ISSN: 1646-8929

IET Working Papers Series

No. WPS09/2010

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Designing a Technology Assessment post-graduation programme: experiences, limits and needs

IET

Research Centre on Enterprise and Work Innovation

Centro de Investigação em Inovação Empresarial e do Trabalho

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Designing a Technology Assessment post-graduation programme: experiences, limits and needs

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Abstract

The post-graduation in the field of Technology Assessment (TA) is recent and that are several and different ways to be organised. Most experiences are related with the Masters diplom level (2nd cycle of graduation in high education). Just one in PhD level is explicit in the field of TA, and some other PhD courses include also TA topics in their programme structure. In this chapter we will analyse the problems related with the design of a post-graduation (MA, MSc or PhD) programme in the field of TA using as reference some international experiences. Hereby, the main conclusion seems to address labour market needs in the specialised knowledge of TA, of technology management or technology innovation. In this sense TA should be included as "minor" into post-graduation courses which may range from engineering disciplines to social sciences. As a graduation programme it can fill an expertise gap between technicians, engineers, scientists and the strategic decision makers or policy makers.

Key-words: Technology Assessment, post-graduation, high education, decision making

JEL codes: A23; O32; Z13

1. Current developments in the field of TA

Technology Assessment (TA) as a scientific approach aims to identify and to evaluate systematically the impact of technological innovation and developments with regard to the social, cultural, political, economic, and environmental systems. Such approach can be identified as “watchdog”, or an early warning system for risks caused by technology (cf. Bechmann et al., 2007).

In recent developments, TA has been understood as a contribution to technology governance and innovation policy, in particular, in areas of uncertain knowledge. In addition, TA is increasingly involved in the debates on futures and visions integrating foresight as one of its main elements (van Merkerk and Smits, 2008; Smits and den Hertog, 2007; Grunwald, 2007). Some concepts have a new epistemological approach, such as the so-called “ethical, legal and social implications” of technology (ELSI) or “environment impact assessment” when they are related to TA. Also, the Health Technology Assessment (HTA), and “risk and safety” studies can be regarded as specifications of the basic idea of TA to specialised ends and purposes (Perleth and Wild, 2001; Hennen, 2001).

The ongoing process of analysing developments in science and technology, with its close relationship to innovations, their social and societal consequences, and the discussions about those innovations are usually mentioned as a “tracker” approach to TA. In this sense, there is a growing professional market with specific training needs. This also implies an increased involvement of political structures and dynamics into the impact analysis of technological developments or scientific options. These involvements are also very much based on the needs and demands of civil society, i.e. public institutes, NGOs and others. Consequently, this type of involvement also is based on specific qualification and methods to perform those assessment studies (i.e. participation methods). Not only on the level of scientific skills and methods, but also with the increase for the need of inter-disciplinary teams has this type of expertise to be developed.

Also an increased number of senior professionals in large companies of different sectors as the energy, telecommunications, automotive, transport services, or health services, are returning to university to develop their expertise through enrolment in post-graduation programmes, especially in PhD programmes. This enables them to follow new knowledge fields and integrate new tools to apply and propose in their professional fields. This process will continue and will lead to the necessity to provide young people and higher ranked professionals with TA knowledge and skills.

The notion of the precautionary principle of technological developments with regard to societal decision-making processes still is a basic idea of TA. This high expectation also means a need to raise awareness and to create knowledge also *or* especially at educational level. To tackle this needs recently emerged several post-graduation experiences around the world.

Usually, the students have developed their interests in Science, Technology and Innovation studies through undergraduate projects or work experiences. In most cases, those that have chosen TA related course topics are those enrolled in engineering studies, or biology, chemistry, physics, geology and other natural sciences. But among the issues they choose it can be also the need for improvement of knowledge on innovation methods, on ethics of technological developments or on management of innovative ideas and projects. The aims of such TA related studies are the improvement of scientific and technological opportunities for research into the management of innovation and change, and the feasibility of decision making related to technology. It combines a consideration of technological and organisational change and management innovation. It gives these technology related students the opportunity to get involved in social sciences based concepts and to respond adequately to new market demands, as the need for technology policy decisions in organisations with higher dual competences (technical and socio-political and ethical).

Such new needs bring “labour market needs” or “demand” on technology assessors. In fact, at the beginning of the 21th century there are new expectations and challenges towards TA. Usually TA has not to deal with the consequences of individual technologies, products or plants, but frequently with complex and conflictual situations between new and emerging technologies, enabling technologies, innovation potentials, patterns of production and cultural and political strategic decisions. Expectations towards 'responsible innovation' (MASIS 2009) can be seen as a core to which all of these research and assessment branches contribute, setting out from different premises, using different perspectives, and applying different TA methodologies.

Most of TA topics represent new challenges in terms of technology research and policy decision making processes. In the meanwhile, these processes are part of assessments and social and political processes and should be taken into account when teaching and researching TA at university level. Thus, the ubiquitous and comprehensive importance of technology in modern societies should be both strengthening research and being implemented into different curricula in academia. This refers not only to the area of social sciences but also at the natural sciences and engineering. As experiences show TA practitioners are needed who are capable of integrating comprehensive knowledge on social and technical expertise. Furthermore, the TA approach should also be implemented to many other professions in order to raise the awareness on these complex processes.

Young researchers, but also practitioners in industry, have already joined up with the established community of TA. Their involvement in TA conferences, collaborating with research projects, enrolment in post-graduation studies, are examples of that participation.

The sections before briefly sketched the current challenges of the implementation of TA issues into research and education: the importance to support initiatives on education at post-graduation level to provide TA practitioners with specific competences, and to understand the different educational practices over the same

field of topics. From this, we may conclude that the education in TA has just started as a post-graduation specialisation.

2. Tradition(s) of teaching TA

Teaching TA has several background settings. It can be an integrated part of social sciences like sociology of technology, of ethics of science and technology or of political sciences with regard to technology policy.

But in many cases it is also integrated as a marginal topic in the courses of MSc level in technology or engineering education. Here “marginal” means a complementary field of knowledge in the basic MA and MSc courses (in some cases, it could be as “minors” of master studies).

Worldwide there is only one specific PhD course on Technology Assessment,[1] however there are information related with this complex and comprehensive "field of TA" both in Europe (Germany, Netherlands) and in the US and Japan. In this sense, one can mention several cases of technology management, innovation management, innovation studies, technology change, technology management or even impact assessment in these same countries. Thus, the following examples are only that: examples. They are not exhaustive, and we tried to present the possible wide variety of topics, methods, teaching strategies, institutional links or organisational issues related with the structuring of these courses. The following table illustrates some of those cases:

[1] The PhD programme on TA in Portugal, with several courses directly related to TA and aiming at a diploma on TA.

Country	University	Research Centre	Units/Areas
Germany	University of Bielefeld	Institute for Science and Technology Studies IWT	Chair of Economical and Social Sciences Didactics
UK	University of Manchester	PREST/MIIR (Manchester Institute of Innovation Research)	
	University of Sussex	SPRU (Science and Technology Policy Research at the University of Sussex)	PhD in Science and Technology Policy
the Netherlands	United Nations University (UNU-MERIT)		• PhD Programme in Economics and Policy Studies of Technical Change, • PhD programme on Innovation Studies and Development
	University of Twente	Institute for Innovation and Governance Studies	• Post-Graduation on R&D evaluation
	Netherlands Graduate Research School of Science, Technology and Modern Culture (WTMC).	Twente University (PSTS) Utrecht University (SIM) Maastricht University (ESST)	• Diagnosis of the Modern Research System • Technological Development and Societal Regulation • Cultural Roles of Science, Technology and Rationality
	Marie Curie Training site programme		• European Doctoral School in the Economics of Technological and Institutional Change
USA	Harvard University	School of Engineering and Applied Sciences (SEAS) in the Faculty of Arts and Sciences and Harvard Business School (HBS)	• PhD program on Science, Technology and Management
	Indiana State University	College of Technology	• PhD on Technology Management
	Massachussets Institute of Technology	Engineering Systems Division (ESD)	• PhD on Technology, Management and Policy track
	Georgia Institute of Technology	School of Public Policy	• PhD on Public Policy
	Massachussets General Hospital	Institute for Technology Assessment (ITA)	• PhD on Technology Assessment
Japan	TokyoTech-Tokyo Institute of Technology	Department of Innovation Management	• Ph.D. program in Management of Technology
	Yokohama National University	Graduate School of Environment and Information Sciences	• Phd programme on Technology Management

Some universities are giving their education expertise in the field of science, technology and innovation (STI) studies to young researchers. Others offer their education within comprehensive research interests as the societal differentiation and integration, participation, governance, risk analysis, knowledge and organization. Many of their graduates come from backgrounds in the physical and natural sciences, engineering, social sciences like economics, psychology, and sociology, or interdisciplinary programmes such as international relations and cultural studies. Few others have followed courses in history of science, science and technology studies, or innovation studies.

At PhD level some German universities offer courses on TA, in particular, the Universities of Karlsruhe (KIT), of Bielefeld and of Stuttgart can be mentioned (Bora, 2009). In terms of Master degrees, some institutions offer TA studies as the Technical University of Berlin with its Centre of Technology and Society (ZTG), FernUniversität Hagen, the Technical university of Darmstadt, the Technical University of Clausthal, and the Technical University of Aachen (RWTH). In Germany the involvement of younger researchers in the field of TA can also be observed through the occasion of the NTA (www.netzwerk-TA.net) conferences from 2004 on. Some of them are developing their post-graduation thesis on TA topics, and others are also working on TA-related ones. This TA network is not only related to Germany, once integrates also researchers from Austria and Switzerland. Is a German-speaking network but presently the largest in the TA fields.

Another important experience in the field of TA education at PhD level has been in the field of health and medicine education universities in the US since the last decade. One case is the Institute for Technology Assessment (ITA) that conducts health outcomes research to guide the development, evaluation and utilization of medical technologies that improve the quality and cost-effectiveness of medical care. Such focused research on the area of “health technology assessment” is a single case. Other cases are related with public policies, but in all these PhD programmes, TA topics are being taught in several courses and they can be taken as experiences for the design of new PhD diploma programme that can have TA as a main topic. To certain extend if some universities develop their competences in a specific field, a joint programme can use the different universities to support the complementarity of education topics. This needs, however, the possibility for universities to cooperate around a common field. In the North-American and Japanese cases TA education is strongly related with science and technology management dimensions or, in general, with innovation issues.

3. The experience of organising a PhD programme on TA

Generally, in almost all OECD countries, TA is of increasing importance in engineering courses as an educational course topic. It was mainly debated among

the economists community as a topic related to technology management, investment decision and economical choice, and to a minor extend among the philosophy and/or political science communities (on ethics issues of technological development, social attitudes towards technology, environmental social movements analysis, for example). What is new is the emergence of TA at science and technology and engineering courses. In a large amount of engineering courses (either in US, or in UK, Germany, Portugal, France) students have the opportunity to learn topics on innovation policies, bioethics, environmental decision processes, history of technology, social aspects of technological change. And European technical universities as Imperial College (UK), École des Mines (France), Technische Universität Berlin, the KTH-Royal Institute of Technology of Stockholm, the Helsinki University of Technology-TKK, or the ETH Zurich are also offering post-graduation in this field.

However, historically, the need of teaching TA courses arises mostly at technical universities. This is valid also for cases of Portugal (either in the field of engineering - at the Faculty of Sciences and Technology at UNL-Universidade Nova de Lisboa, or in the area of economics - at the Institute of Economics and Management at UTL-Technical University of Lisboa). Only at Universidade Nova de Lisboa (UNL) and University of Minho it was introduced at their schools/faculties of engineering or sciences courses of "bioethics", "socio-economic aspects of innovation", or "philosophy of sciences and technology". All other university' Faculties of engineering or sciences (Porto Coimbra, Aveiro, School of Engineering of Technical University of Lisbon/IST-UTL, among others) do not provide such topics: they are indeed only technically oriented.

Furthermore, in Portugal there is no one research centre or laboratory exclusively approaching this concept. As it is by nature an inter-disciplinary concept, the actual policy to support disciplinary specialised research centres based in single university units has even destroyed such possibility. Some researchers at IET (Research Centre on Enterprise and Work Innovation and UNL), or at UECE (Studies Unit on Complexity in Economics, at UTL-ISEG), are the few examples. Thus, one can say that in Portugal, TA is still without critical mass of researchers, although its political importance is growing very fast and the expectations towards TA seem clearly expressed.

Thus, in spite of some experiences in the field of TA and education in Portugal, only the mentioned new PhD programme on "Technology Assessment" is a clear experience. This new programme was proposed by the Universidade Nova de Lisboa (UNL) [2] and started in 2009-10 aiming to prepare high skilled researchers and decision making consultants that will be involved in the policy processes for technology options that are expected to become critical in the short and medium-term. The proposal was made by social scientists at the Faculty of Sciences and Technology of the UNL, but associated also natural scientists and engineers. The

[2] cf. TATuP nº 2, Vol. 18, September 2009

field for research under that PhD programme can develop strong links with the technological fields that constitutes the main frame of education activities there such as, among others, computer sciences, chemistry, environment sciences, robotics, physics and biomedical engineering, material sciences and nanotechnologies, and industrial engineering. The programme develops in four years training course with two years of a curriculum based on TA related courses as the following table shows.

1st semester	**2nd semester**	**3rd semester**	**4th semester**	**5th semester…**	**…8th semester**
Interactive Methods of Participation and Decision (6 ECTS)	Innovation Economics and Management (6 ECTS)	Methods of Foresight Analysis (6 ECTS)	Evaluation in Science and Technology (6 ECTS)	Thesis	Thesis (Total 180 ECTS)
From Analogue to Digital: paths of modern technology (6 ECTS)	Decision Support Models (6 ECTS)	Thesis	Thesis		
Project I (3 ECTS)	Project II (3 ECTS)	Project III (3 ECTS)	Project IV (3 ECTS)		
Add-on I (6 ECTS)	Add-on II (6 ECTS)				
Thesis	Thesis				
	Appointment of the Thesis Committee (for each student)	Winter School	Doctoral Conference		

Students must also include add-on courses from the university (UNL) MA and MSc programmes. Besides this, each semester during the first half od the PhD includes also thesis project seminars.

Students who achieve distinction in their coursework are invited to prepare a PhD proposal, which includes the identification of a topic, discussion of methodological issues relating to the research, and where appropriate, a discussion of the data resources to be used or developed. The proposal also identifies further areas of

formal (class work and workshops) and informal study to be pursued in the course of dissertation research and writing. The PhD proposed plan will be approved in the first year, and discussed and re-evaluated after a public discussion of a more developed proposal at a "Winter School" workshop[3]. A Doctoral Conference will be organized [4] every year where the students present their revised thesis plan with some preliminary results.

This doctorate programme of Universidade Nova de Lisboa on TA presents itself as an alternative to the programmes more directed to engineering and technology topics, and is an advanced training scheme of large potential for technicians that are related with processes of technological choice or technological investments. Such type of technicians can work already in the public administration offices (large national laboratories, or governmental entities with specialisation in these fields) as well in large sized companies where that type of option can be placed for technological re-conversion processes, or for entrepreneurial development.

The TA professionals with this PhD diploma can also work in high-tech companies of medium of small-sized dimensions. They can work with anticipation tools of technological development processes (as for example, biotechnology, nanotechnology, micro-electronics) or can work for highly specialised technological consultancy, providing services in TA fields. In any case, they will be experts that - independently of their basic technical education - need to acquire advanced knowledge in fields related to this type of possible options (of investment and/or of advanced research).

In general, up to now teaching TA mostly happens due to personal engagement of TA researchers and practitioners in postgraduate phases. This means there is no university strategy to provide PhD level courses on TA. The exception is now Portugal, but in other countries there is a much large number of TA practitioners and academic experts than in Portugal.

From the Portuguese perspective the institutional collaboration with other European universities can be considered as a "good practice". The preparation of the PhD programme on Technology Assessment started with the support of ITAS-KIT (in 2007) and some new future steps can be developed in the direction of a more intensive collaborative programme with the KIT, and to extend it to the University of Twente (Netherlands) and other universities that already now cooperate with this 3rd cycle of university studies (according to the Bologna process) [5].

Such collaborative experiences are not reflecting just a (good) intension of some personal options of scholars. They are emerging and disseminating once there is an increased need for highly qualified technicians and experts to get involved in large companies that need a critical thinking on technology options. There is an increased

[3] The first one took place in early December 2010.

[4] The first one will take place in early June 2011.

[5] The Universities of Frankfurt, of Duisburg-Essen, Furtwangen (all in Germany) and Vilnius (Lithuania), are examples, besides the above mentioned KIT and Twente.

need for skill provision on analysis of risks associated to technology and research. There is also an increased need for social analysis capacity and ethical thinking in the fields of technology management and innovation promotion (cf. Moniz and Grunwald, 2009).

After an emergence of this labour market niche, it can happen that younger students holding MA or MSc diplomas would like to follow studies in TA topics or even in TA doctorate programmes. That can be more evident in engineering MSc programmes, like electronics, nanotechnologies and material sciences, on biomedical engineering, on chemistry and physics, and so forth. At the same time, public or private companies, large or small, but dealing with technology-related decisions, will also need such type of expertise. Especially those that act in the field of technology investment decisions, or technology choice, or even those of *ex ante* and *ex post* impact evaluation. These type of industries will search for such TA diploma holders, while their knowledge is critical in a unstable environment (economical, technological, social).

The requirement for such expertise will be evident from the public administration organisations, especially in those departments or sectors that deal with technology decision (energy, transport, or even foresight and planning). The same will happen with larger industrial laboratories, or in scientific research centres.

4. Lessons from experiences

Since 2008, the Institute of Technology Assessment (ITAS) at the Karlsruhe Institute of Technology (KIT), started a co-operation process with the Faculty of Sciences and Technology of Universidade Nova de Lisboa (FCT-UNL) that included the possibility for hosting scholars from both institutions (mostly, sabbatical leaves, post-docs scholarships and PhD students), and to support seminars and colloquia in both institutions. Until now this collaboration is exclusively covering the field of TA. It is, however, expected to enlarge the scopes to other fields of science and technology (energy, environment, nanotechnology, manufacturing systems) but always with strong links to TA activities in both academic institutions.

The foundation of KIT, however, brings about new opportunities for a more coherent PhD programme and for a closer cooperation between TA practice and academic research on TA relevant issues. An important step was the very recent foundation of a KIT focus on "Humans and Technology" which comprises social and economic sciences' and humanities' research on innovation and technology related issues, including TA work being done at ITAS. Within the framework of this focus, new structures for MA and PhD theses will be established, with TA as one of its core elements, with relations to philosophy and sociology of technology and with innovation research.

From most of the experiences we described there is also the acknowledgement that the establishment of cross-disciplinary research in technical universities can provide the skill needs sketched above. Today, universities (and the high education in general) are confronted with the obligation for further collaborations that enable them to offer a better quality for those “market needs” than they could be able to provide if they were alone. The push towards different universities to cooperate is driven by these new occupational needs. That seems clearly the case for TA (cf. Moniz and Grunwald, 2009). In the LERU report on Universities and innovation is said that “at European level, the European Technology Platforms could become valuable means of articulating major cross-disciplinary research needs and stimulating a response from the research community” (LERU: 2005, p. 15). This means also that research universities are recognised as part of the most important institutions where cross-disciplinarity can be fertilised and where there are capacities to create and exploit networks of institutions. Those research universities should be able to promote collaborative links with applied sciences universities and with industry as well.

These are conditions for an increased activity on TA education. Also because TA research activity is mostly done under collaborative schemes of university grounds, as well in research fields that can only be covered by cross-disciplinary technology platforms. New challenges can be faced to follow such collaborative schemes if they are done between universities from different countries.

The complexity of TA demands and tasks can also be seen by looking at a set of TA themes which covers a broad range of topics i.e. reducing emissions from de-forestation, biodiversity and climate change, regenerative medicine, future electricity transmission, biofuels, disruption of the internet, new addiction treatments and possible health effects of the mobile phone. Such themes need cross-disciplinary approaches, and it can be understood that a professional working in the TA field would need also an equivalent learning process that would enable him/her to tackle with such complex issues.

5. Conclusion

From the examples discussed in previous pages we can conclude the following:

a) TA topics are intrinsically inter-disciplinary and need a similar focus in the design of post-graduation programmes. A very wide focus of a programme or a very specialised one can prevent potential students to choose it an enrolment;

b) University faculties act and develop their education activities in a disciplinary way, in some cases very segmented. This can mean an increased difficulty to manage collaboration among different faculties and departments;

c) TA is a discipline that can be understood as useful for the post-graduation curricula in technical universities. Several examples show that. One possible reason is that it can be easier in such universities to articulate technical expertises together with social sciences to propose TA topics for thesis research. Another one, is that TA is been understood by natural scientists and engineers as tool to develop technology in a sustainable way with greater acceptance. The major difficulty can be the availability of social sciences competences in such universities;

d) However, the competencies to teach TA topics are usually found only in social sciences faculties. But these faculties have difficulties to bridge dialogue with technical and engineering faculties. If TA topics are approached by social sciences, their focus is intrinsically technological. The research based on TA is normally developed in technological laboratories and universities;

e) The few successful cases teaching TA at post-graduation level are those in technical universities with departments or faculty chairs in social sciences.

Having these conclusions in mind, one can add another one that would point out the need for inter-disciplinary studies in technical universities. That means there is an urgent need to develop qualifications and expertise in the different fields of TA and even in the different methods of TA. For such reasons the educational initiatives in TA are critical at this stage.

From the labour market point of view, most cases with TA post-graduation intend to develop master diplomas to young university students (MA and MSc). This means that TA professionals or technology assessors should have a specialised training, although a basic one.

The doctorate diploma example clarifies the need for a higher level specialisation on TA, where is offered a learning and research programme to skilled professionals that feel the need for other tools to define new possibilities in the technology decision process in their institutions. To exemplify this, the actual PhD students of TA are working on high-tech departments of large hospitals, on large technology-based companies, on specialised software firms, or even on statistical departments related with innovation policy. As mentioned before, many companies that deal with technology-related decision (investment firms, technology consultants, impact assessment analysts) will search for such TA diploma holders. The requirement for such expertise will also be evident in the public administration sectors related with energy, infrastructure systems or with strategic planning in several fields. Larger industrial laboratories and scientific research centres will need TA experts among their highly qualified staff.

Such expertise “demand” is offering new challenges for higher standards in technical education and for new challenges in university organisation. The traditional disciplinary focused higher education will be replaced by cross-disciplinary learning process. And the most successful experiences will be those that can offer a higher quality teaching system with collaborative capacities where universities from different regions and countries can offer joint diplomas, or can cooperate in the teaching and researching processes. The few experiences are paving the way in this direction.

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