Science vs. Technoscience

a primer (*with an appendix on 'technology,' 'engineering' and the need for making the science-technoscience distinction*)

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future versions to draw on the contributions of many others

While the distinction between science and technoscience is analytically sharp, it is not classificatory or taxonomic. Many concrete research practices of the particular sciences or technosciences cannot be attributed unambiguously to the ideal-type of science or of technoscience. This is not surprising since the researchers have been socialized for both roles and since research is framed in both respects. And yet, matters get less ambiguous when one looks closely at a particular way in which researchers relate to an object and at the way in which they present this object in a research publication.

Even where one can look at research from either perspective, it makes a big difference whether a research practice is considered to be scientific or technoscientific. After all, depending on the choice of perspective
- theoretical physics/evolutionary biology command the most prestige ***or*** chemistry/environmental science
- research advances universal Enlightenment and search for truth ***or*** demands for innovation.

For the collaborators in the GOTO project, the purpose of this table might be to situate their object of interest in this field of tensions – or to see where it disrupts it.

Science – the knowledge-production of *homo depictor* that often uses technology to create phenomena and make representations (e.g. theories, models, diagrams)	**Technoscience – the knowledge-production of *homo faber* that often uses scientific representations (e.g. theories, models, diagrams) to make things work**
description of practice in contexts	
there is a rich interplay of "intervention and representation" in terms of research technologies, instrumentation, theory, experimental technique, modeling practices	there is a rich interplay of "intervention and representation" in terms of research technologies, instrumentation, theory experimental technique, modeling practices[1]
this interplay takes play in the service of producing true (correct, empirically adequate …) representations – here, research technology is required, for example, to establish laboratory conditions that isolate causal processes	this interplay takes place in the service of establishing predictive and technical control of phenomena and processes – here, for example, theories appear as tools (algorithms) for constructing models of the phenomena
objective knowledge is propositional: hypotheses, theories, statements of fact have been found to be true or false, empirically adequate, more or less probable, predictively correct	objective knowledge consists in the acquisition, demonstration, and reporting of capabilities to produce processes and phenomena (this can be basic knowledge when it involves fundamental capabilities of measuring, visualizing, modelling, manipulating)
the standard scientific paper takes the form "We tested a hypothesis" or "We produced evidence that serves the evaluation of a hypothesis"	the standard technoscientific paper takes the form "We have produced this phenomenon" or "We made a nano-widget"[2]
there are boundaries between science and the public (expert vs. lay knowledge), lab and field	porous boundaries and mixed practices, "mode-2", new social contract, entrepreneurial, post-normal
science and technology are thought to be distinct, much technology results from the application of science (linear model)	the term "technoscience" indicates that science and technology cannot be held apart (hybridization) – the distinction between basic and applied is not possible
corresponding idea of pure or basic science, technology is either a research-tool subservient to	so-called basic science develops theories as tools for so-called application-oriented science; research

science or an outcome of "pure" science	develops very basic capabilities for manipulating, visualizing or modeling phenomena and processes
philosophical characterization:	
how to bridge mind and world? (how can one achieve agreement between theory and reality?)	what is the relation between making and understanding ? (how can one achieve understanding through making?)
since the rich interplay of representing and intervening is to result in a representation of a mind-independent reality, it requires a work of purification: in order to discern the mind-independent features of reality, one has to distinguish in an observation (in the field or of an experiment) between what owes to the world (facts) and what owes to the conceptual and technical contributions of the researchers (artifacts) – this is an attempt to determine the moment when human activity (creation of experimental setup) stops and when "mere observation" begins[3]	the work of purification has been abandoned either because it is impossible or because it is unnecessary or both: – *impossible*: while in a classical experiment, facts and artifacts can be separated ("we make the vacuum, nature makes the column of mercury fall"), technological conditioning extends further, for example, in experiments with specifically tuned laboratory animals or plants – *unnecessary*: where research proceeds in the manner of building and making, in a design mode[4]
ontological concern: the need to distinguish true evidence from experimental artefacts – if you are seeking to ascertain the existence of the Higgs Boson, you better make sure that it has a mind-independent reality and that it is not an artifact of the experimental set-up[5]	ontological indifference of the maker and builder: if you are working to control the growth of carbon nanotubes, the question does not arise whether the resulting structure is natural or technical: indeed, it is supposed to be an artifact, co-produced by nature and the technological set-up [6]
questions of ontology	
the world is made of facts and not of things	things exist in their own right, they are attractive and powerful
the thing thus becomes the *Gegen-stand*/object (*ob-jacere*) – it is that which opposes the subject and that becomes "secured" in true propositions that express facts	things demand intimacy, things are partners that afford possibilities, create successful connections to the world
dispositions – permanent property that allows for substantial definition and support the work of purification as one learns facts about the behavior of substances	affordances – a relational property that becomes salient only in respect to human purposes and material agencies
substantia – gene as explanatory concept in theories of heritance with variation – carbon as element in the periodic table	*potentia* – gene as tool for bioengineering - carbon as a device affording functionalities
what an object is, it is forever (appears immutable, timeless, depersonalized)	what an object is depends on its own contingent history (biography, agency, subjectivity)
nature as a given exhibits resistance and recalcitrance, leads to compromise and negotiation	world as field of potential to be explored and opportunities to play with
stability and instability – control is vertical, mastery that serves as evidence for truth of theories	control and surprise – control expands horizontally as stabilization of surprising properties and the performance of objects
limited world: conservation laws are constitutive – adaptation to limits that are posited as absolute – to the extent that researchers are concerned to explain or represent things theoretically, they are living in a limited world and play zero-sum games	limitless world: conservation laws are a technological constraint with the mandate to liberate powers of renewal, expansion, dematerialization, intensification; researchers are seeking to transgress limits, create sustainable win-win situations
questions of epistemology	
controversies about realism vs. constructivism, about the rationality of theory choice, about models as intermediaries (fictions, similarity), about truth	emerging discussions concerning the reducibility of know how to know that, about the justificatory role of technological functioning, about iterative procedures and the possibility of internal, seemingly circular validation
how do propositions about the world become	how to judge claims of having achieved a technical

justified by evidence from the world? how important is it for the justification of belief about the world that it is demonstrably non-circular? for questions of scientific knowledge the problem of external validation is the main philosophical concern	capability? does the existence of a thing, does the demonstration of an object's competence to perform (e.g. the working of a machine) validate or vindicate itself or stand in a relation of mutual reinforcement with other technical capabilities? for questions of technoscientific knowledge the problem of (seemingly circular) internal validation is the main concern:
hypothesis-testing as typical research genre	proof of concept, demonstration of capabilities as typical research genre
objectivity results from the elimination of distortions that may have been introduced by the subjective and historical contingencies at the time of discovery and invention – it is intersubjectivity achieved over the course of time and of extended, temporally unlimited discussion that approximates but never achieves the final truth (Enlightenment as a historical process)	objectivity results from the delocalization of laboratory objects as they acquire stability and robustness and as they move out of the laboratory and into the world (conquering the globe)
credibility and trustworthiness rests in an ideally unbiased, uncontaminated, impartial, critical expert culture	credibility and trustworthiness results from social and technical robustness, multi-expertise of all stakeholders as objects are integrated into the mundane

… and what about "technology"? [7]It is a complex of techniques, devices, systems, practices through which humans regulate their relation to the material world (which may well implicate other humans).[8] As such it is a bit like language which is a complex of gestures, vocabularies, grammars, practices through which humans regulate their relation to other humans (which may well implicate material things). Indeed, one could stretch this further and consider language a technology and technology a language. Trivially, both technology and language play a role in science and in technoscience and both can be affected in their development by science and by technoscience. *So, "technology" is obviously a much broader notion than science or technoscience and cannot be assigned to one or the other.*

… so what about engineering and the engineering sciences?

Engineering is the designing, producing, crafting, building and making, modifying and implementing of technical artifacts, procedures, systems. Again, this is a much broader notion than technoscience or science. Engineering often involves old and familiar design principles, a lot of work is vested into adapting technologies to the specific requirements of use. The functioning of a technique, device, or technical system is its criterion of success. Though scientific and technoscientific knowledge enters in, engineering is a lot more than the application of scientific, technoscientific, engineering scientific knowledge.[9] This is why technoscience is here defined (see above) as the acquisition and demonstration of capabilities of control and not as the building and making of artifacts.

And this leaves finally the systematization and formal teaching of engineering knowledge, including the *engineering sciences* (a term coined only in the 1960s). These can be considered as sciences, of course, especially to the extent that they seek to represent technical artifacts, to figure out how they work. They arrive at true propositions regarding the means necessary to achieve an end, to elaborate a body of knowledge about the interaction of materials in design contexts etc. Like any other science, the engineering sciences produce propositional knowledge that will be judged true, false, probable as a measure of achieved agreement between theory and reality. And the history of the engineering practices, professions, and sciences will reveal that on many occasions they affiliated themselves with the larger Enlightenment ideals of the scientific enterprise with theoretical physics as its standard bearer. But formal engineering knowledge and the engineering sciences can also be considered as technosciences to the extent that they are interested in the creation of artifacts.[10] They rely on model-substances, model-organisms as prototypes to rehearse general capabilities of intervention and manipulation and transfer to other objects. In these contexts, they use theories as tools and are not involved in hypothesis-testing. The criteria of success lie in the demonstrations of achieved capability (not in the functioning of a concrete device, not in a proof of truth of a proposition). And rather than promote Enlightenment as an unending quest for truth, the engineering sciences are committed to innovation. In other words, the distinction between science and technoscience cuts across the specific disciplinary differences between and among research practices in the engineering sciences, social sciences and humanities, nursing science, chemistry, physics, and all the rest.

While the terms "applied science" and "engineering science" are well established and adopted by research communities, this is not the case (as yet?) for the term "technoscience." And thus, finally, the most important question of all: ***Why should we make the science-technoscience distinction at all?***

Perhaps the readers of this are now convinced that an analytically sharp distinction can be made along the lines suggested here. They will also note, however, that the distinction does not cut nature (or in this case: human research practice) at its seams: Along the lines suggested by Max Weber, it is not classificatory or taxonomic but isolates two ideal-types which serve as orienting myths, analytical perspectives, and "images" of the role of (techno)science in society. So, why bother to maintain this distinction at all? Wouldn't it be easier to just lump everything together under "science" (the majority view) or "technoscience" (sometimes attributed to "controversial" theorists like Bruno Latour or Donna Haraway)?

- Like all conceptual tools, the distinction helps us formulate questions, identify relations, address problems that we couldn't before. Regarding science/society relations, this was accomplished by the similar mode 1/mode 2 distinction, regarding the self-understanding and "image" of science this was accomplished by the similar academic/post-academic distinction, regarding the science-technology relation this was accomplished by Forman's modernism/postmodernism discussion. In these pages here, the emphasis is on question of epistemology, methodology, ontology, on philosophy and history of science and the relation between the two. As the philosophy of simulation modeling has demonstrated already, technoscience raises new questions that cannot be addressed with the conceptual means of traditional philosophy of science.

- It is no accident, of course, that these distinctions have come to the fore in recent years. They help to articulate or "give voice to" ambivalence within research communities (including those of history and philosophy of science). "We couldn't have published papers like this 20 years ago," "What these physicist do is no longer physics," "We are learning to be quite good at producing hype, but ours is really basic science as usual," "In terms of quality, this is still good science, except of course, that it isn't science anymore" – statements like these express ambivalence or inner conflicts about the different ways of valuing and pursuing research. Even if science and technoscience have co-existed for a long time, there has been a rise of technoscience in recent decades in regard to cultural prestige, societal expectation, sense of historical mission. And this conflict in the way of valuing research may become more poignant and pressing if the change in research technologies makes it objectively more difficult, if not impossible, to satisfy the epistemic values of science. Thus, the question about science as part of Enlightenment and technoscience in the service of innovation raises a larger societal issue: "What do we want from academic research, from our universities and institutions of higher learning"? And the question whether the epistemic values of science can still be satisfied to the extent desired (e.g., whether we can have the kind of true propositional knowledge that is taken to be required to manage the modern world) raises important questions about new methodologies of social learning, political decision-making, the interaction between research communities and publics.

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[1] Ian Hacking has drawn attention to this interplay and did not distinguish between science and technoscience: His book is addressed to the activities of *homo depictor*, it considers science an activity of representing the world but argues that intervention (the creation of phenomena) and theory both produce representations. Since Hacking cuts across science and technoscience, some philosophers and many historians of science take it as license for not distinguishing (or seeing no need to distinguish) between science and technoscience.

[2] This was pointed out/parodied with particular clarity in a lecture by Richard Jones (S.NET 2010 in Darmstadt), mentioned in Jones 2011, see also www.softmachines.org/worldpress/?p=73

[3] This is how Bruno Latour defines technoscience – it is *all of science* once we understand that a work of purification is required that tries to separate out the different elements or agencies whose association was required in the first place. An additional Latourian claim appears to be: though the work of purification – which defines modernity – was always difficult, perhaps futile, it is getting increasingly difficult in a world where the hybrids take over.

[4] This is a criterion for distinguishing science and technoscience: is the work of purification pursued or not? However, the two reasons for not pursuing it point in two very different directions and thus to an ambiguity in the notion of 'technoscience': Does the technological conditioning of research practice transform it to the extent that notions of explanation, understanding, modeling are transformed, too? (In the quest to "penetrate" reality deeper and deeper and to elucidate ever more complex situations, one finds that one can only understand in the course of making or of reproducing the phenomena and no longer by way of producing representations.) Or is research shifting to an engineering mode in which the actual control of complexity is the more urgent and feasible challenge than the development of theory? If there is a here a divergence of motives (backing into the corner of technoscience vs. developing the regime of technoscientific promising) this may still involve a convergence in terms of methodology, conception of research objects, etc.

[5] Because of this distinction between ontological concern and ontological indifference, another juxtaposition does not appear in this list, that of matters of fact and matters of concern (Latour) – matters of fact are also a matter of concern, namely the concern for purification, detachment, etc. And Latour's matters of concern are not only matters of public interest/concern but also of curiosity.

[6] Daston and Galison point to ontological indifference towards the end of their book on *Objectivity* – when they ask whether the problem of 'objectivity in/of science' is presently undergoing another shift, one so profound that one exits, in a sense, their history of objectivity.

[7] Nothing depends on the following definition – it is yet another in a long list of proposals (see Jean-Claude Beaune's list of 46 definitions). The upshot of this paragraph is in the last line.

[8] In the German language, there is a difference between *Technik* and *Technology*, sometimes translated as *technics* and *technology*. Under the influence of English usage, it is getting more and more difficult to maintain a clear distinction. Since *Technologie* contains within it a reference to the *logos*, we are inclined to associate

particular devices and techniques with *Technik*, and as *Technologie* technical systems, infrastructures, procedures, and the formal setting in which particular techniques and devices are employed, produced, taught, or made sense of. The definition of technology given here encompasses both, as does the normal English use of the word. With or without particular reference to the *logos* (reason) in the German *Technologie*, this term is distinct from systematic knowledge or research which is *engineering science*.

[9] This is a subtle point of little consequence but worth noting. When we think of the science-technology relation we can agree or disagree and meaningfully reflect upon the notion that technology is applied science, that is, premised upon the identification of lawful regularities in nature. When we think of the technoscience-technology relation we can agree or disagree and meaningfully reflect upon the notion that (techno)science is technology, that is, science and technoscience are ways of regulating our relations to material things and controlling them (see above). But when we think of the relation between science and technoscience to engineering and the engineering sciences, there is no problem with the idea that, both, scientific and technoscientific knowledge are sometimes taken up or applied in these contexts, as long as we recognize that the engineering sciences do more than that and actual engineering a lot more even than that.

[10] For the distinction between the knowledge required for representing technological artifacts and for creating artifacts, see Peter Kroes and Maarten Fransens at the meeting of the CLMPS 2011, or Houkes 2010.