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Kornelia Konrad

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Constructive Technology Assessment – Linking TA to Innovation Processes

Kornelia Konrad
Science Technology & Policy Studies (STePS), University of Twente, the Netherlands

Science, Technology, and Policy Studies (STePS)
Faculty of Behavioural, Management and Social Sciences
University of Twente
P.O. Box 217
7500 AE Enschede, NL

www.utwente.nl/en/bms/steps/

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Contact
Kornelia Konrad
STePS, University of Twente
k.e.konrad@utwente.nl

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ABSTRACT

Constructive Technology Assessment (CTA) aims at integrating anticipation and assessment of technologies into the development and societal embedding of technologies. This paper explains basic theoretical underpinnings of CTA and how concepts and knowledge of science, technology and innovation studies inform the methods and forms of CTA. Finally, it reflects on the possibilities and conditions for CTA approaches in different contexts and due to developments in the science policy and educational landscape.

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1. INTRODUCTION

In line with its origins, technology assessment (TA) is mostly understood as a form of policy advice. In addition, supporting an informed, critical public and mediating between the public and policymakers is another important role (van Est & Brom 2012). A core aim of TA is to identify and assess possible societal *impacts* of a technology, a plausible objective from the perspective of policy and the public. Accordingly, the conceptual underpinnings of these forms of TA typically refer to political and democratic theories.

Constructive technology assessment (CTA) takes a different starting point, namely processes of technological development, innovation and the societal embedding of technologies. CTA inquires into how technologies and their societal embedding can be *shaped* in such a way that impacts are likely to be socially desirable. These aims are not contradictory - at least if one disregards very early TA ideas that started from a more or less given technology - but it constitutes a change of perspective that brings other actors and other theoretical perspectives to the fore. In the 1980s and early 1990s, at the time when CTA emerged, this turn to technology development as a starting point for TA efforts was rather exceptional. In the meantime, various related concepts have formed, such as real-time technology assessment (Guston & Sarewitz 2002) or value sensitive design (Friedman 1996), that are close to CTA or explicitly take up its core ideas, but exhibit methodological or conceptual differences (for more detail see for instance chapter 3.4 in Grunwald 2019).

In the following, first the basic theoretical underpinnings of the constructive technology assessment approach will be explained. Then I show how concepts and knowledge of science, technology and innovation studies inform the methods and forms of CTA. Finally, I reflect on the specific possibilities and conditions for conducting CTA in different contexts and due to developments in the science policy and educational landscape.

2. WHY *CONSTRUCTIVE* TA? THEORETICAL UNDERPINNINGS OF CTA

The core ideas of constructive technology assessment (CTA) were formed in the late 1980s and especially the 1990s in Denmark and the Netherlands (Remmen 1991; Schot 1992; Schot & Rip 1997; Rip 2018) and have been further developed for various settings since the 2000s. Forms of CTA have been taken up in different countries in Europe and outside. Still, a review of academic literature indicates that many activities remain concentrated in the Netherlands.[1] The term Constructive Technology Assessment expresses CTA's aim to contribute to the construction of new technologies and the way technologies become embedded in society.

The theoretical background of the turn to processes of technology development, innovation and societal embedding form a number of social-constructivist research lines such as social construction of technology, social shaping of technology, (quasi-)evolutionary models of innovation and science and technology studies. All these approaches do not take technologies and their specific form for granted, but rather examine how and why certain technologies are shaped in particular ways and by whom. To anticipate on a recurring objection: a social-constructivist understanding of technology does not imply that technologies can be designed arbitrarily according to whatever interests certain actors may hold. Actually, technology dynamics and path dependencies are an important subject of investigation in these research lines as well. Still, it is assumed that technologies can be shaped in different ways and that an understanding of the underlying socio-technical processes allows *to some extent* to anticipate

[1] This is indicated by the number of entries in the Scopus literature database that are retrieved by a search on "constructive technology assessment".

possible directions of development, impacts and ways to influence them. Furthermore, these approaches ask whether legitimate needs and interests of certain groups of actors risk to be neglected in the process of development and societal embedding.

With the turn to innovation processes and thus also innovation actors, in addition to policy and regulatory actors as primary agents, many other groups of actors and processes that can or should have an influence on the shaping of technologies and their societal role come into view. Here, too, I would like to emphasize that policy and regulation are by no means outside the radar of CTA approaches, but rather that they are seen as a group of actors shaping innovations alongside others. Their specific role may vary from case to case.

An important conceptual starting point for CTA is the so-called Collingridge dilemma (Collingridge 1980: 17f.). According to Collingridge, in the early phases of technology development there is plenty of room for shaping technologies and their use, but comparatively few knowledge for evaluating possible design variants and their societal effects, as exactly these social consequences are still very uncertain. In later phases, when technologies are in use and more and more strongly anchored in social structures, appraisal and evaluation are more realistic, but the scope for shaping technologies and the way they are embedded in society is greatly reduced due to the very fact of being already firmly rooted in society. The dilemma does not seem to be easily resolvable. Collingridge (1980: 20) himself advocated as one solution to keep technologies as flexible as possible in order to preserve possibilities for intervention in later phases.

As compelling as this diagnosis may be, it is worthwhile to consider that the Collingridge dilemma actually describes two extreme states. In between these states, a more or less continuous transition from rather high configurability and uncertainty to increasing consolidation can be expected. In addition, depending on the specific technology area, the degree of reversibility and possibilities to assess can be very different, as may become apparent when comparing software technologies to large infrastructure systems[2], or specific products and applications compared to more generic cross-cutting technologies such as nanotechnologies. Therefore, we are not dealing with a yes/no decision (Rip et al. 1995: 7), but with gradations to which approaches have to be adapted. Often in early stages there is no need to finally decide for or against a technology, but rather to provide clues in a stepwise manner, as to which development directions are likely to be more or less socially desirable. CTA suggests to include TA early when a technology and its social embedding still offer leeway, and it addresses actors - though not exclusively - who are involved in the ongoing technology development and innovation processes. In this way, TA should become linked to innovation activities.

Another key assumption is that actors who have different positions and roles in relation to the technology in question also have different perspectives and tend to assess the development and possibilities differently. What is more, it is not to be expected that different actors will readily anticipate and take into account the positions and assessments of other actors. This assumption builds on the work of Garud and Ahlstrom on different assessment strategies of insiders and outsiders in a technology field, also referred to as enactors and selectors in the CTA context (Garud & Ahlstrom 1997; Rip 2006). Enactors refer to those groups who actively promote a certain technology development, typically place this at the center of their considerations and often have a positive bias, while selectors refer to those groups of actors for whom the same technology is only one possible option among others. The consideration of different stakeholder perspectives is a feature shared with many other participatory

[2] The material effort to change a technology is of course only one aspect besides more social path dependencies, resulting from institutionalization, established user habits, standardization etc.

TA approaches. CTA work often takes a stakeholder approach, focusing on and differentiating groups of actors according to their presumed role with regard to the technology considered, be it in the innovation and embedding process or in the expected use, rather than addressing the general public (Rip & Robinson 2013: 47).

A third constitutive assumption of CTA is that despite the fundamental limitations of the possibilities of anticipation, the co-evolutionary development of technologies and their societal embedding still follow regularities and patterns. Such dynamics and patterns occur on different levels and in different areas, ranging from industrial dynamics to processes of user appropriation and from local micro-level processes to meso level dynamics in research and technology fields to society-wide processes. Accordingly, CTA uses various socio-technical concepts and theories in order to identify and study ongoing socio-technical dynamics in the field of interest and to speculate in a 'controlled', that is empirically and conceptually informed manner about possible future developments that practitioners in their day to day business are less likely to take into account (Parandian & Rip 2013: 2). These possible future developments are then condensed in the form of socio-technical scenarios that serve as starting points for discussions and reflection in stakeholder workshops.

3. METHODS AND CHARACTERISTICS OF CTA - THEORETICAL MEANS AND INTERPRETATIONS OF CTA PROCESSES

How are concepts and theoretical elements of science, technology and innovation studies used in the concrete implementation of CTA projects? Generally, the core idea of CTA to introduce TA elements early on in the technology development allows for quite some variety in the concrete methodical implementation, and the different research groups and institutions that have applied CTA for diverging technologies and contexts have all done so in their own ways. In the following, I will first concentrate on CTA forms that have been used in multiple projects at the University of Twente. In these projects theoretically informed socio-technical scenarios constitute an important element. In the remainder of the paper, CTA variants developed and used at other institutions will be addressed as well.

As a first step, we usually conduct a thorough analysis of the technology field in question, such as a specific application field of nanotechnology. This analysis is guided by theoretical perspectives that may vary from case to case, and reflect to some extent the analytical interests of the CTA analysts. In any case, the perspectives need to capture processes that are essential for the current and further development of the field, technology, or product at hand. The decision on the focus to take requires usually a first open exploration phase. Which processes are most relevant may depend on the type of innovation, its stage of development, or whether the study addresses an emerging technology field or a concrete product. Emphasis may be given to innovation dynamics, user practices or governance interventions, to processes within the field or its wider environment. Thus, it is necessary to be open to draw on various strands of science, technology and innovation studies.

Therefore, choices need to be made as to which potentially relevant aspects are considered. Overall, the analysis should be rather broad, for example, by including multi-level dynamics (Rip & te Kulve 2008; te Kulve & Konrad 2017a; Stegmaier & Visscher 2017). This preliminary analysis may already generate contacts with actors in the field, e.g. through interviews, attending congresses or via a wider project contexts, as in the Dutch nanotechnology programs NanoNed or NanoNext (Rip & van Lente 2013). Here, too, breadth and intensity may differ, ranging from selective contacts to a continuous involvement in the circles of innovation actors (Rip & Robinson 2013). These studies do not only use concepts of science, technology and innovation studies; they partly also form the starting point for research in its own right (Parandian et al. 2012; te Kulve & Konrad 2017a; Loft et al. 2022).

On the basis of these preliminary studies, socio-technical scenarios are developed (Rip & te Kulve 2008; te Kulve & Rip 2011). These scenarios are not necessarily aiming at long-term consequences, but rather anticipate, on the basis of developments that are already taking place, multiple development directions that could plausibly emerge from ongoing developments, as well as which events, strategies or context developments may contribute to or impede certain directions. This approach is in line with the mentioned idea of emerging irreversibilities, that is gradually developing stabilizations. Technical and scientific innovations may break up existing structures and initially create more openness and uncertainty for further developments, yet these developments may also solidify into new patterns and institutions, such as dominant designs, actor constellations or industry standards (Rip & te Kulve 2008). These stabilizations gradually make some directions more difficult and others easier, though not in a deterministic sense.

Finally, conceptual elements of science, technology and innovation studies inform the scenario development as well, in the sense of a theoretically informed scenario development, not a strict implementation of a particular scheme (for a detailed example see Parandian & Rip 2013). As with the preliminary analysis, the used concepts depend on the specific field and the perspective chosen. Examples would be recurring niche dynamics, multi-level dynamics that also include sector developments, further social, political and cultural developments, strategic games, possible dynamics and changes in actor constellations, typical dynamics of technology expectations or the interpretative flexibility of a technology (Parandian 2012; te Kulve 2011; Robinson 2010; Konrad et al. 2006). In a study on applications of nanotechnologies in the areas of food and water, possible applications and user needs were examined, just as the processes that lead to the formation of specific needs and user requirements. It became clear that usage scenarios and user needs were not clearly structured at the time of the study, rather the field was in a process of ongoing development, formation and articulation of forms of usage and needs. Furthermore, this process was not confined to the world of users, but involved actors and processes across the entire sector and its regulatory environment (te Kulve & Konrad 2017a; 2017b). Accordingly, actors across the sector and from regulatory organizations were included in the CTA workshops.

This study focused on the interaction of a technology field with sector dynamics. Other CTA studies examined the expectations, perceptions and evaluations of various actors in the health sector, in particular of patients, for applications that enable or require self-management and technically mediated relationships between patients and medical staff. These studies also dealt in more detail with specific products and their design rather than with an entire field of technology (Maathuis 2014; Krabbenborg 2013).

The socio-technical scenarios serve as a basis for bringing together different stakeholders in workshops and creating a dialogue that allows them to reflect on possible future developments that reach beyond the horizon of day-to-day concerns and reflection. A clear link to current developments and problem situations is important though, not the least in order to create interest among the participants. As for the selection of actors, it is important to include influential actors in the field, just as 'latent' stakeholders, whose perspectives and evaluations may else be easily overlooked. Sometimes, actors need to be brought into conversation who are in principle well aware of each other but have few points of contact in day-to-day business. These workshops are intended to give the participants the opportunity to question and further develop their own perspective, their own assessments and strategies in dealing with the perspectives of actors who relate to a technology in different ways.

The topics, the scope and the degree of concreteness of the scenarios can differ considerably from one CTA study to another. Common traits are their often narrative character, a rather smooth transition from reconstructing previous developments and events to speculative future developments, and the exploration of effects of strategic actions and possible future events. These scenarios constitute not so much an abstract description of differently structured contexts, a common trait of 2-dimensional scenario sets. Therefore, it is easier for participants to feel involved in the possible developments and 'worlds' and to imagine possible implications. According to Krabbenborg (2013), the resulting interactions and discussions in a workshop can be understood as a form of dramatic rehearsal in the sense suggested by the pragmatist Dewey (1957). Such a dramatic rehearsal enables the participants to imagine and reflect on how social practices may develop, how roles and responsibilities of actors may change, which problems may arise, and concrete implications for groups of people and particular situations.

The workshops are supposed to unfold their effects in particular through learning processes among participants, or through the formation of new networks. Such learning processes were traced systematically in some of the projects (Parandian 2012; Krabbenborg 2013; van Merkerk & Smits 2008). Learning processes related to possible development paths and their wider implications, to the perspectives of other actors or, in a more general sense, attention was drawn to social aspects that were not considered in the day-to-day business of participants. This may seem modest, but it corresponds to the concept of soft intervention, i.e. modulation of the so-called de facto governance of innovation (Rip & Robinson 2013). The idea of soft intervention builds on the assumption that the governance of innovations cannot be steered directly towards certain goals, but rather modulates ongoing developments, for example by changing which future developments actors anticipate and consider (Rip 2010).

Thus, CTA can be considered a form of technology assessment in which the forward-looking element has shifted from primarily anticipating the consequences or social implications of a technology to anticipating possible forms, development directions and ways of using a technology or a technology field in the first place. This applies in particular to work that deals with so-called emerging technologies. Since CTA is grounded in a co-evolutionary understanding of technology and society, according to which social consequences of technologies are not a unilateral result of a given technology, but rather co-develop in socio-technical constellations that mutually influence each other, social impacts are nevertheless considered. Social implications are part of the emerging or changing socio-technical constellations that include technical innovations as well as their forms of use, institutional and organizational changes or possible indirect and far-reaching changes that are only partly influenced by new technologies. Since this is generally a step-by-step and complex process, impacts are not defined once and for all, and the scenarios are often open-ended. Just as for the assessment of possible developments, CTA mostly does not aim for conclusive, unambiguous judgments. It rather aims at making the evaluations and underlying assumptions of various groups of actors visible and discussable, similar to many other participatory-deliberative processes, and at integrating them into an open-ended collective process of reflection and evaluation.

4. CONTEXTS AND CTA VARIANTS

As mentioned above, CTA is an approach, not a precisely defined method. The specific form a CTA project takes depends on various aspects, some of which are due to the specific context of a project, such as available resources, the time frame, the type and state of development of an innovation, the involved actors, the expertise of the CTA analysts and the institutional and political-cultural context.

In section 3, I referred to CTA studies that work with narrative scenarios exploring complex developments over time. The development of such scenarios requires, however, quite specific knowledge of processes and actors in the respective field, and these scenarios also expose the recipients to a considerable degree of complexity. Some CTA studies have worked with more sketchy scenarios that describe alternative, possible future constellations rather than detailed pathways (Hamaker-Taylor et al. 2018; Fleischer et al. 2019; Stegmaier 2020). Such scenarios still allow to discuss implications of these constellations for different groups of actors, but lack the assumptions made in the dynamic scenarios about events and strategies that may lead to these constellations. Another option is to include a step before the development and collective discussion of scenarios, in which the envisaged participants formulate scenarios individually, and thus make implicit ideas explicit and comparable (van Merkerk & Smits 2008). In a similar vein, Hamaker-Taylor et al. (2018) used individual interviews on possible future alternatives instead of collective workshops, when stakeholders were not willing to join a more time-consuming workshop set-up. Thirdly, Roelofsen et al. (2008) developed scenarios that were considered desirable by the participants, and thus served as a normative orientation rather than as an open-ended exploration of possibilities (Roelofsen et al. 2008).

The variants mentioned so far differ with regard to procedures and set-up. CTA scenarios may furthermore differ with regard to the type of co-evolutionary processes examined. Philosophically inspired approaches have focused on co-evolutionary dynamics of technologies and moral standards, social understandings and conventions of normality, or changing human-technology relationships (Boenink et al. 2010; Stemerding et al. 2010; Boenink et al. 2011; Kiran et al. 2015). As visible in the very term constructive technology assessment, CTA was primarily developed with a view to technical innovations. In some studies, the CTA methodology was also used for non-technical, or at least not primarily technical innovations, for example for social innovations such as certain participation processes (Voss 2016), service innovations such as climate services, or governance innovations in the form of governance arrangements and business models in the field of forest ecosystem services (Stegmaier 2020).

All these CTA forms were mainly carried out as social science projects, even if some were part of larger, technology-oriented research and innovation programs. In the context of these larger research programs, the ambition emerged to link CTA more closely to the technology-focused research projects, ideally across the program as a whole (Rip & van Lente 2013; Walhout & Konrad 2015). Therefore, we have experimented with different forms of compact CTA variants - also referred to as CTA-lite – that are largely carried out by the technical researchers themselves, often doctoral students, in some cases also senior scientists, under guidance or supported by people with CTA experience (Schulze Greiving et al. 2016; Schulze Greiving & Konrad 2017). This approach corresponds well to the core idea of CTA of closely connecting TA activities with ongoing development. However, the limited time resources and the fact that concepts and methodology have to be designed in such a way that they can be grasped and executed by people who did not follow a professional social science education requires to work with concepts and methodologies that are to some extent simplified and ask less time and effort. Possible elements are for instance the analysis of possible socio-technical configurations in which an innovation may be embedded or a stakeholder analysis, sometimes complemented with stakeholder interviews or an expert workshop. This setting implies some limitations, but it allows to expand the scope of the use of CTA approaches. Such an expansion of the scope of CTA studies has been facilitated by institutional and political conditions that have called for such a far-reaching integration of TA approaches, respectively forms of responsible research and innovation, into the corresponding research programs (Walhout & Konrad 2015).

In a similar direction points a decision of the University of Twente that requires all bachelor programs to include educational components that allow and encourage students to reflect on the conditions and implications of their research and disciplinary work from social, ethical, historical and philosophy of science perspectives. In this context, similar CTA elements as those described above were integrated into some programs, linking them to the graduation theses. Also some master programs have introduced such elements. In the context of teaching, the goal is not necessarily to immediately influence innovation activities, even if the qualification work is partly integrated into ongoing research. The aim is rather to generate learning effects and sensitize students, some of whom will be the technology actors of tomorrow, in a way that it becomes more concrete by relating it to the students' thesis topics. Some of the students can connect to actual stakeholders by conducting interviews. Furthermore, as a way to make stakeholder perspectives and interactions more tangible, Visscher (2020) has developed an educational workshop format that draws on elements of the CTA approach and methods of improvisational theater.

It is still too early for a final evaluation, but these examples indicate that in the context of ongoing developments in the scientific and university landscape – albeit cautious and often controversial – opportunities for new starting points and forms of constructive technology assessment arise.

5. CTA IN A CHANGING INNOVATION ENVIRONMENT

In this article, I have outlined essential conceptual and methodical elements of a TA approach that aims to closely involve technology and innovation actors in the TA process, and that builds to a large extent on approaches and insights from science, technology and innovation studies, both in its motivation and methodological design.

As indicated by the structure of the chapter, the history of the CTA approach can be roughly divided into different phases, starting with the theoretically inspired development of the core ideas and first attempts at implementation in the 80s and 90s. In the 2000s, we see various projects drawing on the CTA approach, experimentation with, but also some consolidation of methodical approaches. At the same time, TA approaches with similar goals have emerged that explicitly refer to CTA as a source of inspiration, for example real-time technology assessment in the USA (Guston & Sarewitz 2002), but that could not be dealt with more closely in the scope of this chapter. In the last five to ten years the subject area has been expanded and accordingly we see further experimentation with methodological variants.

It remains to be seen which CTA forms prove most useful in particular institutional contexts, for which types of innovation contexts, and which new members may be added to the CTA family. Relevant differences may not only refer to whether innovative elements are pending towards the technical, social, service or governance area, or whether early, so-called emerging technologies are investigated, some of which may still be largely imaginary, or concrete, tangible products. A further question refers to differences in innovation processes, systems and cultures. Are innovation processes widely distributed, even globally spread, or more locally organized? Are processes open or closed? Such questions are relevant for all TA approaches, but are particularly salient for an approach that aims to analyze and assess technologies not only from a distance, but to proceed in close contact with innovation processes. I would welcome if this article motivates some readers to take up these questions and the challenges that are part of them.

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UNIVERSITEIT TWENTE
Drienerlolaan 5
7522 NB Enschede

Postbus 217
7500 AE Enschede

053 489 9111
info@utwente.nl

UNIVERSITY OF TWENTE.