TECHNOLOGY ASSESSMENT: EDUCATIONAL CHALLENGE

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Summary: The paper presents some key problems of the relatively new research area which contains – mainly in the domain of technical sciences - problems of the impact of innovative technologies and product on widely seen social dimension ("Technology Assessment" – TA). In particular, the author introduces his opinion about possibilities of implementing research carried on in the discussed area within the scientific discipline Production Engineering and points to the need to take account of this category of problems in curricula of universities, especially technical ones.

Key words: Technology Assessment, engineering education

1. Introduction

In the contemporary world, the world of enormous development of technology, the new questions are asked as following this technological revolution. One of the most significant question is concerned with the potential impact of innovative technologies and product on widely understood society. This question, together with some extraordinary experiences with putting innovative solutions into practice (like project "Manhattan" resulting nuclear weapon), created the background for research embedded in interdisciplinary and multi-threaded area, which contains investigations of impact of innovative technologies and products (so are of "technical origin") on non-technical area, which no doubt contains functioning of human both in individual (unitary) dimension and – may be first of all – in social (group) dimension. The whole area of mentioned issues is named in English literature usually by term „Technology Assessment (TA)". The commonly used approach shows the activities oriented on developing and presenting the opinions about possible (expected?) impact of innovative technologies and/or processes as a specific processes, named "TA processes".

Area of problems described by the mentioned term has kept already its own philosophy, reached out terminology, also the content of the set of participants of TA processes is widely discussed. However, following discussions of scientists focused on these issues one can see a clear vulnerability in some fields. No doubt, the research field which contains methodology of TA processes can be treated as such a "scrap area". There are relatively few research works dedicated to formal identification and description of tasks which constitutes TA processes as well as to tools of solving these tasks. But – in the opinion of the author of this paper – the most important one between these "scrap areas of TA" is the field of education.

We intend to put the criterion of social impact to the set of criteria which are taken into consideration in all possible decisive elements of TA processes. If so, especially two of the set of basic questions: "what?", "why?", "who?" and "how?" have to be answered first of all. We know in general what and why we intend to do.

The first one of the remaining questions should then be formulated as follows: who is (or potentially should be) involved in TA processes. When we will find the appropriate answer, the next question ("how?) appears which in fact needs to be answered in two levels:

1. What kind of competencies (knowledge and skills) is necessary on the participants of TA activities?
2. How to create such competencies, i.e. how to educate participants of TA processes?

Let's state that the TA-oriented research area is very interesting because of many reasons. Overall, investigations of impact of technologies and products on widely understood social live clearly goes beyond the framework not only a single discipline of science, but also a "classic" field of science. This requires so – first of all - join efforts and the involvement of researchers representing really wide range of fields and disciplines of science. The knowledge as well as competencies of representatives of technical sciences as "creators" of products and technologies will be certainly useful, but the participation in such surveys of researchers representing social sciences (sociologists, psychologists or even philosophers), specialists of chosen areas of medical sciences, economic sciences (especially - the science of managing), and – last but not least – legal science.

Coming back to the question about educational dimension of TA: the formulated postulate of interdisciplinarity leads us evidently to the problem of adequate methods and tools of solving educational tasks in the introduced area. Two next parts of this paper shows some thoughts of the author, concerning the above formulated questions.

2. Participants of the TA processes

Some of the problems, mentioned in the introductory part of this paper, were briefly presented by the author in his earlier publications ([1], [2], [3]). In particular, the first approach to the identification of participants of TA processes was introduced in [1] and [2].

The starting point for this identification was based on extracting in the set of the participants some specific subsets:

- Subset of decision-makers treated as the "intermediate" consignees of innovative technologies and products,
- Subset of experts ("asses-makers", i.e. creators of the evaluation),
- Subset of final recipients of the results of the evaluation.

The last one of these subsets contains both the groups (organized or non-organized) which function in the society and the units who are or can be affected by the results of assessment in a final reckoning. Certainly, such a selection is inherently out of focus: decision-makers and experts are not insulated out from the society, therefore they are also the "final recipients".

The Fig. 1 shows a scheme of the above presented selection of the set of TA participants, with regard to relationships involving various subsets/groups:

1. Group of policy makers with the extracted subgroups: senior policy makers (**D1**), regional policy makers (**D2**) and local policy makers (**D3**),
2. Group of experts (**EXP**), responsible for the presenting TA expertise,
3. Group of final recipients (users) of innovative technologies and products (**FRTP**).

It seems to be reasonable to consider in the model presented in Fig. 1 the presence in TA processes also tenderers/supplier of technologies and products (signed as **TSTP**). The relations which are linking the technology suppliers with other participants of TA processes are in Fig. 1 of "one-way" form, but the real nature of these links should be carefully examined in further research.

Apart of being an illustration of the structure of TA processes, Fig. 1 can be also treated as a "road map" of recognizing and solving problems concerned – first of all – with some specific feature of TA participants. Namely, it can give us a possibility to analyze potentials of knowledge and skills in all the subgroups shown in Fig. 1. Such an analyze ought to be based on the following questions which have to be asked (and answered):

1. What is the range of competencies for every subgroup of TA participants which enable them to perform effectively the tasks which belong to them in the discussed processes?
2. How to evaluate the competencies of TA participants?
3. Are there some needs (and possibilities) of extending/completing the existing competencies or building new ones?

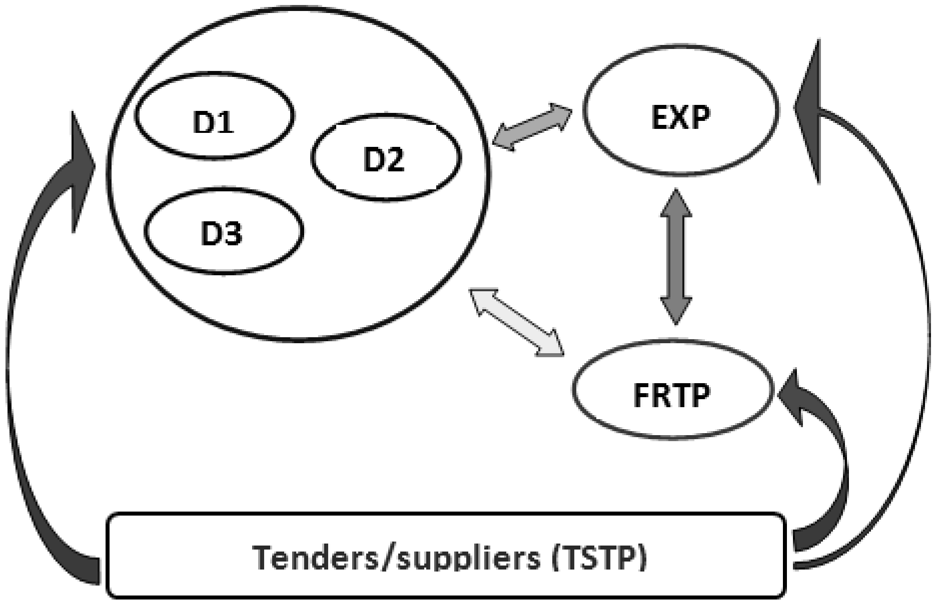

Fig.1. Participants of TA processes and the scheme of relations between them

It is easy to note, that the above formulated questions led us to the problems of education. Probably every mentioned subgroup of TA participants will have specific educational needs. The additional question appears, what is a real scale of necessary educational activities.

Practical cases of TA processes, currently realized and described in publications, are in majority oriented on supporting decision makers of the highest level (**D1**). Such a type of activities has even some institutional infrastructure. In particular, since many years the European network EPTA (European Parliamentarian Technology Assessment) exists and works which is oriented mainly on supporting decisions on level of national (and in some cases – regional) Parliaments [4], [5]).

If we consider the "educational needs" of this subgroup of decision makers, the problem of competencies seems to be not very significant. Especially, because in so limited number of cases it is usually possible to find experts, who are able – in cooperation with the decision makers – meet all the requirements of the terms of reference. But both the so-called „daily practice" and the reported research show that the need for an assessment of the products and technologies appears more and more often on the regional and local level (**D2/3**). Therefore, the factor of scale appears: we need the competent (well-educated) decision makers as well as many competent, interdisciplinary – oriented experts. It shows the educational needs: we need the adequate educational offer for all the mentioned above subgroups of TA participants. There were still reported some research oriented on evaluating competencies of local decision makers in some specific areas, like the urban noise ([6], [7]). It was confirmed that the proper methods and tools of education can increase significantly the competencies of deciders.

We should also remember about the third subgroup of TA participants: direct („final") consumers of the technologies and products, potentially affecting the social environment. It was reported in some publications (like [8] or [9]) that the so called „participatory approach" can be effectively applied for stimulating the active participation of this group in the TA processes. It also creates some – quite specific – educational needs.

3. Proposals of an approach to educating of some of participants of TA processes

Concluding the considerations presented in the previous chapter of this paper it seems to be evident, that the general problem of educating the variety of participants of complex and interdisciplinary processes is not easy to be solved. As in each case of educational problems, the possible solutions are of two main kinds:

1. We can create a totally new educational system, oriented on recognized needs,
2. We can adopt for these needs some existing systems, with necessary modifications as well as extensions.

In his earlier publication [3] author of this paper has presented some reflections focused on a new look at the Engineering, seen as a one of the areas which can offer the "educational background" for the needs concerned with Technology Assessment.

Shorter version of these considerations is presented below, as an illustration of many aspects of educating "new engineers", able to participate actively in TA processes. The modern understanding of the term "Engineering" is focused on evident reference to practice, but creative and conceptually related. This is also clearly expressed that the engineering is based on applied sciences, with important relation to basic research. Let's add that for engineers such tasks as streamlining and modernizing products, services and processes are of high importance. Just this asset of extending the "classic" sense of the role of engineering (and an engineer as the entity of engineering) should form our thinking about problems set in a field of TA. Let's remember that the contemporary understanding and use of the terms "engineering" and "engineer" is far wider than in the "siècle of technology". We are not astonished by terms "bio-engineering", "genetic engineering" or even "social engineering".

We can base the considerations about the engineering as the field of creation and the role of the engineer as a creator, who forms – both in the dimension of abstractive "track" and materialized "product" – the environment of humans in the range of "technosphere" (in opposition to "biosphere"), as proposed many years ago by Professor Janusz Dietrych [10]. Let's consider his model of the "process of meeting needs" (as shown in Fig.2).

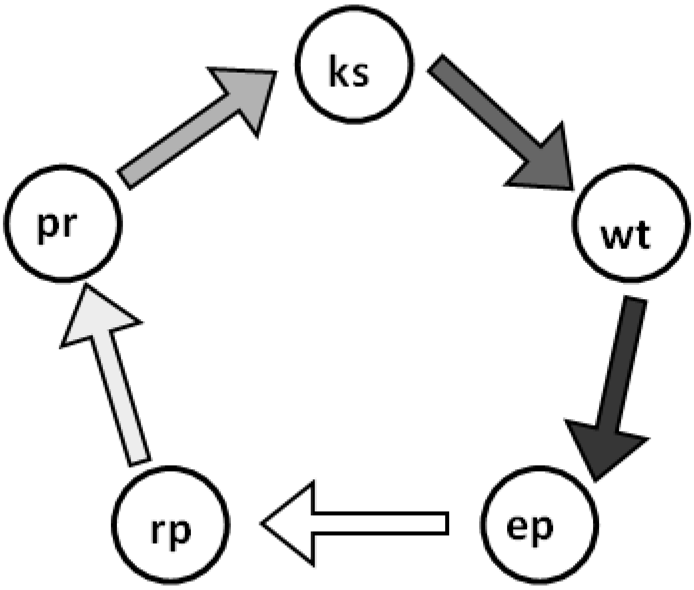

Fig. 2. Model of the process of meeting needs (according to [10])

In accordance with the mentioned model, successive types of engineering activity (**rp** – recognition of needs, **pr** – conceptual designing, **ks** – constructing, **wt** – manufacturing (production) and **ep** – operating with manufactured product) are forming a close loop. The model is based on the assumption that:

1. The "general" engineering contains some "partial" types of engineering activities, in particular: engineering of needs, engineering of designing and constructing, engineering of manufacturing and engineering of exploitation (and maintenance);
2. Because of existing relationship, none of the "sub-engineering areas" can be considered in separation from others,
3. The relation between the phase of operating with product and phase of recognition of needs is of special meaning: set of observation from exploitation and maintenance processes creates the background for starting the recognition of needs in a "next cycle".

In the next cycle as mentioned above, the identified needs should lead to "new or significantly modified" product, process or technology. We can see here the reference to the idea of innovation in its technological aspect.

If we accept the engineering activities as derived from the model shown in Fig.2, it will lead us to some formal operation: "dividing" the field of Engineering into some separate (autonomous?) parts. It is possible to consider four sub-areas in this meaning:

1. Engineering of recognizing needs („Engineering of Needs"?)
2. Engineering of designing and constructing (it seems to be reasonable to consider the activities dealing with abstractive parts of engineering together)
3. Engineering of manufacturing („Engineering of Production Processes"?)
4. Engineering of products' operation („Engineering of Exploitation and maintenance of Technical Systems"?)

It can be easily seen that the proposed areas contain some new challenges. For instance in the model of meeting needs, the new need is coming from experiences of operating with products. In contemporary times, we can note that needs are recognized, but also are stimulated or even designed.

A general concept, as introduced above, offers also some practical remarks, which can be applied as elements of a "guide-book of modern education of engineers". Experience of academic staff involved in teaching activities and then in building the "scientific foundations" of technical education have showed that in many cases:

- a new look at "classic" problem of engineering is necessary when we try to teach students how to manage technical objects and systems. The good example of such situation – derived from my didactic experience - is the difference between the "classic" understanding of area of exploiting of machinery, based on theory of reliability, and the new approach focused on management of exploitation and maintenance of technical objects and systems,
- it is reasonable to displace accents within the particular area of engineering. It is – for instance – the case when we put the main attention not on the base of physical examination but we teach students how to support effectively decisions concerned with the particular technical problems,
- the elements of programs were "classically" treated as belonging to economic or social sciences even if the "technical" aspects of the problem seemed to exist. Thus, it was necessary to extend a "technical leg" in the particular area of teaching. As our graduates have reported, such a "technically-extended" look at problems of management gave them significant advantage in their jobs.

Therefore, if we try to discuss about the didactics containing some specific elements, as excited by TA problems, the above listed cases are also worth to be taken into consideration. Formulating new tasks and targets for developing interdisciplinary educational projects we also ought to think about:

- Redefining the "classic" look at technical (as well as non-technical) areas of research based on needs of management in engineering activities,
- Looking for interdisciplinary areas, exploring both the borders of disciplines within the domain of technical sciences and the disciplines o different domains, "lying close" in a perspective of potentially important research,
- Considering potential niches for research which are still not well-explored or even are not finally defined (and transfer of results of such research into didactics),
- Looking for "external" as well as "internal" niches in the classic curricula of engineering education (as well as in "classic" disciplines of sciences).

4. Conclusions

And now we can ask the question: how to teach the engineers with taking into consideration all the mentioned factors? Evidently, it is only a sub-part of the general question about education of all (not only "technically oriented") participants of TA processes.

The presented in this paper considerations are certainly not complete (and perhaps chaotic), but – in the assumption of the author – should rather present some manner of thinking than to give solutions "ready-to-be-applied".

The introduced above problems, namely concerned with processes of Technology Assessment, creates significant challenges. The challenge for decision makers, who are expected to be competent and rational. The challenge for experts, who ought to combine the experience and knowledge with an adequate ethical behavior. The challenge for „final consumers", who should be ready and competent in taking active (participatory) part in the processes. And in general: the challenge for systems of education, seen as a synergy of interdisciplinary contents, modern curricula and teaching media and – last but not least – people who can effectively ply the role of "educators".

It has been the intention of the author to introduce his point of view, mainly as an accelerator for further debate. Such a debate, with participation of scientists of many disciplines as well as practitioners, should significantly improve the quality of education, not only TA-oriented.

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