What skills and knowledge should a PhD have? Changing preconditions for PhD education and post doc work

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Introduction

During the conference The Formative Years of Scholars, a range of topics was covered in the presentations and in the discussions and comments throughout the meeting. Besides developments inside the knowledge system, structural developments on the national, European and global level as well as labour market demands, and the content and structure of doctoral programmes, the further careers of post docs were discussed as was the question of mobility.

This chapter elaborates on a few themes that were brought up during the presentations and the discussions; we will partly combine them and perhaps summarize from them. Thus, not all ideas and points which were touched upon by the participants are discussed here. First, we note briefly some of the changes that seem to be presently ongoing in the sector of higher education and research, with subsequent challenges for the system and those involved in it. Secondly, we concentrate on the doctoral phase. New demands are put on PhD-education programmes, and new skills and competences are demanded of those who earn a doctoral degree. PhDs are increasingly not just educated for academic research, but for the labour market in general; the postdoctoral phase will be discussed in close relation to this. There has been an increased focus on the postdoctoral phase of research careers. As with the developments in the doctoral education, new structural components are included in postdoctoral programmes and new competences are required. Also, the comprehensive topic of mobility and the closely connected discussion about 'brain drain and brain gain' will be elaborated upon in this context. Finally, the last section tries to summarize the shift in the prerequisites of the formative years.

Changes and challenges

As with the conference, this chapter begins by discussing the changes inside and outside of science systems, and the consequent challenges. It is worth noting that

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the three science systems that are covered seem to show similar developments (natural sciences, social sciences and engineering). The changes that are described here seem to be only slightly different between disciplines and not completely distinct. No contrary statement or opinion was pointed out.

Regarding changes and developments inside of science systems, the growing complexity of science seems to be a key issue. Science today is more about accepting uncertainties and unpredictability, and dealing with chaotic models than before. The growing complexity implies stronger interdisciplinary approaches. At the same time, developments in communication techniques and computer sciences (digitization) change the mode of work, allowing, for instance, computer simulations instead of laboratory work and also cross-border virtual teamwork. Furthermore, the growing complexity leads to a higher demand in interdisciplinary approaches in research and education. Consequently, students need to master a high level of knowledge of other disciplines in order to understand the latest developments in their own discipline. Similarly, cutting-edge research depends increasingly on teamwork between different disciplines.

Besides these internal more specific changes, more general trends that are extraneous to science were described at the conference. They have an impact not only on science and higher education but on society as a whole. First, the term globalization can be used to summarize the changes happening on international level. The shrinking importance of national borders has a severe impact on the academic world.

- Private research and development (R&D in companies and firms is increasingly international. The 'home-country' of a firm is of very little importance when the research facilities are planned and located. R&D units are located where there is a steady supply of trained personnel from which employees can be chosen. When many companies act in the same way, the R&D units are thus located at the same places. R&D clusters are formed around the main universities. The access to highly educated staff is more important than old national ties or low salaries. We see a trend towards concentration of private R&D to what is perceived as the optimal locations in knowledge terms, wherever in the world they may be [1].
- The flow of students across national borders is increasing. As countries like China, India and Indonesia develop in economic terms, greater proportions of their populations are able to send their children abroad for higher studies. The birth rate is usually higher than the rates of the European countries, altogether creating a severe pressure on the education systems, first and foremost in these countries, but with obvious spill-over effect on Western universities as well. Growing numbers of young people are interested in advancing to higher education and a degree from the perceived 'good' universities in the West, predominately in the UK and the USA, is the goal for many. This cross-national interest in the most renowned and well-known universities increases the competition between international and native students for places in undergraduate, postgraduate and PhD programmes, as well as between universities in terms of recruiting the most promising candidates. At the same time, these foreign students are a source of funding for Western universities to which students pay tuition fees. This has for long been the case in USA and recently in the UK. Quite suddenly, everybody wants to get on this 'train'. Australia's

move is a prominent example. Debates are ongoing in The Netherlands, Germany and France, for instance, about the possibility and the benefits of charging foreign students who wish to come and study there, regarding tuition fees in general. Universities are preparing to compete for foreign students, thereby making themselves as attractive as possible. Free higher education, which to a large extent has been a core feature of the European countries, is a principle undergoing change.

- Some countries are rapidly expanding as science-producing nations. Heavy investments in R&D accompanied by political liberalization have resulted in significant growth of the number of published journal articles, indicating a corresponding growth of the research capacity. Examples of such countries are South Korea, Taiwan, Singapore, China, Mexico, Brazil and Turkey. Many other countries that used to be small players are growing as well, although not necessarily as fast as the above-mentioned ones. The overall trend is equalization among the world's countries as science producers. Big producers lose shares to small newcomers; the USA and the European Union (EU) lose shares to newcomers in Asia or Latin America ([2–4].

Closely connected to such global changes which influence the knowledge system are changes of societal, institutional and micro-social context in Europe and in individual national knowledge systems [5]. On an international level the forces and challenges of globalization will lead to a sharper competition between nations. They are competing for the best researchers, resources and innovation potential. On a European level, the European Commission has reacted to this competition with the Lisbon Strategy, which has the aim of making Europe the most competitive research area in the world. The discussion during the conference portrayed Europe as being in competition with the USA and Asia. The interests of the individual states and competition within European were seldom mentioned. Critical participants doubted this view and asked why it is less dramatic for, say Spain, to 'lose' a good researcher to another European country than to the USA. Even so, the result is the same (the researcher is gone), the European discourse neglects such a nationalistic view. So, no clear answer could be given.

A key feature underlying this development is the so-called 'knowledge society' in which knowledge is seen as the basis for social and economic development. People's knowledge, skills and experiences are crucial assets for any company which desires expansion and increased profit. It is also crucial for any university that wishes to climb in the ranking lists, or to whole countries with the ambition to develop. Those people who possess the most advanced knowledge are seen as the most crucial.

On organizational, institutional (companies, universities, institutes, units) or national levels, the result of this process is competition, co-operation and positioning [6,7]. In addition, this development is accompanied by the consequences of 'mass higher education' of Western states on national levels. As Peter Scott (see Chapter 3) described well, the paradigm of growing competition, efficiency, outward orientation and accountability at the universities exists in many states. Academics become more professional in either research or teaching. To some extent they can even be described as a kind of 'knowledge worker'.

On the individual level (of the academic or researcher), globalization was also defined in the growing access to non-national research funding. Political initiatives and large private trusts have changed the strongly nationalized science production and created a trend of denationalization. Most obvious ones are probably the framework programmes and other programmes run by the European Commission, e.g. COST (Cooperation in the Field of Scientific and Technical Research). Organizations like the Human Genome Project, the Human Frontier Science Program, the Intergovernmental Panel on Climate Change and Intelligent Manufacturing Systems grant research projects with very little respect paid to national borders and national origin. The main American funding organizations like the National Institutes of Health and National Science Foundation are other possible sources for scientists wherever they are based. Several other organizations and large private trusts could be mentioned as well. These funding bodies are perhaps not completely global and accessible for anyone but still the trend is clear: researchers rely to a lesser degree on national sources. In a case like the framework programmes of the EU, it is not an internationalized or denationalized European research arena which is the first goal, but the funding programmes are one of many instruments to achieve political goals and to integrate the European countries socially, economically as well as scientifically. Other funding bodies may have political goals also. Science production and scientific practise has become a tool in public policy, in social policy and in regional policy as well [8, 9].

Overall, the preconditions for science and higher education seem to have undergone significant changes in recent years, during the past decade or sometimes even longer. A few major trends are at play which affect and reshape the preconditions. These trends are of economic, political and social kind, and they may be entwined or at work individually [10–14].

The exaggerated picture presented in the first part of the conference was one of a changing academic world. Inside and outside of the science systems, new demands on institutions and individuals are taking place. Today, a young scholar is no longer entering the safe and untransparent world of a single-discipline ivy tower, but a 'managed' university in a competitive world. But what are the consequences for his or her 'formative years'?.

Request for widened skills of PhDs

What does a PhD stand for today? This question was addressed by the majority of comments and led to the most lively discussions, with two lines of interpretation being suggested. First, a traditional view where a PhD is seen as a kind of diploma certifying one's ability to carry out independent and original research. The traditional view split between those who believe that the thesis is the ultimate evidence for being a researcher, whereas the modernists argue that the researcher, not the thesis, should be the product of the process. Secondly, a utilitarian view where the PhD is seen as a professional degree and the postgraduate programmes are regarded as a high-level education which follows the Master's degree. Pure research work is in those programmes only a part of a broader training.

Is the completion of the thesis enough or should a PhD student acquire a certain wider range of competencies? Arguments for the second line were most

loudly voiced. Potential employers from both the private and the public sectors want researchers with a wider set of skills and competencies than just specialized knowledge in a given topic. The skills, competencies and abilities that a PhD graduate ought to possess in order to meet the demands from potential employers today could include (but are not limited to):

- managerial and leadership skills;
- the ability to communicate with the public;
- the ability to connect with foreign colleagues in networks;
- administration of projects;
- dealing with and understanding political circumstances;
- negotiating with business partners;
- cultural understanding.

These examples point towards a broad bundle of necessary skills with growing expectations on the PhD student with regard to preparation for the world outside of academia.

One group interprets the need for this bundle of skills as a result of a 'market failure': if more graduates earn a doctorate degree, the imbalance of career positions in science and academia, and the increased number of doctorate holders leads to a higher percentage of doctorate holders going into business and other sectors outside of academia. Consequently, these doctorate holders need competencies that are different from those necessary for continued work within academia (what one participant at the conference referred to as "a survival kit"). In contrast, many participants disagreed with this perception that a career outside of academia should be regarded as a failure. They emphasized that a such a career path provided additional opportunities and that those who chose it should not be regarded as not good enough for a scientific career. They argued that all doctorate holders, independent of their future careers, need to develop a certain range of competencies.

All researchers are working and living in a highly competitive, rapidly changing and complex world. It is no longer enough to be a good researcher; to a certain degree, researchers also need to be teamleaders, managers and marketing experts. Consequently, they need communication and presentation skills, and knowledge about leadership and human-resource development, as well as knowledge about administration procedures and finances. An insight into cultural differences and human relations is another prerequisite ([15,16]. The formative years therefore have a double function. They prepare the young scientist for his or her career in academia, but also for a position outside of academia. This double function may lead to 'over-burdening' of both graduates and their supervisors. Society expects the doctorates but also of their supervisors to be multi-skilled persons; researchers, managers and entrepreneurs.

The question remains as to how these competencies can be acquired, and where and when the competence development takes place. At least two views were put forward during the conference. One being that these competencies need to be part of a structured doctoral training programme, similar to the UK GRAD programme for example. From this perspective the traditional 'master–student model' does not guarantee adequate development of competencies. The opposite view emphasizes that competence development takes place alongside the research

work [17]. Perhaps this argument carries heavier weight in the engineering and natural sciences as they include disciplines that traditionally combine doctoral research with project work inside or outside of the laboratory. Doctoral students are in daily contact with other researchers and often also their supervisor. Solitary research work with irregular meetings with the supervisor has rather been typical in the humanities and, in part, the social sciences. Therefore, it can be assumed that both views depend on which scientific area we look at and which academic culture we deal with [18]. Still, in both views, the question of an adequate training of the supervisors is rather neglected. The broadened demands on doctoral training have of course consequences for the responsibility and expectations on the supervisors. Structural changes of doctoral programmes cannot be forced externally, but must include the supervisors as the main actors. So, the question remains: who trains the trainers in academia?

Another slightly underrepresented argument was the kind of impact that improved competencies of the future Bachelor and Masters graduates will have on PhD programmes. Most countries combine a stronger focus on the so-called key skills within the introduction of Bachelor and Master programmes. Consequently, it can be assumed that future graduates will probably have a different competencies background than current ones. Also, independently of the Bologna Process, the individual background and further qualification need to be considered when structured programmes are discussed. A fresh graduate continuing his/her studies has a far different background to that of an older doctoral student who comes back to university after working for several years. The need for an individual programme design was still somehow neglected in the discussion.

In those countries which have a dual higher education system, the impact of the Bologna reform was also discussed in regard to the structure of the higher education system. By granting universities and polytechnics the right to grant the same degrees, it may be asked in how far the the Bologna Process blurs the differences between both institutions. Should polytechnics get the right to grant doctorates or should there be a dinstinction between academic and professional doctorates? A similar question arises after the presentation of new programmes granting so-called 'professional doctorates'. How much variation can there be without making the two doctorate degrees into two completely different degrees?

Besides this more or less inside view of academics on academics, the question of external assessment of the value of a PhD education — summarized in the term employability — was referred to throughout the discussion. Here, national differences were pointed out. In countries like Germany, the UK and others, primarily in the northern part of Europe, PhD holders are often attractive in the labour market. Employers value their ability to work independently and be highly reflective and critical. Here, improving one's position in the labour market outside of academia can also be one of the motivations for undertaking a PhD. In other countries, for example Italy or Portugal, employers are not yet used to PhDs working outside of academia and, hence, they have a higher risk of unemployment. Janet Metcalfe's argument (see Chapter 8) for increasing the attractiveness of PhD on the labour market was that one needs to educate the employer about the 'PhD degree', what kind of skills a PhD holder has and why these skills are attractive and

useful. Another participant added that it is easier to convince employers if there is already a PhD in the company which one can refer to.

In an historical and maybe a little exaggerated view, it may be argued that employers and Society in general demand always higher qualifications. White-collar jobs, which were done by apprentices only a few decades ago, are now being offered to university graduates. The demands on education increased as industrial production and societal organization became more advanced. More young people were admitted to higher education. One can observe 'Society's push' of the dividing line. Now, the PhD degree ought to be broader and less specialized. Employers want people with even higher competence than the Masters level provides, but it should still be broad. As scientific practice and a scientific mentality increasingly diffuse through all of Society, there is a demand for people with an understanding of science who are not just specialized in a particular area. This is also a consequence of the continued mass higher education during the last decade. Thus, arguments are raised in order to change the PhD programmes accordingly. With the 3-year PhD education stipulated by the Bologna process, the de-specialization of the PhD degree might be completed. The increasingly common organization of PhD education in cross-disciplinary research schools is yet another indication of this change. A PhD degree will represent a very advanced education with some personal experience of scientific research, but in many fields, it will not be enough to get a position as an independent researcher at a university or any other research organization; the next section shows that for these positions, postdoctoral experience will be increasingly required.

Focus on the postdoctoral phase

As a consequence of the debate and focus on the graduate level, the postdoc phase has received much focus in recent years. In order to get a research position, a postdoctoral experience is often required. In recent years, certain fearures of postdoctoral prgrammes differed between different countries. In the USA, postdoctoral work is frequently characterized by low pay and long hours in the lab, where the idea is to get the necessary experience and prove oneself worthy of a tenured position [19, 20]. There is a debate about the conditions for postdoc scholars and the working conditions are often questioned [22]. Very rarely does a young American scientist's postdoc period involve working abroad [23]. In Europe, as in the USA, a postdoc can mean a position in one's home country, or it can mean a corresponding period abroad at a university or a laboratory. The conditions, economically and otherwise, differ between the European countries.

It was stated during the conference, that in many European countries, roughly 15–25% of PhD graduates go abroad for a limited period to do a postdoc every year. The period varies between 1 year and several years, but is rarely more than 3–5 years. In normal cases, they return to the home country after 2 years abroad. National figures are sparse but there are some studies which indicate the numbers (see [24–26]). Whether this picture is generally valid for the member states of the EU remains to be investigated; it is certainly the case in the Nordic countries, France and Germany.

The comments presented a concerted view that the postdoc phase is the most productive time for a researcher. It is during this period of postdoc studies or postdoc research that a young researcher actually proves to be worthy of his/her PhD degree. The young scientists or scholars develop independent scientific skills, starts on a their own research paths, open up a new line of research or deepen their knowledge on the area in which they had previously worked. It is during the postdoc phase that the specialization occurs; the specialization that is neccessay for continued academic work. In Sweden, for instance, it is practically impossible to get a tenured research position in the academic sector without having completed a postdoc period abroad, at least in medicine, the natural sciences and technology. The circumstances are, in part, different in the social sciences and the humanities. But no one gave any particular reason as to why the situation would be radically different in other European countries, even though some circumstances naturally will differ between countries [27]. Nowadays, the required in-depth research skills and field competence are acquired after the PhD graduation, during the postdoc period.

In accordance with the demands on graduate education, the conference showed that in postgraduate education, the term interdisciplinarity has become key. Postdocs are required to be able to both work and communicate with different disciplines. But, how can this demand for cross-disciplinary thinking be implemented in graduate education? Again, a discourse about 'theoretical courses' against daily life experiences started. Professor Wittrock promoted, in this regard, the Centres of Excellence in Sweden where researchers of different disciplines live and work together. Similar experiences were reported about cross-disciplinary doctoral programmes in which doctoral students from different disciplines are brought together to discuss their thesis. As with developments at the doctoral education level, there is also a trend to include further coursework into postdoctoral programmes: Many include entrepreneurial aspects, leadership training (Swedish academic council), communication skills and research management aspects. As described above, the growing competition makes it inevitable that researchers know early in their career how to apply for a grant, how to manage a research group and how to find grants. In accordance with the development at the graduate level, these programme elements seem to serve a double function. As one presentation showed, only one-third of sciecne-based postdocs go on to work in science (one-third work in administration and the other third in industry). Thus, in an output-oriented perspective postdocs need to be trained for all three careers.

Problems that were mentioned with regard to postdoctoral education referred to the unstructured and unformalized character of this period. Some problems with this somewhat new situation were also mentioned, the main problem being the fact that the postdoctoral period occurs after the education is completed and before proper employment begins, an in-between period without many regulations. The 'postdoc' does not need to follow regulations that are normally associated with being a student on the one hand, or having employment on the other. Few social benefits are available as these are usually dependent on having a salary. There are postdoctoral positions which include a salary, but in many cases, the scholar relies on various kinds and combinations of scholarships and grants. The security otherwise associated with employment or admittance to a university is, in many cases, lower for postdoctoral scholars. All this would perhaps not be a

major problem if the young researchers were indeed young. The problem reported is that they are no longer that young. They are often well into their 30s. The student lifestyle is, in part, stretched out and causes economical insecurity and problems regarding family formation. The lifestyle that most live in their 20s, significantly fewer find bearable in their mid-30s [19,23,26]. A possible and negative consequence, which was discussed, is the decreased attraction of pursuing a scientific career in comparison to much more attractive working conditions outside of academia. Not that there are real problems in attracting people to the universities in general, but the question is who are attracted? The best, or the most persistent ones [28, 29]?

The selection of postdocs is furthermore influenced by demands oriented towards the personality and competence of the researcher. Congruent with the developments at graduate level, postdocs, in their role as future researchers are increasingly expected to possess so-called key skills too. It was presented that the funding modes for research work are supporting this development. Successful research results are no longer the only prerequisite to being selected by a funding organization. Funding organizations, like the German *Volkswagenstiftung*, look for management abilities, teamwork, interdisciplinary approaches as well as personal characteristics when they select scholars. The tendency of external funding fostering the demands for key skills is maybe one of the strongest forces of change related to scientific production today. This development broadens the above stated question of "Who are attracted to academic research?" The best researchers of their field or those who have the best key and presentation skills? And, what is the attractiveness of being a researcher today? If business and academia are converging in their demands regarding key skills, such as teamwork abilities, management and presentation skills and if the academic world is overtaken by the characteristics of corporate organizations, what constitutes the attractiveness of the academic workplace?

Mobility as a tool for creating contact surfaces

An elaboration on the formative years of scholars needs to include the issue of mobility. Besides the fact that mobility was a hot topic during the conference, it has attracted considerable attention for a long time, and over the last couple of decades increasingly for students and young researchers. The relatively vast mobility schemes initiated by the European Commission have played an important role in the European context; ERASMUS being the largest one in terms of numbers. More recently, the focus has been broadened to graduate students and postdoctoral scholars as well, particularly through the Marie Curie mobility scheme. National mobility schemes of a similar scale have developed simultaneously. The phenomenon of research and student mobility, even when limited to young researchers and graduate students, is a complex topic and one that receives much attention within science studies, studies of higher education and related fields.

In an attempt to structure the arguments covering the topic of mobility during the conference, five different levels of 'mobility' could be identified: individual, institutional, national, European and global.

With regard to the individual level, there was a largely positive assessment of mobility. It is seen as a very important part of the career for developing new

research contacts, to get to know the latest methods in one's field and to broaden one's mind. In particular, in the natural sciences, mobility is a key aspect of the formative years. Recent figures [29a] show that half of Danish graduate students have spent average half a year abroad during their PhD education. Similar or perhaps even higher figures are known or likely for many other European countries as well. As already touched upon, many of those who continue with an academic career go abroad to do a postdoc period as well. In truth, to be a trained as a researcher requires that one is mobile. A negative aspect, as already mentioned above, is the need to combine these 'forces of mobility and flexibility' with the researchers' desire for private and family lives.

At the institutional level, mobility was also assessed as positive in many regards. Outgoing and incoming researchers foster research contacts, the exchange of the latest development and research methods as well as the institutional networking. Still, negative aspects were also mentioned as the mobility of an institute's own employed researchers implies the danger of brain drain mainly to the USA. Surveys show that travel to the USA is considerable as it has the world's largest scientific national community, and is leading the scientific development in most areas. A high percentage of European young researchers go there, learn what they are working with and try to establish contacts for the future. It is often a very promising venture, not only from a pure scientific point of view but also from social, career and merit-related perspectives. Because of the fact that some American institutions can afford to select only the best, it was suggested that there exists a kind of a 'US halo effect'. People go to the USA so that they can claim "I have been to the USA". Reference is made to the nation or to a well-known university, not to the work that was done there. Besides high-quality research institutes and the unbeatable US image, it was argued that the attractiveness of the USA lies in the transparent and bigger labour market than in the EU. The employment structures are more flexible than most European tenure track models.

On a national level, not many comments were made. As already mentioned, it was mostly argued from a European perspective. The perspective was solely on the competition between Europe and the USA and Asia (here China), rather than on the competition for "human capital" between single states. It seems that the old Latin saying remains true: *a common enemy unifies*. The question remains as to whether the USA will keep or loose its attractiveness? Will other countries become new or stronger competitors? There are new nations presenting themselves in the global scientific arena, they develop rapidly and produce increasingly qualitative scientific knowledge. They were not counted as particularly strong science nations 10 or 15 years ago, but today they have universities of highest standards and institutions and centres that compete successfully with the leading ones in certain fields. To mention a few obvious examples, we think of countries like South Korea, Singapore, Taiwan, China, India, Mexico and Brazil. So, how will Europe react to this new challenge?

Interestingly, it was also suggested mobility should be assessed on a global level. Here, national interests and therefore, the discussion of brain drain and brain gain looses its validity and, thus, only the positive overall net gain of mobility would be the result on the global level.

Shift of the prerequisites of the formative years

The graduate and postdoc periods are probably equally important and formative for a scientist or a scholar, but the formation processes are oriented differently. We can speak of a formation of the professional identity and a socialization process with respect to the disciplinary origin. A third period can possibly be detected as well; that would be the period after the postdoc phase when the researcher has an assignment prior to a senior position. But we argue that the truly formative period first and foremost refers to the graduate and the postdoc years.

There are also professional formation and socialization processes going on during undergraduate studies. It could be suggested that, during this period, the socialization is connected to the usefulness of the topics studied: "What can I do with this knowledge, what use is there for this competence, what job can I get with these skills?" Such practical questions, and their answers, define the professional identity and the comptetence that a given student in a given discipline has at undergraduate level. The formative process during undergraduate studies and the socialization process of a student depend, to a large extent, on how the outside world values the education.

The graduate education has a tacit curriculum in addition to the prescribed coursework and thesis-writing: it includes a socialization process *vis-à-vis* the discipline at hand, to become an economist or a chemist for instance. It is important for the student to know the discipline in order to become an economist or chemist. This process involves solid theory knowledge, familiarity with the founding fathers of the field and the discipline, and an understanding of the main area of study and its methods. The history of the discipline is important as well, and even more so, the borders of the discipline. What features and characteristics does the discipline have? How does the discipline differ from other disciplines? How are we 'x-ists'?

Another socialization process occurs during the postdoc period: one of becoming an independent researcher, an expert in the field or a reliable project co-ordinator/leader/contractor. During the postdoc period, it may be important to distance oneself from one's former supervisor, to distance the research from the PhD thesis and to develop a new line of research. It is with some distance that the postdoc scholar can look at his/her origin as an x-ist and relate to the expected features of such a person and the features of the discipline as a whole. It is rather important to show maturity and prove that one has taken one step further in individual development. During the postdoc period the young scholar must show that he/she has the ability to drive a research idea and initiate interesting research. After this period, if successful, one ought to attract funding and start building a group or, in the humanities and social sciences, attract funding and become a renowned name in the field and recruit graduate students.

One can summarize the results of the discussion at the conference by suggesting that the formation and socialization logic of the undergraduate period is gradually extended into graduate education. How the outside world values the PhD education and the competence and skills resulting from it matters increasingly for how a PhD graduate looks upon him or herself as a professional. The socialization process *vis-à-vis* a certain discipline as described above probably remains but carries less weight with regard to identity as an economist, chemist or whatever.

Identification with the discipline will become relatively weaker. It is instead during the postdoc phase that the socialization as a scientist will occur most strongly. It may, however, not be as closely related to a certain discipline in the future, as the field specialization and the in-depth scientific experience during the postdoc period targets problems in a particular field or subfield, possibly involving people from different disciplinary backgrounds, rather than a pure traditional discipline.

Summary

Society's need for PhDs with a wider range of skills than scientific expertise can be taken as one of the main outcomes of the conference. Industry and public organizations both need highly advanced experts with scientific experience, but also with managerial and administrative skills, as well as cultural and social competence. Furthermore, academia needs researchers with much the same skills, plus an in-depth knowledge in a particular given field. The theories regarding Mode 2 [30]or Triple Helix [31–33] have their weaknesses and have been tested and criticised accordingly [34–36], but they hint at relevant features of the conditions for modern scientific practice. There is an entangled relationship between work and knowledge production at university, in industry and in governmental bodies; there are new forms of knowledge production occurring where transdisciplinarity, heterogeneity and organizational diversity, to mention a few Mode 2 characteristics, are features which fairly well capture what goes on and which conditions do influence the scientific work today. The request for a wider set of skills and less specialization of PhDs can be seen as an example of how society speaks back to science [37].

A modernized PhD education, which takes into account such requirements, is one consequence of this development. It was presented, that this is already taking place, to some extent, in research schools and through formalized PhD networks. Hence, one can conclude that the education system is adapting to the demands and will keep adapting even further.

Academia's continued request for specialized researchers will probably lead to similar demands for a more formalized and structured postdoc period [22]. Today it is highly insecure and unstructured. Informal contacts decide where a young PhD can go to do a postdoc; the success in writing applications decides if and which funding will be provided; job security and social benefits are often low; and whether the content of the postdoc period proves to be useful and valuable may often seem as random outcome. There is evidence that many postdoc scholars are given 'missions impossible' by the hosting research leaders [26]. If they fail with a laboratory project, they will come home with no useful results at all. Finally, the return after the postdoc period, be it to the previous home department or to a new department, is a risky transfer. Most negative experiences of the postdoc period can be referred to the process of return [38]. This period is characterized by uncertain employment conditions and unclear and unstructured demands. These are conditions which reduce the attractiveness of a scientific career. Consequently, there is a strong need for better structure and better conditions for young researchers during their postdoc period.

The presentations and discussions during the conference have pointed to Society's need for researchers with skills beyond scientific ones, and to academia's need for enhanced in-depth knowledge in a given field; however, instead of representing a dichotomous view of how PhD education ought to be organized in order to meet the demands, the two views rather seem to converge as there is a need for researchers with a broader set of skills even within academia. Thus, the PhD education is about to be transformed and will include more utilitarian skills, while the requested scientific specialization necessary for continued academic research will occur during the postdoc phase.

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