Skills and tools: A philosophical perspective on technology

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Abstract:

Culture should be seen as the *first* nature of human beings. However, the rich diversity of cultural objects present within the life world of humans presupposes the all-embracing role of *tools* en *technology*. What appears to be unique and distinctive in human tool-making is the innovation to use tools in the production of other tools. Simpson even discerns in this ability a defining trait: humans are "the only living animal that uses tools to make tools." Against this background attention is given to prominent scholars and their views on technology and its development. It starts with the philosophy of Descartes and Hobbes and proceeds by considering the views of Dijksterhuis, von Bertalanffy, Heidegger, Weber, Habermas and Ellul – with special attention given to the rise of machine technology. The Enlightenment ideal of progress is related to an over-estimation of technology present in what Schuurman calls *technicism*, which ought to be understood in terms of the dialectic between nature and freedom in modern philosophy. The technocrats assume universal cultural laws while the revolutionary utopians accept an open future for human freedom. In the final part of the article an assessment is given of some implications entailed in the preceding analysis. It is noted that technology is not "applied science" and that technology and tools should be understood in term of both subject-subject relations and subject-object relations. Since subjects and objects are determined and delimited by applicable cultural norms and principles attention is also given to such principles, intimately connected to an account of the mening of technology. In conclusion it is pointed out that the nature of technology and the all-pervasive use of tools confirm the opening remark regarding culture as the *first* nature of human beings.

Sometimes culture is seen as the second nature of human beings, whereas in fact it should be appreciated as the *first* nature of humankind. This remark is confirmed by the fact that the general history of human civilizations is assessed in terms of the artefacts they produced. However such artefacts could not have been produced without the development of multiple *tools*. And with the advent of tool-making technology irrevocably entered the scene.

The life-world of humankind is unthinkable without the presence of a cultural environment, including cultural objects such as clothes, cutlery, furniture, houses, roads and so on. Just contemplate the diversity of cultural designs evinced in functionally differentiated cultural objects: analytical artefacts (test tubes) lingual artefacts (books), social artefacts (homes), economic artefacts (money), aesthetic artefacts (paintings), legal artefacts (houses of parliament), moral artefacts (wedding rings) and certitudinal artefacts (church buildings).

Philosophical views and a few contours of the historical development of technology

The question is: how do these functionally differentiated cultural objects come into being? Are they shaped by conforming to instinctively secured constant behavioural patterns typical of animals?[1] Or do they rather reflect unique features of human beings? It appears that the cultural environment of humans is indeed shaped by the employment of *tools*. Since both animals and humans *use* tools, the crucial question is if there is anything distinct about human tools? Are humans perhaps unique in their ability to *make* tools? (see Overhage 1974:359).

In order die find answers to these questions we have to move a step ahead by contemplating that only when tools are made in order to make *other tools* something distinctly human is present. Simpson even defines human beings summarily as "the only living animal that uses tools to make tools" (Simpson 1969:91). Using *tools* embodies the basic structure of *technique*. By using *diverse* technical tools multiple distinct cultural objects are produced, as briefly mentioned above. The remarkable fact is that tools are the only cultural products destined to *make something else*. They are *made* (their technical formative foundation) and they are made *to make something else* (representing their technical formative qualification).

This unique feature caused the archaeologist Narr to discern the spirituality present in human "cultural activities." He points out that producing human tools presupposes the free, formative fantasy of humans, which is absent in animal life. It forms the foundation of all *technical inventions*. Von Königsberg is therefore justified in claiming what we stated above, namely that a person is a cultural being: "without culture no Dasein [concrete human existence] worthy of being human can be contemplated" (Von Königswald, 1968:150). He also mentions that human tools are conceptualized with a view to future use and he states that true inventions already appeared in the earliest phase of the Paleolithic Age, i.e. the early *stone age* (Von Königswald 1968:167). The presence of a person's inventive formative imagination provides the foundation for practically useful archaeological criteria in terms of which typical human tools can be identified:

(a) The form of the produced tool should not be suggested;
(b) The function of the tool should not be suggested; and
(c) The manner of production should not be suggested – keeping in mind tools must be formed by means of (formed or unformed) tools (cf. Narr 1974:105, Narr 1976:99-101).

While our richly diversified cultural environment presupposes tools (as well as tool-*making* tools), we also have to ask what is presupposed by tools?

One striking condition for the effective use of tools is that they always employ a particular *goal-directedness* or *purposefulness*. *Tools are made in order to make something else – still*

[1] Compare the analysis of Eibl-EIbesfeldt in his authoritative work on animal behaviour: *Grundriß der vergleicehen Verhaltensforschung* [Portraying comparative animal behaviour] (2004:138 ff.).

to be made in the future. The possibilities enclosed in the use of tools therefore opens up a future that is not fixed in advance. The just mentioned free formative fantasy of humans may explore the future creatively either in norm-conformative or in antinormative ways (to which we shall return in the final section).

What is implicitly presupposed in the usage of tools is therefore the analytical ability to identify and distinguish *means* and *goals* – as well as the ability to *plan ahead*. In other words, technical skills entail an awareness of the future while constantly exploring prior analytical skills.

Analytical skills are therefore *foundational* for the ability to exercise *technical* skills. Within a differentiated cultural environment engineers are constantly challenged to be intellectually skilful, innovative and responsible. The implicit assumption is that they have mastered both intellectual and technical skills. Yet, as Heidegger points out, early Greek thought initially, i.e. before Plato, actually identified the ability *to have insight* or *knowledge* with *technique*. *Techné* was the same as *epistémé* (see Heidegger, 1982:13).[2]

The contribution of engineers to our cultural environment is intimately connected with the nature and the role of tools as technical objects[3] within a differentiated society. Since diverse social spheres entail varying kinds of challenges related to what engineers have to design and construct, we will question below the widespread view that technology is applied science. On the basis of intellectual skills tools serve human society in a cultural-historical way.

Initially tools occupied a central place in the history of civilization because it was used to demarcate historical epochs. It begins with the Stone Age (with various subdivisions), then proceeds to the Bronze Age and terminates in the Iron Age. Eventually this attachment to objectified cultural objects was deepened through an awareness of what is historically significant – captured in inscriptions, monuments, written histories, and so on. The differentiation of society caused technological developments to follow a corresponding historical differentiation. More recently we witness an amazing integration taking place, particularly exemplified in multifunctional electronic tools such as the cell-phone and similar electronic devices.

During the Enlightenment (18th century) the ideal of progress and of (unlimited economic) growth emerged. Eventually these ideals were fused with science and technology, accompanied by a process of differentiation and integration. The original meaning of biotic development (differentiation and integration) recurs within all the post-biotical aspects of reality since they *analogically reflect* these biotic features. But since the logical-analytical and all the post-logical aspects are *normed*, historical differentiation and integration should be appreciated as specific historical principles – principles awaiting formative control (form-giving, positivization – similar to the formative control exercised in tool-making). Likewise,

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2 The main ideas of Heidegger on technology are found in a lecture of 1953 on "Die Frage nach der Technik," which was subsequently included in a volume on "Technik und die Kehre." (He sees technology largely as machine technology, but objects to the view that technology is a neutral instrument open to use or misuse.)

3 We refer to technical objects as *technology*.

the principle of historical continuity represents another peculiar historical principle – based upon the coherence between the historical aspect and the aspects of space and movement.

A brief look upon the history of technology cannot avoid contemplating the important consequences for civilization entailed in the origination of *machines*. This new tool expanded the traditional dependence upon human skills and strength by exploring the tremendous energy resources of the earth. Before the Western year count commenced the Chinese discovered oil but could not effectively use it owing to a lack of suitable tools. Machines soon obtained a relative independence in their energy operation (such as in weaving and spinning machines). The steam engine accomplished something beyond the reach of the individual. Automation was carried further in the spectacular development of computer technology.

At the same time it should be noted that the development of machine technology eventually gave rise to a mechanistic world view, flowing from the Renaissance ideal to control all of reality by the autonomous freedom of humans.

Prominent scholars and their views on technology and its development

After the disintegration of the medieval unified ecclesiastical culture early modern philosophers, such as Descartes and Hobbes, gave shape to a new ideal of *logical construction* causing Dijksterhuis (1980) to speak of the rise of the *mechanistic worldview*. For example, Descartes portrays the human body as a machine and Hobbes believes that he can describe the human soul as a *mechanism* of emotional *movements* – all of them represent natural scientific modes of description and explanation.

The upshot of the initial successes of the natural science ideal was that human life was considered to be entirely subject to inviolable natural laws, foremost that of cause and effect, i.e. the law of *causality*. It also gave birth to the idea that not only the universe, but also human society ought to be (re-)constructed from its simplest elements, the individuals. Von Bertalanffy strikingly sketches the overall picture when he characterizes the mathematical *more geometrico* worldview, followed by the *mechanistic view* of the universe as particles in motion (Von Bertalanffy, 1968:66). Add to this what Heidegger pointed out, namely that modern "exact physics" represents nature in such a way that it is set up "as a power-coherence calculable in advance" which enables a total control of nature (Heidegger, 1982:21). Almost a hundred years ago Max Weber stated that technology inherently entails control [*Herrschaft*] over nature and humans (see Habermas, 1973:50). Alongside Ellul we must note that also Heidegger discerns in modern technology absolute and imperialistic traits, which impregnate ineradicable marks upon everything. He writes: By this conception of the totality of the technological world, we reduce everything down to man, and at best come to the point of calling for an ethics of the technological world. Caught up in this conception, we confirm our own opinion that technology is of man's making alone. We fail to hear the claim of Being which comes to expression in the essence of technology (see Heidegger, 1969:34).

In a subtle way modern political philosophers further explored this underlying technical attitude – one in which society is theoretically construed by means of a thought-experiment, manifest in a hypothetical social contract. This *theoretical tool* soon materialized in devastating practical consequences for the human condition. John Locke developed his political philosophy based upon his atomistic contract theory and the ideas of the classical school in economics (Adam Smith and his followers). They were both in the grip of the natural science ideal (see Viner 1965:92). During the industrial revolution these ideas accompanied the increasing employment of *machine technology* and they caused serious distortions within society because they did not have a proper understanding of the normative task of the government of a state.

These developments made philosophers sensitive for the rise of the mechanistic worldview which in turn paved the way for the eventual emergence of a *technicistic worldview*. From a historical perspective the preceding era of *handicraft* (trade) had a focus on *trade-tools*, but the technical activities of the craftsman, the smith and the carpenter, were still encapsulated within a non-technical context (see Schuurman 1993:191-192). Within the guild system there was not yet a differentiation between "capital" and "labour." The development of modern industrial technology – during the "industrial revolution" – therefore played a decisive role in shaping the social complexity of modern Western societies. Backed up by the mentioned intellectual ideal of *progress* emerging from the rationalistic Enlightenment era, modern technology soon turned into something upon which trust for the future could be built. The ideological expectation that technology may redeem us from the defects present within society thus accompanied the rise of modern technology. Schuurman characterizes overestimating our technical abilities strikingly:

> Technicism entails the pretension of human autonomy to control the whole of reality: man as master seeks victory over the future; he is to have everything his way; he is to solve all the problems, including new problems caused by technicism; and to guarantee, as possible consequence, material progress. … Technicism reduces science to its instrumental use. The economy, as is obvious in Western culture today is also interpreted technicistically, with utilitarian economics as a complement (Schuurman, 1995:140).

Particularly in this sense modern technology appears to be a *historical* power which, supported by scientific development and skills, can assume the *totalitarian traits* of an encompassing *technocracy* – well-understood by Von Bertalanffy and Heidegger:

> To the new utopians of systems engineering, to use a phrase of Boguslaw, it is the "human element" which is precisely the unreliable component of their creations. It either has to be eliminated altogether and replaced by the hardware of computers, self-regulating machinery and the like, or it has to be made as reliable as possible, that is, mechanized, conformist, controlled and standardized. In somewhat harsher terms, man in the Big System is to be – and to a large extent has become – a moron, button-pusher or learned idiot, that is, highly trained in some narrow specialization but otherwise a mere part of the machine" (Von Bertalanffy, 1973:8).

Heidegger considers present-day scientific thought as becoming increasingly calculating. In the Introduction to Heidegger's work on *Identity and Difference* Stambaugh mentions the term “overwhelming” in connection with “the manner in which Being reaches beings. It preserves the meaning of sur-prise (over-taking) and thus of incalculability” (Stambaugh 1969:17). This preference for the *incalculable* reveals an irrationalistic element in the thought of Heidegger – at once also demonstrating the primacy of the humanisties personality ideal in his thought.

In the light of the intrinsic divide generated by the science ideal and freedom ideal radically opposed expectations from modern technology are to be expected. The one extreme is represented by the technocrats (such as Kahn, Wiener, Steinbuch and the Marxist Klaus) and the other extreme by the revolutionary utopians (among them Bloch, Marcuse, Koch and to a certain extent also Habermas).

The technocrats aim at determining the future on the basis of the past by applying the technical-scientific method. The first challenge is to discover the universal cultural laws in an empirical fashion and then to proceed to the construction of alternative plans for the future. Partial plans embedded in encompassing plans will address economic, political, social and other sectors of societal life in order ultimately to choose a specific plan to be implemented, be it by means of a democratic decision or by means of those currently in power.

Obviously this technocratic method will result in a totalitarian and absolutistic control of every sector of society by eliminating differentiated responsibilities – as already recognized by Ellul and Heidegger. In their opposition to these technocratic visions, which will result in a technological world state as bearer of the future, the revolutionary utopians reject every deterministic approach to the future.

The revolutionary utopians make a plea for an attitude towards the future which does not affect human freedom and which leaves the future open with its surprising novelties (reminding us of Heidegger's preference for “incalculability”). Freedom and fantasy must get a chance but this can be accomplished only through the chaos of a revolutionary process of change. The neo-Marxist utopians advocate the continued revolution that will prevent the formation of new groups of power within human society. The revolutionary dialectic which comes to an end in Marx's assumed communist utopia has no end in neo-Marxism. In opposition to the requirements of the established technocratic society – such as order, efficient production, economic growth and productive labour – the revolutionary utopia demands peace, freedom, happiness, love, lust, playfulness and eroticism which has to break through in creatively spontaneous qualitative changes. In the argumentation of the revolutionary utopians the initial modern ideal of freedom aims at liberating itself from the technocratic Frankenstein which it created.

Implications and assessment

In the preceding analysis attention was given to the essential foundational role of tools and technology for the predicament of human beings as embedded in cultural environments. Certain historically significant features of the development of technology occupied our attention, followed up by discussing some of these features in the light of the views of prominent scholars.

This concluding section will now look at the results of our analysis and consider some of its implications. It will also highlight some new perspectives that surfaced in this study.

In the background of our discussion the significance of the intellectual skills which engineers are supposed to have mastered constantly played a role. These intellectual skills are based, formed and enhanced by exploring insights from the disciplines of mathematics and physics. Designing a simple everyday object, such as a chair, may implement (mathematical) knowledge about the interaction of various physical forces (such as gravity and the physical strength of the material used or regarding spatial considerations pertaining to the size and shape of a chair).

In their exposure to these two disciplines, the intellectual skills of engineers are also enhanced by obtaining the ability to avoid ill-founded arguments – similar to obtaining critical skills related to mathematical and physical fallacies and contradictions.[4] However exploring this issue further here will exceed the confines of the present article.

We rather direct our attention to the question if technology is "applied science"? – followed up by contemplating the status of cultural-historical principles related to the use and development of technology. This concerns the issue of historical normativity and an enduring technical service to society.

Technology certainly discloses possibilities entailed by the natural sides of creation. It is accomplished by formative means resulting in cultural objects serving human culture in its multifaceted complexity. Yet technology does not uncover any secrets of nature, just as little as technology could be equated with "applied science" (a common misconception – correctly seen by Heidegger). No technical solution is built upon a scientific inference. What is essential to technology is the embedded and mediating role it plays between human subjects and what humans can objectify.

The fact that tools and technology are embedded in the cultural environment of humans must be seen as part of the multiple subject-subject relations within human life. But all subject-subject relations are embedded in subject-object relations. Even talking to a friend presupposes the subject-object relation between the human person (as lingual subject) and the physical sounds produced in uttering words and sentences – which are thus objectified into *speech sounds*. Interestingly, the distinction drawn by Habermas between communicative and instrumental actions in vain and incorrectly attempts to *separate* subject-subject relations and subject-object relations. When these two relations are acknowledged in their interconnectedness the way is opened towards the equally intimate connection between scientific knowing and technical inventing which in turn relates to the *meaning* of technology. In his analysis of the thought of Heidegger the Dutch engineer-philosopher Schuurman develops a a critical assessment of the inherent dialectic in the thought of

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4 For example, the supposed "exact" nature of mathematics is questioned in Strauss 2012.

Heidegger: “On the one hand there issues from Being the necessary destiny of Being (*Seinsgeschick*) to which man is subordinate and because of which he is thus not free. On the other hand, Being must give man freedom. Heidegger’s idea of Being is intrinsically contradictory” (Schuurman, 2009:141).

However, when the normed nature of technical tools is observed, the meaning of technology blossoms:

> Technology can alleviate in part the bind in which humankind naturally finds itself. Technology can increase life's possibilities, decrease physical burdens and difficulties at work, and free people from routine activities while opening the door to all kinds of mental and creative labor. Natural disasters can be averted, illnesses overcome, and, in a certain sense, with the aid of electronics and microprocessors, the deaf can hear again, the blind see, and the lame can walk again. Technological development can provide houses and food, supply a degree of social security, and increase available information so as to extend and deepen communication. Greater harmony between technology and nature is possible. Through all of this the responsibility of humankind grows as well. Material prosperity will not have a stranglehold or gain the upper hand, if it keeps in step with mental and spiritual well-being. The many gifts and diverse qualities of individuals and peoples will have a chance within technology and by its means. When it is situated within the perspective of an integral framework of norms that holds for all cultural activity and its hazards are kept within bounds, technology will make room for re-creative activities and a rich cultural involvement that are in balance with a conscientious stewardship of nature (see Schuurman 1995:102).

However, as we noted earlier, since the Renaissance the West was dominated by the tension between the ideal of an encompassing natural science and the ideal of an autonomously free personality (*nature* and *freedom*). Since the Renaissance the controlling power of the Roman Catholic Church disintegrated, although the human being was now reduced to a causally determined configuration without any freedom. An integral view on technology and human society first of all has to notice the cultural-historical significance of technological developments. Sometimes human history is simple equated with the history of technology.

The fact that technical tools are both historically founded and historically qualified – as mentioned earlier (they are made in order to make something else) – underscore the key position of technology within human society. Schuurman discusses the significance of norming principles in his analysis of the meaning of modern technology. He pays attention to the (lingual) norm of information, the economic implications of efficiency and stewardship, and the norms of harmony, justice, care, love and trust (Schuurman 1995:96-99).

These norming principles are *constant* even though they make possible the *dynamic* development of new technologies. Within all areas of human life we are challenged to come to a proper understanding of the uniqueness and coherence of *constancy* and *change*. In addition it is remarkable to note that analogies of the kinematic and physical aspects are found in all typically normative functions, including the mentioned logical-analytical, cultural-historical, lingual, social, economic, aesthetic, jural, ethical and certitudinal aspects of the universe.

Typical historical events always manifest the struggle between progressive and conserving tendencies. If the former gets the upper hand a revolution is at hand and when the latter wins the battle a reactionary attitude will rule the day, disallowing any meaningful historical chance. Realizing that both revolutionary and reactionary attitudes represent antinormative options presupposes an awareness of historical normativity to begin with. Tradition protects historical continuity and provides the basis for constructive historical change. Change is not antinormative per se, as long as it is not occurring at the cost of historical constancy. It is tradition, the protector of historical continuity that paves the way for the principle of historical continuity manifesting itself in a process which transforms reaction and revolution into *reformation*. The above mentioned opposition between technocrats and revolutionary utopians represent these two antinormative extremes, reaction and revolution.

Within countries where the first and the third world are both present the process of technological development is faced with a dilemma, caused by the struggle between new technologies (progressive tendency) and the persistence of old technologies (reactionary tendency). Full-scale mechanization may be economically beneficial, but it may also cause an excessive loss of jobs and contribute to increasing unemployment.

South Africa suffers from a persistent culture of corruption and mal-administration which leaves many municipalities and even provinces with a growing backlog in basic maintenance and service delivery. Unauthorized expenditure, running into more than R30 billion per annum, adds significantly to this problem. Currently the rate of unemployment in South Africa is back to 26.4% – where it stood in 2000 (the extended unemployment rate is currently 36.1% – see “Die Volksblad” May 27, 2015, page 16). This situation is co-determined by insufficient planning and technical maintenance – which demonstrates how important the acquisition of basic intellectual and technical skills and tools are for everyday life.

Interestingly the historical principles of continuity (reformation in opposition to reaction or revolution), differentiation and integration are not only guidelines for the development of a civilization, since observing them may enrich every sector of a differentiated society. Typical administrative responsibilities cannot avoid the normative appeal of these cultural-historical principles.

The just mentioned utopians, although pushing their cause too far, indeed opened our eyes for the *negative sides* of technology in our culture, partially exploited by economic power structures – evident in excessive luxury, waste, and environmental contamination. Labour is reduced to productive labour that ought to be “economically justified,” while the emptiness experienced by the workers is compensated for by more consumption. Rather than employing technical skills and tools to liberate humans and using it in support and service, care and creativity, it largely terminated in banning out meaningful forms of labour.

While avoiding these extremes modern technology should be appreciated positively for the contribution it can make towards liberating the human body from exhausting donkey-work, for avoiding the onslaughts of nature, in caring for human material needs, and for the conquering of diseases. It also includes the elimination of unnecessary burdens, the creation of leisure time, advancing rest and peace and disclosing and enriching culture by enhancing reflection, by stimulating communication and by enabling a diversity of job opportunities.

The excess of technological "large-scale-ness," designated by Schuurman as the *Babel*-motif in our culture, may lead to catastrophic consequences – for example when the large scale capturing of sun-energy generates a condition where all forms of vegetation are threatened.

We have to observe the old Genesis-motif of cultivation while being custodians sustaining the natural resources available to humankind. This normative challenge presupposes a sound theoretical awareness of the foundational coherence between constancy and change. A meaningful development of society ought to observe the historical principles of cultural continuity, cultural differentiation and cultural integration which come to light when analogies of non-historical aspects are considered. The principle of cultural continuity (historical constancy – embodied in tradition) analogically reflects the meaning of uniform motion within the cultural-historical aspect. This entails that the basic acknowledgement of constancy pertains to the core meaning of the phoronomic or kinematic aspect of reality – uniform rectilinear motion. This awareness is captured in the law of inertia: a body in a state of uniform motion will continue its movement except when some force impinges upon it.

Although Plato has already accounted for the possibility of knowledge by appealing to constancy (elevated to his metaphysical realm of supposedly eternal, static ideas), it was Galileo (inertia) and Einstein (the velocity of light in a vacuum) who realized that persistence is presupposed in all change. As an original mode of explanation motion is not in need of a cause. Only a change of motion requires a physical cause (acceleration or deceleration) (see Von Weizsäcker 2002:172).

This insight is reflected in Einstein's theory of relativity, which is in the first place a theory of the constancy of the velocity of light in a vacuum (see Einstein 1982:30-31; and 1959:54).

This insight is decisive for a positive appreciation of modern technology, because new tools always contain two elements: a similarity with past tools and developments evincing the novel change at hand.

Twentieth century physics supported modern technology in multiple ways. From a theoretical perspective it went beyond the mechanistic main tendency of modern physics since Galileo who liberated it also from the modern mechanistic worldview which led to the technicism, currently still alive in distorted views on technology.

Concluding remark

Sound thinking habits, sensitive to the impasse contained in reductionist theoretical designs and involving intellectual skills and tools in service of sustainable technical development, ought to be cultivated within the academic context of tertiary technical institutions. Without such an intellectual culture the future will be threatened by increasing insecurity and accompanied by a disintegration of the necessary intellectual and technical foundation of highly differentiated societies. A proper theoretical understanding of (numerical, spatial, kinematic and physical) natural laws should guide technical endeavours in exploring these theoretical insights as intellectual tools in the practice of the technical, planning, design and innovation. Contemplating the foundational coherence between constancy and change (technocratic control versus revolutionary utopia) may transform reaction and revolution into the pathway of Reformational change. The nature of technology and the all-pervasive use of tools confirm the remark with which this article commenced – culture should indeed be seen as the *first* nature of human beings.

Literature

Altner, G. 1976. *The Nature of Human Behaviour*. London: Allen & Unwin.

Benacerraf, P. and Putnam, H. 1964 (Eds.). *Philosophy of Mathematics, Selected Readings*. Oxford: Basil Blackwell.

Böhme, W. (Ed.) 1988. *Evolution und Gottesglaube*. Göttingen: Van den Hoeck & Ruprecht.

Brouwer, L.E.J. 1964. Consciousness, Philosophy, and Mathematics. In: Benacerraf et.al., 1964, pp.78-84.

Diels, H. and Kranz, W. 1959-60. *Die Fragmente der Vorsokratiker*. Vols. I-III. Berlin: Weidmannsche Verlagsbuchhandlung.

Dijksterhuis, E.J. 1980. *De mechanisering van het wereldbeeld*. Amsterdam: Meulenhoff (4th impression).

Eibl-Eibesfeldt, I. 2004. *Grundriß der vergleicehen Verhaltensforschung, Ethologie*. München: Piper Verlag

Einstein, A. 1959. Autobiographical Notes. In: *Albert Einstein, Philosopher-Scientist*. Edited by P.A. Schilpp. New York: Harper Torchbooks (pp.2-95).

Einstein, A. 1982. *Grundzüge der Relativitätstheorie*. Reprint of the 1969 Braunschweig edition (original edition 1922). Wiesbaden: Friedrich Fieweg & Sohn.

Einstein, A. 2006. *The Collected Papers of Albert Einstein*. Volume 10 (Translator: Ann Hentschel). Princeton: University Press.

Habermas, J. 1973. *Technik und Wissenschaft als "Ideologie"*. Frankfurt am Main: Suhrkamp Verlag.

Heidegger, M. 1982. *Die Technik und die Kehre*. Fifth Impression, Verlag Günther Neske Pfullingen (1962).

Heidegger, M.1969. *Identity and Difference*. Translated and with an Introduction by Joan Stambaugh. New York: Harper & Row, Publishers.

Heidegger. M. 1959. *Unterwegs zur Sprache*. Pfullingen: Verlag Günther Neske.

Husserl, E. 1979. *Aufsätze und Rezensionen* (1890-1910), Husserliana, Edmund Husserl, Collected Works, Volume XXII, From the Husserl Archives in Leuven, guided by Samuel Ijsseling with the aid of Rudolf Boehm, Editor with text additions, Bernhard Rang. The Hague: Martinus Nijhoff.

Lorenzen, P. 1976. Zur Definition der vier fundamentalen Meßgrößen. *Philosophia Naturalis* 16:1-9.

Lorenzen, P. 1989. Geometry as the Measure-Theoretic A Priori of Physics. In: Butts, R.E. & Brown, J.R. (eds). *Constructivism and science*. Dordrecht: Kluwer.

Luyten, N.A. (Editor) 1974. *Fortschritt im heutigen Denken*? Publication of the "Görres Gesellschaft für Interdisziplinäre Forschung"; Series: Grenzfragen, Vol. 4. Freiburg: Alber.

Narr, K.J. 1974. Tendenzen in der Urgeschichtsforschung. In: Luyten, N.A. (Editor) 1974.

Narr, K.J. 1976. Cultural Achievements of Early Man. In: Altner, 1976.

Narr, K.J. 1988. Von der Natur der frühesten Menschheit. In Böhme 1988 (pp. 273-302).

Overhage, P. 1974. Die Evolution zum Menschen hin. In: Huttenbugel, J., ed. *Gott*, *Mensch*, *Universum*, Graz: Styria.

Planck, M. 1910. Die Stellung der neueren Physik zur mechanischen Naturanschauung (Vortrag gehalten am 23. September 1910 auf der 82. Versammlung Deutscher Naturforscher und Ärzte in Königsberg i. Pr.). In: Max Planck, 1973:52-68.

Planck, M. 1973. *Vorträge und Erinnerungen*, 9th reprint of the 5th edition. Darmstadt: Wissenschaftliche Buchgesellschaft.

Rensch, B. & Schultz, A.H. (Eds.) 1968. *Handgebrauch und Verständigung bei Affen und Frühmenschen*. Symposium der Werner-Reimers-Stiftung für anthropogenetische Forschung. Bern: Huber.

Schuurman, E. 1993. *Techniek*, *Technologie en het Technisch Wereldbeeld*. In: Van der Ploeg et al (pp.191-206).

Schuurman, E. 1995. *Perspectives on Technology and Culture*. Sioux Center: Dordt College Press.

Schuurman, E. 2009. *Technology and the Future*. 2nd edition. Jordan Station: Paideia Press.

Simpson, G.G. 1969. *Biology and Man*, New York: Harcourt.

Stafleu, M.D. 1980. *Time and Again*. *A Systematic Analysis of the Foundations of Physics*. Toronto: Wedge.

Stambaugh, J. Introduction, In: Heidegger, 1969.

Stegmüller, W. 1970. Main Currents in Contemporary German, British and American Philosophy. Dordrecht: D. Reidel Publishing Company, Holland.

Strauss, D.F.M. 2012. (Oor)aftelbaarheid. Koers 76(4) 2011:637-659.

Van der Ploeg, A., Dulhaart, M.H.J., Vlug, A.E. 1993. *Tastend Zien, Opstellen in dankbare herinnering opgedragen aan dr. F. De Graaff*. Sliedrecht: Merweboek.

Von Bertalanffy, L. 1968. *Organismic Psychology and Systems Theory*. Massachusetts: Clarke University Press.

Von Bertalanffy, L. 1973. *General System Theory*. Hardmondsworth: Penguin University Books.

Von Königswald, G.H.R. 1968. Problem der ältesten menschlichen Kulturen. In: Rensch, B. & Schultz 1968.

Weinert, F. 1998. Fundamental Physical Constants, Null Experiments and the Duhem-Quine Thesis. In: *Philosohpia Naturalis,* 35:225-251.