Doctorates scheme finding that 1. The scheme helps develop new and strengthen existing intersectoral collaborations, 2. the quality of applications was commended resulting in a larger talent pool, and 3. those interested in industrial careers from the start reported that the EID fellowship helped strengthen their career prospects [ECIndDoc]

In these doctorates it is recognised that there can be a danger of too much direction by a company which is inimical to the PhD which must allow the candidate to drive the research and to develop and prove their own ideas. Universities are the custodians of the standards of their doctoral degrees so most are conscious of this tension. Regulators licence Universities to award degrees and they cannot be awarded by industry or by research organisations (such as the Max Planck Society and CNRS). In Brazil the Institute for Pure and Applied Maths can grant doctoral titles but this is a rare exception.

The differences between PhDs, industrial doctorates and professional doctorates need to be articulated more clearly and with clear statements about quality of output standards. Perhaps Professional Doctorate programmes with their shorter research period could provide a more cost effective – in both financial and time spent by candidates – way of encouraging research informed practice and innovation? We must ensure that the output standards are still at doctoral level which some question.

6. Features of research environments to enhance the employability of doctoral graduates

The insertion into a strong environment is recognised as the most important factor in ensuring high quality doctoral education [ECCharter, EUAQuality, LERUQuality] The mechanisms for ensuring strong research environments vary greatly across the world with funding, assessment, regulation, and quality assurance regimes all playing a part. The growth of new systems, particularly in the developing world continues to be a challenge. LERU's report on 'Maintaining a Quality Culture of Doctoral Education' gives four necessary components: clear stated expectations, scrutiny processes involving independent experts, measurements to inform the scrutiny, and feedback and enhancement to improve the culture. Data on career destinations of doctoral graduates should also be part of the assessment of research organisations.

While measurements can help, judgement by experts is required since there are no absolute measurements that guarantee quality. [ECImpact]. All agree that critical mass of researchers is an important characteristic. However it is generally agreed that there is no standard answer for 'critical mass' with specific numerical targets being unhelpful. The European Commission reviewed this issue but found that 'it

depends' – on discipline, location, collaboration and effectiveness. The EC's U-Multirank is a multidimensional, user-driven approach to international ranking of higher education institutions. It compares the performances of higher education institutions in the five dimensions of university activity: (1) teaching and learning, (2) research, (3) knowledge transfer, (4) international orientation and (5) regional engagement. The U-Multirank web tool enables comparisons at the level of the university as a whole and at the level of specific study programmes. Based on empirical data, U-Multirank compares institutions with similar institutional profiles ('like-with-like') and allows users to develop their own personalised rankings by selecting indicators in terms of their own preferences.

Structured programmes have developed over recent years. While there are many models of such programmes they all aim to embed doctoral training into a cohort experience with some element of formal programmes while retaining the primacy of the individual original research project. The benefits of structured PhD programmes have been highlighted by many [EUA structured, Eurodoc Structured] resulting in changes in funding schemes such as the Centres for Doctoral Training in the UK and the Ecole Universitaire de Recherche doctoral programmes in France. It is encouraging many Universities to move towards bringing all students into cohorts at least at the beginning of their programme to aid orientation and induction and also to alleviate the danger of isolation which is a well known concern for many doctoral candidates.

The measurement and maintenance of quality is a particular challenge for the developing world. Collaboration with other institutions with more developed research environment and culture can help develop critical mass. Given the importance for many countries in training researchers for academia collaboration would be very beneficial. However this would also help with the enhanced mission of training for innovation in their economies. Doctoral programmes aim to push candidates outside their comfort zone which is an important experience as part of developing high level research skills for future careers and for driving innovation and change based on rigorous research. It is recognised that doctoral education enhances status and prestige - even in the US where many do not grant doctoral degrees most do aspire to do so. The Liberal Arts Colleges have faculty engaged in research although few grant doctoral titles. Are the research quality assessment systems, many of which are controversial, the right way to assess in the developing world where doctoral education is more recent?

There is significant pressure in the USA for Universities to innovate – largely because it is recognised that academic careers need to change. This is different in the developing world where there is a strong need for more PhD prepared Faculty. However the drive to push up standards is also important in the developing world.

Are there specific needs associated with particular levels of a country's development and its trajectory and aspirations? There is a strong view that preparations for the developing world should be the same level as in the developed world – currently developing countries gain a lot from researchers who return from undertaking research training in the developed world. It is crucial that they are trained to be

creative in research – but also creative as to how to develop relationships with colleagues and collaborators in other Universities and in companies and ministries. The training, as at all levels, must teach people to learn. We should not create different qualities in the developing world.

Rather than expand a research system quickly, it would seem prudent to first develop the research system in some institutions rather than open doctoral training to all from the start. However this can be difficult in centralized systems. It takes significant resources to establish doctoral programmes. Developing countries hence need to develop research excellence in a few places first. Establishing critical mass also enables dynamism and flexibility in each candidate's formative years. They may change their mind about their research interests and when there is a critical mass there may be other professors willing to serve as thesis advisors or committee chairs allowing a candidate to really develop their own specific interests. Should all Universities should aspire to having doctoral programmes in active research areas?

Since research is international, mobility it is important to train researchers to be comfortable to move beyond national borders. The MSCA programme has been particularly successful in this regard. It is also seen as a vehicle for breaking down cultural barriers in Europe and beyond and enhancing European integration.

As highlighted above intersectoral mobility is also important. In Europe the majority of EU Member States do not have a dedicated national funding system to support this although a number do have national public or private funding sources to support intersectoral mobility within the country [ECIntersectoral]. European level funding is the only financing source for schemes which combine intersectoral and international mobility. The EC report found a strong demand for PhD and post-doctoral researchers among industry, especially STEM subjects and a stronger demand for researchers in non-STEM subjects, social sciences, arts and humanities in public and third sector. However there are proportionately more schemes targeted at industry than at the public sector and third sector. There is a higher level of awareness among larger firms than SMEs about the benefits of engaging with PhD and post-doctoral researchers. The study also found a lack of interest among researchers in developing a career outside of the academic setting which increases the need to raise awareness amongst researchers in academia to open their horizons to careers beyond academia.

If research and research training aims to help society tackle its grand challenges operations should be based on collaboration rather than competition. There will inevitably be an element of competition but this should not hinder appropriate collaboration. Research has become more competitive in recent decades which has decreased some willingness to co-operate. Our research training environments should be promoting collaborating mindsets and highlight mechanisms to help alleviate the damaging effects of competition. The Russian system for example lacks competition and yet this does not enhance collaboration either. The grant system and peer review are not well developed so there is no place to compete and learn from success, failure and feedback. Collaboration is needed as it strengthens quality hence works together with competition.

Across the world there is a huge degree of differentiation between the missions of different types of Universities. The community should embrace and celebrate the full range of missions of Universities. In the US Golden Goose Award [The Golden Goose Award, 2019] aims 'to recognise the tremendous human and economic benefits of federally funded research by highlighting examples of seemingly obscure studies that have led to major breakthroughs and resulted in significant societal impact'. Recently it made an award to a study of implicit bias. The Marie Skłodowska Curie Association awards their fellows who provide excellent ways to reach out to society, or towards policy making based on a short video the fellows send in <http://msca2019.eu/award-competition/> Are there enough such awards that celebrate excellence in doctoral training and do they get enough profile? This could help raise standards. Some countries (e.g. Russia) retain the apprenticeship system for doctoral education and if the supervisor is poor then the experience will likely be poor. Not only is critical mass required but doctoral training also needs a robust Quality Assurance system to ensure consistency

7. Conclusions

We have outlined some recent thinking on highlighting some of the challenges that face Universities and research systems in countries at all stages of economic development. There has been considerable re-orientation towards producing doctoral graduates to help drive innovation in the economy. The training, while still primarily focused on producing and defending a piece of substantive original research, has also seen a significant growth in skills training both for better execution of research but also for future career needs and prospects. These opportunities are quite variable between countries and doctoral candidates need to be helped to develop career agency skills while reviewing the opportunities in their local context. There is certainly a need to celebrate the very wide range of potential careers open to doctoral graduates.

These changes are widely recognised within the University sector but less so by potential employers. A key challenge for the community is how can we better persuade society and employers, especially small employers, of the value of the new doctoral graduates? They are still often seen as over-qualified.

The new emphasis on skills has been highlighted. But are we developing all the right skills? The need for research and trained researchers is widely recognised as an engine for prosperity but the skills needed are inevitably changing and we have highlighted some of the changes that are needed.

With research and recruitment now so international some degree of consistency would be beneficial for aspiring researchers, between countries and between disciplines while respecting and taking value from differing academic traditions.

This chapter has aimed to consider how best to think about doctorate on a global scale for the wider role expected. The situation is variable across countries hence there is a need for Universities and their funding systems to have flexibility while recognising the potential for international mobility that doctoral graduates have. Are we preparing global PhD citizens? Are we doing this effectively and optimally? Are they prepared for smaller companies which have little tradition of research and

innovation? While some large companies have many PhDs employed some have very few. Are there ways to improve awareness of doctorate level skills and even perhaps status of doctoral education?

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[ECCharter] Charter and Code for researchers <https://euraxess.ec.europa.eu/jobs/charter>

[ECImpact] A NEW HORIZON FOR EUROPE. Impact Assessment of the 9th EU Framework Programme for Research and Innovation, p. 70

[ECIndDoc] EU Commission, European Industrial Doctorates - towards increased employability and innovation. Final report. Study 2017

[ECIntersectoral] Study on Fostering Industrial Talents in Research at European Level (2018) https://cdn5.euraxess.org/sites/default/files/policy_library/final_report_intersectoral_mobility.pdf

[ECOpenSci] EC Open Science Web Site <https://ec.europa.eu/research/openscience/index.cfm>

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[Eurodoc structured] Eurodoc Survey on the Structure of Doctorates across Europe <http://www.eurodoc.net/news/2019/eurodoc-survey-on-the-structure-of-doctorates-across-europe>

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[The Golden Goose Award, 2019] <https://www.goldengooseaward.org/>

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[NatAcadskills] [https://www.nsf.gov/attachments/245525/public/Graduate STEM Education 21st Century Rudin.pdf](https://www.nsf.gov/attachments/245525/public/Graduate_STEM_Education_21st_Century_Rudin.pdf)

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[RDF] Researcher Development Framework <https://www.vitae.ac.uk/researchers-professional-development/about-the-vitae-researcher-development-framework>

[RoySoc] The Scientific Century – securing our prosperity. Royal Society (2010)

[SERU] Student Experience in the Research University Graduate Student Survey
<https://cshe.berkeley.edu/seru/about-seru/gradseru-survey-design>

[VITAEWhatdoPhDs] Vitae What do researchers do? Early career progression of doctoral graduates (2013) <https://www.vitae.ac.uk/vitae-publications/reports/what-do-researchers-do-early-career-progression-2013.pdf/view>

APPENDIX 1

Skills developed by Doctoral Candidates (LERU, 2010)

- intellectual skills, which comprise the ability to
 - think analytically and synthetically,
 - be creative, inquisitive, and original,
 - take intellectual risks,
 - deploy specific technical, research-related tools and techniques;
- academic and technical skills, which comprise the ability to

- understand, test and advance complex theories or hypotheses and to deploy sophisticated concepts, methodologies and tools in the chosen subject to a very high level,
- be able to identify issues and translate them into questions amenable to scholarly enquiry, - successfully pursue original research in the chosen field,
- use critical judgment in an objective manner based on verifiable evidence,
- apply highest standards of rigour in the proof of ideas,
- manage a high degree of uncertainty both in method and in outcomes,
- develop and demonstrate academic credibility and become recognised as a member of an international scholarly community,
- understand the workings of a specific high level research-intensive environment,
- transfer new knowledge to scholarly communities and communicate it to society,
- work according to ethical principles,
- work in an interdisciplinarity setting or on an interdisciplinary topic;
- personal and professional management skills, which comprise the ability to
 - persist in achieving long term goals,
 - manage projects with uncertain outcomes in diverse settings and organisations,
 - take a project through all its stages: from developing the original idea, to developing a plan, garnering the evidence, and communicating the results and their significance,
 - be self-motivated and autonomous,
 - work to achieve results with minimum supervision,
 - be flexible and adaptable in approaching complex and uncertain problems,
 - communicate very complex concepts,
 - network internationally,
 - work in a team,
 - speak and present effectively in public;
- The following skills are sometimes also developed:
 - the ability to lead other researchers,
 - the ability to teach and train others,
 - the ability to organise conferences and workshops.

APPENDIX 2

Other relevant links:

On Career Destination information

OECD report on careers of doctorate holders mentioned is this one:

https://www.oecd-ilibrary.org/science-and-technology/careers-of-doctorate-holders_5k43nxqs289w-en

UNESCO website has % share of population with a doctorate for almost every country (some country stats are not available). See <http://data.uis.unesco.org/> under Education/Educational Attainment/Share of population by educational attainment Also UNESCO Science report beyond 2030 but a quick glance did not identify anything relevant to careers of doctorate holders.

The ESF (**European Science Foundation**) has a report Career Tracking of Doctorate Holders

<http://www.esf.org/scientific-support/career-tracking-of-doctorate-holders/2017-career-tracking-survey-of-doctorate-holders/>

In the UK **VITAE** has a series of publications 'What do doctoral graduates do' <https://www.vitae.ac.uk/doing-research/are-you-thinking-of-doing-a-phd/what-do-doctoral-graduates-do>

European Science Foundation http://www.esf.org/fileadmin/user_upload/esf/F-FINAL-Career_Tracking_Survey_2017_Project_Report.pdf

USA <https://www.nsf.gov/statistics/2017/nsf17306/static/report/nsf17306.pdf>

France: <https://www.adoc-tm.com/emploi-2017?lang=en>

European reports highlighting broad career destinations and training

LERU Reports on Doctoral Education

<https://www.leru.org/files/Doctoral-Degrees-beyond-2010-Training-Talented-Researchers-for-Society-Full-paper.pdf>

<https://www.leru.org/files/Good-Practice-Elements-in-Doctoral-Training-Full-paper.pdf>

<https://www.leru.org/files/Maintaining-a-Quality-Culture-in-Doctoral-Education-Full-paper.pdf>

Salzburg Principles of Doctoral Education (**European Universities Association**)

<https://eua.eu/resources/publications/626:salzburg-2005-%E2%80%93-conclusions-and-recommendations.html>

<https://eua.eu/resources/publications/615:salzburg-ii-%E2%80%93-recommendations.html>

European Commission Principles of Innovative Doctoral Training

<https://euraxess.ec.europa.eu/belgium/jobs-funding/doctoral-training-principles>

US Reports on competencies and careers

Regarding core competencies for the PhD (item 1) and the professional doctorate (item 2)

[https://www.nsf.gov/attachments/245525/public/Graduate STEM Education 21st Century Rudin.pdf](https://www.nsf.gov/attachments/245525/public/Graduate_STEM_Education_21st_Century_Rudin.pdf) Chapter 5 on PhD core competencies and other skills

[https://cgsnet.org/publication-](https://cgsnet.org/publication-pdf/4923/ArticulatingLearningOutcomesinDoctoralEducationWeb.pdf)

[pdf/4923/ArticulatingLearningOutcomesinDoctoralEducationWeb.pdf](https://cgsnet.org/publication-pdf/4923/ArticulatingLearningOutcomesinDoctoralEducationWeb.pdf)

Regarding Professional Development for doctoral students – the first focuses on STEM and the second on the Humanities

<https://cgsnet.org/meeting-professional-development-needs-today%E2%80%99s-stem-graduate-students>

<https://cgsnet.org/nextgenphd-consortium>

Career Pathways

<https://cgsnet.org/and-outside-academia-humanists-say-their-phd-programs-prepared-them-well>

<https://www.nsf.gov/statistics/2017/nsf17319/nsf17319.pdf>

[https://cgsnet.org/ckfinder/userfiles/files/CGS CareerPathways April%202019 Web Final.pdf](https://cgsnet.org/ckfinder/userfiles/files/CGS_CareerPathways_April%202019_Web_Final.pdf)

[https://cgsnet.org/ckfinder/userfiles/files/CGS CareerPathways December2018v8.pdf](https://cgsnet.org/ckfinder/userfiles/files/CGS_CareerPathways_December2018v8.pdf)

https://cgsnet.org/sites/default/files/global_perspectives_on_career_outcomes_for_grad_students_tracking_and_building_pathways.pdf

Regarding making the case for basic science and research

<https://www.goldengooseaward.org/>

<https://www.researchamerica.org/polls-and-publications/fact-sheets#investment> It is worth exploring this website to see what one organization is doing about making the case for investments in basic research

Mobility in Doctoral Education

<https://era.ideasoneuropa.eu/2019/01/14/mobility-in-doctoral-education/>

<http://unike.au.dk/publications/unikenotes/>