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Three Dogmas of ICT-Driven Development

Philosophical Investigations of ICT-Driven Projects in the Developing World

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Introduction

All disciplines entail dogmatic assumptions; beliefs or assumptions that are not questioned by the standard practices of a discipline. Though dogmas are unavoidable to a certain extent (cf. Kuhn, 1996), it is important that one is aware of the prevailing dogmas in one's own discipline. Often gaining new understanding requires refuting existing dogmas. When dogmatic views go unquestioned, they tend to bias and hinder interdisciplinary endeavors and projects that rely on disciplinary expertise. In this article we analyze what we take to be three dogmas in information and communication technology (ICT)-oriented development projects, viz., *universality*, *progress*, and *liberation*.

By and large, these dogmas are held in computing fields more generally. It seems that the ICT era has resurrected the somewhat naïve belief that technological modernity shows a path to a better future for all of humankind. We frequently encounter the dogmas of computing in beliefs that culturally neutral, ever-progressing technologies will liberate poverty-stricken people of their perennial suffering. Hence, it is reasonable to criticize these dogmas in the context of development where those dogmas are especially lucid.

The first of the three dogmas we wish to address is the dogma of universality. The dogma of universality holds that theories of computing as well as computing technologies are value-free, culturally neutral, and universal. Universality is a common idea in computing disciplines, and from computing disciplines the dogma also comes to haunt ICT-oriented development projects. In this article we discuss the difficulties with views that hold computing to be value-free, culturally neutral, and universal.

The second of the three dogmas we wish to address is the dogma of progress. Similar to the dogma of universality, also the dogma of progress pervades computing disciplines: the history of computing is seen as a history of constant and fervent progress. People in the computing disciplines commonly hold that technology progresses in the course of time, that progress is inevitable, and that progress has a direction. In this article we take each of those common beliefs under closer examination and show that every one of those beliefs faces insurmountable difficulties. Especially we note that taken into development projects, the dogma of progress is not only ambiguous but also misguiding.

The third of the dogmas we wish to address is the dogma of liberation. By liberation we mean the belief that some forms of technology create benevolent social forms, and by creating benevolent social forms those technologies free people from cultural oppression and poverty. This dogma is often reflected in development projects, many of which are based on the belief that access to technology will enhance human well-being. Among the technologically oriented people it is quite often thought that access to technology brings more income to poor people, as if cultural, political, and human factors of well-being (such as health, feeling of security, and literacy) could be ignored.

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On the Universality of Computing Technology

Computing as a discipline has its roots in mathematics, engineering, and natural sciences. The traditions of the discipline that those roots exhibit are the theoretical, design-oriented, and empirical traditions (Denning et al., 1989). Those traditions lead to juxtapositions between theory and practice, pure and applied, academy and industry, abstract and concrete, global and local, science and technology, profound and popular, and so forth. Those juxtapositions manifest the difference between something that is universal (or, alternatively, objective) and something that is particular (or, alternatively, subjective). Despite some claims of inseparability (e.g., Knuth, 1991; Denning et al., 1989; Forsythe, 1968; Wegner, 1976; Hopcroft, 1987), those two faces of computing are often thought of as different spheres altogether.

The popular outlook on the theoretical, pure, or academic side of computing is that abstract ideas are separated from their social surroundings, they are derived using a neutral form of inference, and that they are culturally neutral. Generality is valued highly: computing researchers take that higher level of generalization is, as a rule, intellectually superior to detailed descriptions of particular phenomena, and consequently high level of abstraction is something to strive for. The popular outlook goes that also the artifacts that the applied side of computing disciplines produces are neutral and value-free. If some technologies seem to unfairly benefit some people more than the others, that unfairness is typically not considered to derive from biases in science or technology, but from biased institutions and social structures, as well as from differences of income and education.

Sure enough, institutions and social structures certainly do distribute the benefits of science and technology unequally, but that is not the whole picture. The focal points and mechanisms of scientific research are also biased by institutions and social structures, insofar as they favor some research traditions over others and insofar as they influence the public image of research and design (cf. Bowles, 1996). Priority in research is easily put on those research topics that have direct economic applications, that have been hyped up by the media, or that are heavily funded by governments—regardless of whether those topics are the ones people need the most.

The idea of cultural neutrality is one of the reasons for the belief in universality of science; it is an idea that social or psychological factors do not influence the subject of science. The basic realist interpretation is that scientists *discover* truths rather than formulate them. On the contrary, the nominalist objection to the dogma of universality is that scientists are able to produce science that they afterward experience as something other than a human product. Nominalists claim that even though the mechanisms and fabric of the physical world are observer-independent, *concepts*; such as atoms, quarks, and gravity; are human constructs, and thus necessarily socioculturally influenced.

Computing Is Human-Made

In its most fundamental form, the belief in universality of the *theories of computation* is manifested as a belief that concepts of computation, such as algorithms, exist independently of people. Computing is sometimes even considered to be a natural science (Denning, 2007). We argue that unlike natural sciences, computing is an artificial science: instead of focusing on naturally occurring phenomena, computer scientists study the fundamental limits and applications of very specific human-made constructions. There are a number of ways to argue for the human-made characteristic of computing, and we propose here two arguments.

Firstly, there is a notion that undermines the universal and eternal character of computing. Consider two contradicting arguments: (1) the argument that mathematical, logical, and computational truths (and falsehoods) exist without any intelligent beings (e.g. Kurt Gödel held this view; see Shapiro, 2000:10,12); and (2) the argument that those truths exist only with intelligent beings (the idealist and nominalist ontological views hold this argument; see Shapiro, 2000:25-26). The former argument holds that something immaterial exists, which contradicts what natural scientists usually argue for (that is, natural scientists tend to argue that in order to exist, things need to have mass or at least some kind of energy). To argue that mathematical and logical truths exist without any intelligent beings would be to argue that something immaterial and eternal can exist and that people would somehow have access to some immaterial, eternal facts.

The ontological status of mathematical and other abstract objects, including algorithms, is a tricky question (e.g. Smith, 1998[1996]), and it is not our purpose to go further into that discussion here. However, we do note that if algorithms exist independently of people, then *all* computer programs, including erroneous ones and very complex ones also exist independently of people. That is, if algorithms exist independently of people, then the Microsoft Word 98 exists eternally and independently of people.

Secondly, there is a notion that distances computing disciplines from natural sciences. Although concepts from natural sciences; concepts like *electron*, *gene*, *protein*, and *acid*; are constructed concepts, those concepts are intended to inform people about naturally occurring phenomena. But in computing disciplines it is dubious whether either theories about computation or theories about computers can be seen as informing people about naturally occurring phenomena. Although there are branches of computing that study naturally occurring processes, most parts of computing have been characterized as “unnatural”, “artificial” sciences (Knuth, 2001:167; Simon, 1981[1969]). To say that computing is not a natural science is not to say that computing would not be an intellectually respectable *empirical* science; it is just to say that computing fields deal with human constructions.

Finally, it is important to note that instead of dealing with theoretical abstractions, the majority of computing researchers deal with machinery and software, both of which are certainly human-made. Of course, some proponents of universalism in computing disciplines might argue that computers are based on computational theories that are universal, and hence, computers are instances or manifestations of Platonic ideas. Be that as it may, we suppose that the majority of scientists would not object to our claims that (1) computers as phenomena are different from naturally occurring phenomena such as electrons, genes, proteins, or acids; and that (2) the discipline of computing is different from physics, biology, or chemistry in that sense. The claims of universality and neutrality are not as straightforward as they seem from the computing viewpoint.

Cultural Neutrality Argument

Similar to computing research, current technologies are not even intended to equally benefit all people. Financiers, designers, and marketers always have specific customer or user groups in mind. Also previous technological choices affect the future choices. Decisions in computing technology are *never* made independently of other, older technologies—the rallying points might be things like the TCP/IP protocol, RGB video signal, OSI layers[1], the stored-program paradigm, or perhaps 110V/220V voltage if nothing else. In the modern world there are no unconnected techniques, innovations, or artifacts; different innovations belong to large socio-technological systems (Hughes, 1994:104-106). An important part of those socio-technological systems is the social reality; in this section we argue that although machinery may work exactly the same way everywhere, its functions are still not culturally neutral.

[1] TCP/IP = Transmission Control Protocol / Internet Protocol, RGB = Red-Green-Blue, OSI model = Open Systems Interconnection Reference Model

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In the universalist thinking, technological products, such as the computer, are thought to have little to do with culture, and to be suited as well for an American user as for an Elbonian user, mutatis mutandis. The necessary changes that introducing computers to Elbonia (a hypothetical developing country) might take are often considered to be something like introducing literacy, education, and 'logical thinking' to Elbonia. The realist viewpoint to computing technology is that computers are tangible and physical phenomena, not sociocultural phenomena. That is, no matter to which society or culture a certain computer is taken to, the computer certainly functions the same way. People who believe in universality of computing technology also usually hold a belief that in the long run, what matters is technical efficiency—that the intrinsically best or the universally best technology will ultimately triumph, whatever local contingencies may affect particular developments.

The nominalist viewpoint towards the cultural neutrality argument is that computational artifacts and theory are social products; they are created, institutionalized and made into tradition, into "mainstream mental models," by people in the societies in which they emerge. The nominalist can present a number of responses to the belief that in the long run the intrinsically best technology will prevail. For instance, the nominalist may note that the technology that is best from one point of view is not necessarily best from another. The nominalist can also contest that belief by looking at the history of computing technology. For instance, the triumph of Windows series over its opponents, such as at a time technologically superior OS/2 (Operating System/2) Warp, cannot be attributed to solely technological arguments. The classical case is the QWERTY keyboard, which worked well when the main concern of typewriter manufacturers was not having the hammers of the typewriter getting stuck together—it was designed specifically to slow down typists—but nowadays the pervasive diffusion of the QWERTY keyboard prevents competing products that are better in many senses to emerge (cf. Rogers, 2003:10).

The cultural neutrality argument can be challenged by arguing that no matter how ontologically objective the physical world appears, people collectively ascribe functions and meanings to objects, artifacts, and other physical things. One of the famous characterizations of cultural relativity comes from John Searle (1998), who noted a distinction between *brute facts* and *institutional facts*. Although those green pieces of paper that note-printing presses produce do exist independently of what people might think about them, *money* exists only because people collectively agree that certain pieces of paper, or clamshells, or blips on the computer hard drive are money. Creeks exist no matter what people's feelings towards them might be, but a creek becomes a *border* only if people collectively treat that creek as a border.

As an example of the relativity of functions of artifacts, consider the hammer. Assume that intelligent beings create a hammer, and then become extinct. In addition, assume that other intelligent beings find the hammer. The question is, "Is it possible for the finders of the hammer to understand what the function of the hammer is without understanding the intentions of the creators of the hammer?" Without understanding the intentions of the creators of the hammer, the finders of the hammer can *speculate* about the function of the hammer, and perhaps speculate correctly, but not be certain about it. But if they know that the intention of the creator of the hammer was to drive nails through wood, they can be certain that they understand what the function of the hammer is (Tedre, 2006:131). No matter how neutrally artifacts work, their functions are not culturally neutral.

Forcible Algorithmization of Other Disciplines

A belief in the universality of computing may be an innocent by-product of the success of computing, but it tends to have more serious ramifications. It seems that computer scientists are not content with defining theories of computation, conceptual frameworks, computing machinery, and

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other things only within the computing disciplines; but that there are tendencies to extend computation to other disciplines and other areas of life, too. There are attempts to explain, for instance, human mind (Scheutz, 2002), universe (Wolfram, 2002), and culture (Gabora, 1995) as sorts of computation. Philosopher of science Paul Feyerabend (1993:163) used the phrase *chauvinism of science* to refer to this tendency.

Scientists, Feyerabend wrote, are not content with running their own playpens in accordance with what they regard as the rules of the scientific method (Feyerabend, 1993:163). Scientists want to universalize those rules, and they want those rules to become a part of society at large. Furthermore, Feyerabend argued that scientists use every means at their disposal from argument to ridicule and intimidation to achieve their aims. Many computer scientists indeed wish to take the key ideas behind the success of computing to all disciplines (Easton, 2006). Computer scientists at large do not seem to find anything strange in arguing that computational models can explain culture and society—yet quite some computer scientists cringe at the very thought of explaining computing as a sociocultural phenomenon.

The predictive successes of computational modeling have led increasing numbers of computer scientists to participate in the occupation of intellectual territory that is sometimes called *algorithmization* of sciences and humanities (e.g., Easton, 2006). Certainly, algorithms and computational models can often be used to successfully predict the behavior of very many things; including the behavioral patterns of masses of people. But the chauvinistic character of algorithmization is rooted in the view that the capability to model and predict phenomena is the most important feature of an intellectual endeavor.

Now, one must remember that there are different kinds of scientific research, and only a narrow view on the purposes of science can accord with the algorithmizing ambitions. It is often argued that the aims of natural sciences are *exploration*, *description*, *explanation*, and *prediction* of phenomena. Computational modeling is indeed a good tool for some of those aims. However, to be able to model a phenomenon is not to understand how the phenomenon works (cf. Smith, 1998:21,64). In addition, *interpreting* and *understanding* phenomena are the purposes of many branches of social sciences and humanities.

The proponents of algorithmization of social sciences and humanities often fail to recognize that being able to model people's actions is not equivalent to understanding people's actions—understanding people's actions requires understanding beliefs and intentions behind those actions (Wright, 1971:Ch.4). Although algorithms and computational models can sometimes predict human phenomena, they have little say about *why* people behave as they do. Although computational modeling can be of great help for researchers in many disciplines, algorithmization should not go unquestioned, as it tends to funnel all thinking into discrete and tractable simplications.

Universality: A Summary

The dogma of universality is manifested in computing fields in a number of forms. There is the valuation of generality—that is, holding that higher level of generalization is intellectually superior to detailed descriptions of particular phenomena. There is the delusion of neutrality—that is, holding that computers and computations appear in a similar manner to all observers. There is the faith in universality—that is, holding that computers and computations exhibit some universal characteristics of the world, and that the hypotheses and theories of computing are similar to natural laws in that sense. The dogma of universality invites computing professionals to ignore particular, unique features of phenomena and to concentrate on general rules, no matter how important those particular special characteristics might be.

None of the manifestations of the dogma of universality should go unchallenged. Although there might be aspects of computing and computing technology that demonstrate a high degree of epistemological objectivity, a dogmatic belief in universality, generality, and neutrality of computing is detrimental to computing disciplines and to usefulness of computing technology. Ideologically speaking, that belief is detrimental because it restricts thinking by shutting out viewpoints, approaches, and types of inquiry that might turn out to be fruitful. That is, it forces one to see all of the reality through the computational lens. Practically speaking, that belief is detrimental because it prunes the rich complexity of the world into tractable abstractions and logic. That is, it forces reality into finite and deterministic formalizations that can be modeled, predicted, and controlled; yet may leave out all interesting particular aspects of phenomena.

The Ambiguous Concept of Progress

The second dogma we discuss is the dogma of progress. We start the investigation of progress with one of the classic distinctions in philosophy, namely the *is-ought problem* proposed by David Hume (1739:III,507-521). The is-ought problem refers to the distinction between normative statements, “what ought to be,” and descriptive statements, “what is.” Hume noted that there is a fundamental difference between these two kinds of statements, and that one cannot logically derive normative claims from descriptive statements. In other words, by referring to how things are, one cannot say how things should be without adding a value statement to the inference. Thus, if one concludes from the premise “Justus writes computer viruses” that “Justus is evil,” he or she is, in fact, including a hidden premise to the inference, a premise, which states that “writing viruses is evil” (which is a moral statement).

If one accepts the Humean distinction, one should ask, “Are statements about progress normative statements, statements of 'what ought to be' or descriptive statements, statements of 'what is'?” It is not straightforwardly clear how the term *progress* is operationalized in the field of computing, but that term is nonetheless one of the core concepts of technological disciplines.

If statements about progress are purely normative statements, they entail that progress means something desirable, but in that case nothing can be said about what does it mean for something to be 'progressed'—progressed technologies can be simple or complex, novel or ancient, digital or analog, and so forth. What matters is that the evaluator finds the technology good, for some reason. In other words, if statements about progress are purely normative statements, they are statements about the desirability of progress instead of characterizations of what progress is.

Alternatively, if statements about progress are purely descriptive statements, they describe what kinds of technologies can be considered progressed, but leave any statements about desirability of progress unanswered. In purely descriptive sense, one can link the term progress with terms like simple, complex, novel, or digital, but then one should omit any statements of desirability. Progress can also be described as *change*, yet also in that case nothing should be said about desirability of progress.

When one looks at the common connotations of the concept of *progress*, the concept seems to violate the Humean distinction. Firstly, the common notion of progress suggests an idea of *moving forward*. That view seems to include a normative element, insofar as being ahead is considered to be better than being behind (which usually is how the thinking goes). In this sense, statements about progress are value statements without attachment to any particular phenomena. That is, when the concept of progress suggests the idea of moving forward, *progressed* implies *better* and *desirable*. "This technology marks progress from the previous technology" is read as "this technology is better than the previous ones."

Secondly, the notion of progress seems to include an ambiguous descriptive element, too. For instance, most people have no difficulty describing nuclear weapons as more progressed than swords—notwithstanding the fact that the same people might also have hard time labeling nuclear weapons more desirable than swords. That is, the term *progress* is sometimes used as a descriptive term that does not imply if progress is good or not. In its descriptive meanings, progress is often linked with concepts like efficiency, novelty, and complexity. For instance, progress is sometimes considered to constitute of, for instance, faster means of doing things, new findings, or increase in a number of functions and variety of options.

Hence the ambiguity: the term *progress* entails a normative and a descriptive element, and neither one can be detached from the concept without altering the commonly held meaning of the concept. One has to be particularly cautious when adding hidden premises to the inference. Normative arguments such as "more complex is good" have to be defended, not merely implied. Keeping in mind the ambiguous nature of the term, in the following sections we detail some difficulties with the claims that (1) technology progresses in the course of time, (2) progress is inevitable, and (3) progress has a direction. All these are dearly held convictions in technological fields, and also more generally in the Western post-enlightenment thought.

Technology Progresses in the Course of Time

Although the word *novel* is often used as the marketing word in technological conference paper titles, novelty as such does not straightforwardly seem to define progress in computing disciplines. The most oft-used measurement units of progress in computing disciplines, as in many other fields too, include things like speed or efficiency (processing time of certain tasks) and complexity (the number of features). For instance, in processor technology, the mp3 encoding test is a commonly used measure of progress. In algorithm research, the asymptotic time complexity (efficiency) of an algorithm is an oft-preferred criterion over the simplicity of the algorithm. The number of features, such as the number of ready-to-use classes in a programming language, new instruction sets in processors, or the length of Tools/Options list are typical symbols of progress.

The essence of the common view on technological progress seems to lie in something being faster and more complex rather than being something actually recently invented. In other words, and with quite some reservations, the prevailing opinion in the computing disciplines could be framed in sentences such as, "Increase in speed is progress," "Increase in the number of features is progress," and "Improved usability (whatever that is) is progress," yet this is not the whole story yet.

On one hand, if the sentences above were purely *descriptive,* it could easily be shown that in the course of time computing technology has indeed become faster and more complex, i.e., has progressed. But we do not think that is what people generally mean by arguing that technology progresses in the course of time. On the other hand, if one wanted to stick to the *normative* flavor of the term *progress*, one could argue that the statement "Technology progresses in the course of time" means that it is desirable that technology progresses in the course of time. That interpretation does not capture the commonly held meaning of the statement either. That is, without specifying what kinds of changes are considered to be progress, the claim that "progress in the course of time is desirable" is quite meaningless.

If the statements above were merged, they would yield statements such as "It is desirable that in time, tools get more usable" or "Computing machinery gets faster in time (and that is good)." That might indeed be what people in computing field usually mean by the statement that technology progresses in the course of time; those sentences include a descriptive element and a normative element. However, the statement above entails the hidden premises that usability and speed are inherently good attributes of technology. Neither of those premises is, however, self-evident. Preferences are not absolute, they tend to change as time passes, and many preferences are inconsistent or contradictory. Statements about desirability cannot be based on surveys, project work, or empirical research, for then they would only reflect the state of research and opinion of those people included in the study, at that particular moment of time. All in all, it is difficult to see why speed *per se* would count as desirable (Think about the machine gun, for instance). Especially those who do not share the underlying assumptions of Western modernity would have a hard time understanding the rationale behind this normative claim.

Of course this is not to say either that by time technologies would not become more complex, or that it would be unwarranted to regard faster and more complex as better. Although not counterintuitive, neither of those beliefs is self-evident either. The essence of this discussion is that no matter how one formulates such normative and descriptive premises, *progress* as a concept is so complicated that the initial statement “Technology progresses in the course of time” is fundamentally uninformative without some serious clarification. There again, if one makes statements such as “It is desirable that in time, technologies get faster,” one should be aware of the difficulties of mixing normative and descriptive aspects. (For the sake of practice, one might want to substitute *faster*, *more complex*, and *more usable* with other characterizations of progress, such as *simpler*, *cheaper*, *more practicable*, or *pro-environmental*, without affecting the previous argument).

Progress is Inevitable

Quite often one finds computer scientists treating progress of computing as “natural and inevitable” (e.g., Backus, 1981:43). Technologies have indeed changed in the course of time—that much is obvious. But even if one, for a moment, sets aside the problems with the term *progress* and lets it be read as it is often read; as desirable changes in technology; the statement that progress is inevitable is still dubious. Is there any reason to believe that technological improvement is *inevitable* in any sense? Suggesting that technology inevitably progresses in the course of time shows either a lack of understanding of the term *inevitability* or a particular view on technological change, namely, *technological determinism* (Smith & Marx, 1994:*xii-xiii*; Bijker & Law, 1992:1-14). The term *inevitable* refers to something that is impossible to avoid or prevent; in the context of technological change inevitability means that no intervention, innovation, or politics of any kind could prevent a particular development step. Henceforth we are not focusing on the misunderstandings of the term, but we focus on the concept of technological determinism.

The belief that progress is inevitable involves a feeling that time and better (whatever that is) technology are somehow interconnected. For example, those who give away their email addresses because of excessive junk mail; or those who unplug their Ethernet cables in frustration with viruses, port probes, or such; typically face reactions such as “you cannot turn back the clock” or “going back to the eighties.” Similar, it is not uncommon that in reference to developing countries one hears views like “Elbonia still lives in the fifties”—yet it is all too obvious that the whole planet lives the same time, no matter how technologically disparate different societies are.

The common time metaphor suggests that people should keep up with technological changes or they are doomed to follow other people (as 'the fifties' is, eventually, followed by 'the twenty-first century'). The underlying philosophy in this thinking exhibits one face of technological determinism: a belief that instead of a free choice of technological direction, technological development follows a pre-determined route. This belief is also a matter of exercising power—if technological changes are taken to be inevitable, they cannot be questioned. The belief in inevitability justifies the representatives of 'the 21st century' to dictate the future direction of the people in 'the fifties.'

The deterministic belief stems back to the age of Enlightenment, the predecessor of the Modernity. Philosophers such as Georg W. F. Hegel endorsed the idea of historical progress, an idea that as time passes, the world advances in some senses. Hegel's ideas of progress were metaphysical and disconnected from human experience—there were no criteria for measuring progress. (Nisbet, 1980:276-286). The view of human history as a continuous progress was also embraced by classical materialist thinkers such as Karl Marx. When they depicted their ideas of progress, Marx and his contemporaries turned to the structures of society, economy, labor, and technology. But even though they saw progress as societal changes, they believed in deterministic laws of history, unrelated to individual experiences or human behavior (Rist, 1997: 41-43).

The problem with the belief in the universal law of historical progress is that it is scarcely supported by empirical evidence, and therefore tends to be metaphysical by nature, like Hegel's theories are. If historical progress would be inevitable and universal, one would expect progress to behave as other natural phenomena do: there should be laws, probability predictions, or at least rules of thumb of where progress is leading to. But all the attempts to show that technologies have followed a certain pre-determined path are fundamentally problematic, because in retrospect technological development naturally has proceeded through successive series of changes, 'a path.' Yet, it is doubtful whether technological changes have followed the only possible path. Nowadays many sociologists and philosophers do not take progress as a law of history anymore. Instead, technological choices are understood as complex trade-offs between economics, politics, theories, aesthetics, ergonomics, professional and individual preferences, prejudices and skills, design tools, available raw materials, and such (Bijker & Law, 1992:3). In the end, technological progress does not happen without the human—and human actions are hardly inevitable.

As we see it, the very essence of technology lies in the territory of human affairs: for instance, to make human conditions somehow more comfortable, to ease certain tasks, or to satisfy human curiosity. But technological determinism dissociates progress from all human affairs. So we are led to ask, “Can one actually assess technological progress by referring to technological yardsticks only, without a connection to human affairs or human needs?” In fact, one can do so. One can always hold the principle that there is a metaphysical law of history that technology inevitably progresses, but this notion loses its relation to the empirical world. Change might be inevitable, and progress can indeed be defined as change if one believes in such principle. However, we find such principle dubious.

Progress Has a Direction

Earlier in this article, the concept of progress was explained using the metaphor of moving forward. That metaphor relies on the assumption that there is a direction towards which technological changes are leading. However, it is hard to argue for the perspective that there is a natural direction of technological change. To start with, progress is not a smooth, systematic, deductive process. Similar to science, technological development has had eras when development has happened in a systematic, deductive manner. During those eras, developers of technology have aimed at perfecting whatever technological solutions there have been, as well as developing new technological solutions based on what has been already known about technology. However, every now and then there have been scientific or technological breakthroughs, revolutions, which have rendered the pre-revolution technology obsolete and started a new era (Ceruzzi, 2003:3). Radical revolutions can hardly be anticipated—that is what makes them revolutions.

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Suppose that seventeenth century people would be discussing future technology, and a visionary would explain town folks that according to her prediction, someone is going to invent the transistor in a few hundred years. “Transistor, what is that?” would the town folks ask. With tremendous difficulty, the visionary would be able to explain the transistor, only to stop and realize that she just invented the transistor (see MacIntyre, 1984:93-94). Of course radical technological innovations can also be “predicted” a bit before the actual prototypes are built, but what makes them radical is that just a short time before, they were entirely material of science fiction. In addition, often the radical innovations in science and technology occur in spite of the academic-industrial establishment and not because of it (Tedre, forthcoming).

If it is assumed that technological change follows an innate and inevitable logic of progress which can only be seen afterwards, the concept of progress may get a new meaning different from 'a step along the path.' For although change is always movement *away* from something, it is not necessarily movement *towards* something else (Kuhn, 1996:170). However, those who believe that progress has a direction may find it hard to actually tell whether a particular development step is towards the *right* direction or not. There is nothing that logically tells that technological development is currently on the right tracks at all—it may well be that our current technology is on a side track which will be changed later.

Especially if there is no given direction where technological change is heading, or if the goal is unimaginable, the assessment of progress is, well, tricky. Anyone allegedly behind others in technological development could decide to take their own direction. Essentially, in Peruvian jungle people can choose to focus on technologies that do not follow the lines of development of technology in Europe or the U.S., and no technical or scientific argument would logically prove either direction to be correct. The uncertainties about what really is beneficial in the end lead many technology developers to continuously try alternative solutions, and to invest in non-conformist development.

These quite simple ideas tend to get distorted by a widely shared belief in an evolutionist idea of technology, which the Ghanaian philosopher Kwame Gyekye (1997:40) called the *biological model of technology*. Gyekye suggested that people tend to perceive technology as 'growing' from primitive to complex and from low to high forms, as if that growth were a natural phenomenon. Consequently, when encountering 'low' technology, it is often easy to conceive that the next logical step would be more complex, higher form of technology. Yet, technological change is, at least on some level, supposed to happen locally. It is frequently stated explicitly in technology aid projects that one of the project aims is to support the development of local technologies. Unfortunately that development is regularly understood in a way congruent with the biological model of technology. Often the biological model is accompanied by some ethnocentrism, which leads to labeling locally functional, even quite complex technologies as 'low' technology because of their appearance in a non-Western setting.

The distinction between *having a direction* and *not having direction* of technological progress is quite clear. Towards a given goal, say, a manned space flight to Mars or discovering a cure for cancer, there can be a direction of progress; without a goal, the notion of a direction of progress is misleading. So technological progress enables one to reach a given goal effectively, but Hume's problem remains: “Which goals are desirable and which are not?” If one drops the notions of a fixed direction, the metaphor of moving forward becomes weak.

Progress: A Summary

Progress as an idea has a history; a history of determinist belief, born and nurtured in Western thought. It has been a common thought that things such as the world history, technology, and society have a predetermined direction or that nations are on a historical mission. The idea of progress rests on that assumption, almost as if the humankind were progressing towards the goal of that mission. Yet, no one claims to know the grand goal of technological change.

It cannot be claimed that technology progresses unless it is made clear what progress means. Usually it is not clear if progress refers to a description of what change is or a value statement about the desirability of changes. In common language the concept of progress seems to have both of those dimensions. There are indeed great changes in computing technology: it gets faster and more complex, enables a lot more things to be done, becomes more widely available, gets more affordable, and so forth, and those changes are usually easy to measure. In principle, one could label attributes of technology, such as speed and usability, as desirable, and then rejoice when progress takes place. That, however, is an arbitrarily made connection.

Those people who claim descriptions of progress to be value-free do not label speed, for instance, either good or bad. For those people technological progress is reduced to the observation that computing gets faster, without any value statements. Also those who claim that descriptions of progress are *not* value-free probably find it hard to label speed either good or bad: increase in computing speed has enabled the human genome project, but it has also enabled dubious projects such as Carnivore, Echelon, and various nuclear weapon developments. Labeling any attribute of technology as desirable and calling development in that area progress is definitely not a straightforward matter. It seems that attributes of technology should best serve as descriptions without any reference to desirability.

Certainly, in computing faster technology enables new things to be done, but we still have not found grounds for claiming that faster is better. We are not categorically against this argument either—quite the opposite; faster and more complex technologies have often helped to make people's lives better. But we do remain skeptical about any intrinsic measures of progress and about any definite normative connotations of the term progress. Any technological development step may make some certain group's life better (or worse), and simple and slow innovations—even ones that would intuitively seem anti-progressive—can in some contexts make some people's lives better (or worse).

On the Liberating Character of Computing Technology

The world today is a world full of poverty. That is obviously a moral problem. Most people agree that poverty-related suffering ought be fought, but there is serious disagreement about how to do that. In industrialized countries computing technology has successfully been utilized to achieve a number of goals, to relieve people from certain tedious jobs, and to enable a variety of new things to be done.

Perhaps they are those successes of computing technology that have led many to believe that the key to prosperity or at least to a decent life lies in bringing those same technological innovations to the poorer regions of the world. In popular thought, poverty is most often seen as a lack of modernization, and modernization is viewed through its technological symbols. For instance, consider the normative feeling of the claim “Elbonia has a mobile phone diffusion of only 6 phones per 100 inhabitants”. Today, information and communication technologies seem to hold the magic that brings prosperity. In this section we discuss the dogma that holds the technological approach as a means to better life and social liberation; we call that *the dogma of liberation*. Our question is whether technology is indeed a liberating, empowering, and prosperity-creating force.

Modernization Theory

After the Second World War, a number of poor (or, in today's politically correct language, developing) areas of the world became objects of a massive planning enterprise. Poor countries were thought to be able to achieve the living standards of the industrialized countries through large-scale societal development projects. The two key elements of those projects were (1) injecting capital to the national economies and (2) adapting modern technology. The strategy was essentially similar to the aid Europe received for postwar reconstruction, and the strategy was thought to apply universally. Culture was not an issue to be considered; investment capital and technology were. Similar to contemporary aid, in the modernization enterprise there underlay a strong moral conviction of freeing peoples and nations from poverty.

When early societal development projects in developing countries one after another failed, a new theoretical model was suggested in the 1960s; that model became known as *the modernization theory*. Modernization became the key word, and a value-laden juxtaposition between pre-modern and modern became one of the central doctrines. Modern people, vis-à-vis pre-modern people, were understood as being socially free, capable of self-expression, and, inevitably, rich and prosperous. The modern mindset viewed most cultural differences as deviances resulting from different degrees of modernization. (For these topics, see, e.g., Black, 1967:9-26; Harrison, 1985.)

The modernization theory brought about a shift of focus from technology to culture. How could it be, the modernizers asked, that the same technology that was being used successfully ('properly') in Europe and the United States—technology such as modern agricultural technology—was in many areas left unused rusting on the fields? The answer, for the modernization theorists, was that third world people ought to modernize not only technologically and economically, but also culturally. For example, it was argued that African cultures have traditionally valued less precision and exactitude than Europeans (Gyekye, 1997:33-34). Hence new attitudes, at least towards technology, were expected from the recipients of technological aid.

Of course the issues are simplified here, but the tenets of the modernization theory are illustrative of even today's thinking about technology. Given that there are concerns about cultural issues at all, the main question for aid donors has often turned out to be: “How ought these people adapt themselves in order to benefit from our technological solutions?” Two common approaches—ignoring the cultural setting or expecting the 'recipients' to adapt to new technologies—give little room for the real question: “Are these technologies really suitable for the economic-cultural-societal-environmental settings they are exported to?” Although today there is much more sensibility towards cultural issues, the modernization thinking is still implicit in many technologically focused aid projects.

In today's revived version of the modernization theory the concerns are of the blunt form “How can people in Africa benefit from computing technology?” rather than the sensitive form “What kinds of technologies would best benefit particular groups or societies of people in specific areas or cultures?” It even sometimes seems as if all developing countries were treated as one homogeneous group, their dominant and common characteristic being the lack of certain technologies.

The Problem With Exporting Technology

When technology is seen as a liberating force, it is argued to liberate countries from debt, societies from poverty, people from want, workers from monotonous and arduous tasks, and so forth. Although there certainly are cultural patterns of behavior that feed unwanted phenomena (phenomena like oppression, inequality, and violence), it is not certain whether attitudes and behavior that are not in harmony with foreign technology could really constitute obstacles to human and societal development. It is hard to classify cultural habits concerning technologies as obstacles to development and thus obstacles to liberation.

Although modernity and liberation are hardly dependent on each other, the idea of technology's liberating character still lives strong. Perhaps it would be useful to ask, "If high technology has a liberating character, liberation from exactly *what* is it?" People from one culture easily perceive people from other cultures as naturally sharing the same needs as they do, yet view many of those needs being suppressed by the foreign cultures. But most needs are cultural constructs in the first place. The only needs human beings can universally be said to possess, at least with certainty, are needs like a certain amount of calories and enough oxygen to breathe. In fact, a shift from the concept of nutrition to the concept of food already entails a shift from brute biological facts to social constructs. If most needs are sociocultural constructs, one cannot say that modernization opens up a possibility for higher universal needs to emerge, but that modernization creates new needs.

Several theorists have noted that importing and adapting technology does not work so that technologies are adopted while people and societies remain unchanged, equipped with new technology. Instead, people's behavior, culture, and societies tend to change when new technologies are introduced into use. Those changes need not be—and often are not—negative changes, but still those sociocultural changes do suggest that diffusion of technology is a more dynamic phenomenon than merely importing and adapting.

The very idea of technology-induced, universally effective mechanisms of liberation collides also with problems of cultural relativism, which were discussed earlier in this article. John Searle (1998) noted that functions of things are relative to people's collective decision to give those functions to things. Functions of technology cannot be expected to remain the same across different cultural settings. In order for a technology to be the same across communities, certain similarities in cultural settings of those communities are required. For instance, the artifact some people call the *computer* is not a computer for people who have never seen such technology before. One can quite easily import artifacts to a community, but it is much more problematic business to import the social meanings attached to that machinery.

Following Searle's (1996:20-21) argument, from an outsider's viewpoint (intrinsically speaking) there are no such things as computers—there are only things that people treat as computers. Surely, things that are built to be computers do computations much better than many other things, like socks or forks, do. But a computer is still a computer merely because people use it as (or made it for the purpose of being, or regard it as) a computer. The very idea of the modernization theory, as well as of many later theories, was that the problems caused by sociocultural relativity, or by certain subjectivity of meanings, was thought to be solved by altering the sociocultural setting. That is to say, according to modernization theorists people, cultures, and societies should adapt to technologies and not vice versa. But it becomes questionable if that actually helps people anymore. At the very least, such help takes place in a very patronizing context, as outsiders claim to know the true needs of people better than the people do.

Serving Needs vs. Creating Wants

We have now argued that the modernization thinking relies on the idea that there are 'original,' universal human needs, and on the perception that some cultures suppress those needs whereas some other cultures let those needs emerge and then be fulfilled. Now, the liberating power of technology can be seen in a number of different ways, of which we discuss here two. First, from a needs point of view, it can be seen that technologies liberate people by fulfilling needs—be those needs suppressed or conscious. Second, from an economic point of view, it can be seen that technologies make it easier for people to gain a sufficient income.

As to the *question of income*, the problematic issues are quite clear. It is indeed obvious that computing and communication technologies and the like can support existing forms of earning a living. Technologies are often helpful in enhancing one's income. It would be ill-advised to belittle the possibilities that new technologies can open up.

However, one should remain realistic about the possibilities of information and communication technologies. Typical of political and intellectual fashions, successful ICT projects tend to receive a lot of attention, unsuccessful projects little if any. As for the successful projects, it is rarely discussed if the same input would have yielded even better result if invested in, say, education. And all in all, ICT projects do little if anything to change the underlying political and productive forces.

For instance, although ICTs enable small farmers to check, on-line, the local market price of rice, that does not add to the farmers' harvest. Even less does it help to check the world market price of rice if local buyers do not have those kinds of money. Small businesses rarely have either the logistics network or large enough volumes required for successful export business, and much of their products are produced and needed locally. The smaller the business, the more local they tend to be—yet the greatest power of ICTs lies in global business. Successful small scale technology-driven projects exist, but ICTs do not seem to offer a universal panacea for poverty.

As to the *question of needs*, the problematic issues are trickier. People in developing (as well as industrialized) countries surely have many unfulfilled needs, and it can be seen as a liberating matter to be able to fulfill them. Again, the problem arises with the idea of universality of needs. One has to ask, "Why are there, in prosperous and modern countries, so many people with unsatisfied needs?" The old Marxist idea, which states that societies develop by being able to fulfill first the basic and then more complex needs, leads either to asking whether there is an economic and technological state of society where people would no longer have any unfulfilled needs, or to investigating the mechanisms of how new needs are constantly created.

The question of how needs are created is vital since it seems that new forms of social life and technological innovations not only fulfill needs, but also create new ones. Therefore it will not suffice to analyze what kinds of needs does certain technology fulfill, but one must continue to ask what new needs or aspirations are simultaneously born. Balancing some needs against other needs is not a trivial task, though. The modern market economy has no means of prioritizing needs, and it would indeed be hard to think of an order of importance of human needs or a taxonomy of human needs. If mobile phones hold a high cultural value, there will be people who are ready to sacrifice satisfactory meals for owning a mobile phone (Mpogole et al., 2008). There hardly exist objective criteria for prioritizing very different needs, such as vitamin intake and symbols of status.

Since the beginning of technology transfer via development aid, the slogan of the development enterprise has been "freedom from want." One can legitimately ask for a clarification: "Freedom from want of *what*?" It is quite easy to take steps towards liberating people from the want of mobile phones—just quit advertising them, for example. But somehow it seems that when talking about liberation in the context of computing and communication technologies, quitting advertising is not quite the liberation technology advocates have in mind.

Technology and Money

Empirically speaking, it is interesting to see what actually happens when new profitable technologies are introduced in a country. One would assume that directly, or through some sort of trickle-down-effects, money-making opportunities would benefit populations as a whole. But that is not what research results indicate. The research team at Food First Institute has suggested a 'rule of development': If a certain profit-creating technology is introduced to a country in which there is a severe inequality of power relations (such as ownership of land, privileges, possibilities to get loans, or income opportunities), the situation of the poor tends to get worse (Moore Lappe et al., 1998:60). Most social scientists agree that poverty is not as much an absolute phenomenon as a power-relation, which can be magnified or weakened by such factors as technological decisions.

No country in the world is poor in a way that the population would be entirely poor—neither in any absolute sense nor in a relative sense. There are local élites in every country, and the benefits of technologies tend to be channeled to those élites. In some example cases where agricultural technologies were introduced to developing countries, food became increasingly a market commodity, which worsened the situation of small farmers whose competitiveness was not at par with large farms and who were often pressured to sell their farms (Moore Lappe et al., 1998: 62-63). One has to keep in mind that poverty is primarily a political phenomenon, and usually new technology does nothing to change the political power structures. More than often, they are the already most powerful who gain most from new technology. If poor producers had the choice between getting an access to ICT and forming a union, the latter choice would probably bring more increase in their income.

It can be anticipated that information and communication technology, if introduced for the purpose of economic benefit, may indeed be beneficial for skilled and educated users who have contacts to Europe or the United States and who are able to control relevant information through the medium of high technology. The economic benefits for the most impoverished people are much more uncertain.

Technology and Debt

When considering the effects of technological aid, one should also consider who actually gains from the aid. Most technological aid is presented as gifts (machinery) or as grants to acquire technology. Sometimes aid is partially composed of cheap loans. Yet it can be suspected if the underlying aim of such aid—or at least a hidden agenda in that aid—is just to make even more people dependent on certain technologies. Technological dependency is certainly profitable business for technology producers. A comparison of the price of technology on one hand, and the average wages of, say, teachers or doctors on the other hand, might paint an unfavorable picture of technological aid vis-à-vis investments in education and health care. That is not nearly the whole issue, though.

An important question in technology aid projects is the question of actual overall economic consequences. On one hand, from the perspective of most developing countries, modern computing hardware and software are astronomically expensive. On the other hand, from the perspective of hardware and software manufacturers the investments are much less radical than they seem from developing countries' perspective. Donating ten thousand copies of software, €200 each, to developing countries does not cost a software company two million Euros. Even donating hardware costs the company much less than the tag price of machinery. No matter what the motivation is, when technology is provided free under some aid schema, it makes various social functions dependent on specific technological solutions. A gift of today is often a compulsory purchase of tomorrow.

When asking whether modern technology can be a liberating force in and for developing countries, the financial question is one of the very central questions. When developing countries become dependent on foreign technologies, their terms of trade very often get worse. That is one of the mechanisms behind the debt crisis, which is one of the major factors causing poverty in the third world. Trading coffee for computers does not, and cannot, equate. More characteristically to the technological theme, trading large amounts of raw materials of computers for small numbers of actual computers does not, and cannot equate.

So it seems that the developing countries are in a dead end. They are viewed as being in a need of Western technological solutions but are themselves mainly producers of cheap agricultural products and raw materials. Their technological development, however, can lead them to an unbearable burden of national debt, which, when combined with unequal terms of trade, is one of the major causes of present-day severe poverty. The only way for the poor countries to avoid the debt burden would be to produce high technology themselves, but that is exactly what they cannot do (and the last thing most donors really wish to happen is to get serious business competitors.) Alternatively, the poor countries could carry on with less high technology, but in the present world that does not seem a genuine possibility.

Liberation: A Summary

The problem with the liberating character of technology seems to crystallize in a paradox. That is, even if technology could, in some senses, empower people and liberate societies, that liberation is accompanied by technological dependence, which is the antithesis of liberation. The notion that foreign expertise can help to empower people leads to a similar paradox—people are liberated by telling them that they are incapable of determining their own affairs. Apart from technological dependence, also economic dependence is likely to strengthen in the long run.

As the development of technology is not, as seen in the chapter on progress in this article, predetermined in any sense, there is also a *democratic* dimension in the development of technology. One should ask, “Who has the power, capability and the social position to participate in developing the new technologies?” and “According to whose actual (rather than hypothetical or future) needs the technologies are designed?” Exporting technological solutions to people with no control over the technology is, in this sense, highly undemocratic.

Also the long-term consequences of such projects ought to be considered. In the history of development projects, a rule of thumb for the success of projects has been that the motivation for aid is highly significant. Projects that are aimed primarily at giving a short- or long-term boost for the industries in the donating end of the aid, and only secondarily at helping the recipients of aid, tend to fulfill the primary goal and fail the secondary goal, despite the routine win-win rhetoric. ICT might turn out to be merely another chapter in this long story.

Concluding Words

We have argued, in some length, that some deep beliefs in the area of computing and communications technology do not stand conceptual scrutiny. These beliefs are commonly reflected in ICT-related practices. ICT-focused development projects have served as the focus of this text, mostly because of the potentially grave consequences of failed projects and the fuzz around such projects. It seems that old beliefs in the positive power of technological progress have resurfaced with ICT. One of our aims has been to show that a lot less has changed from the earlier failed endeavors on technology transfer than the ICT enthusiasts would like to admit.

As self-evident as it might seem, it needs to be noted that technology is not a power with a logic of development independent of human cultures. Technology is not universal, since technology exists

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to serve human needs, while needs exist only in a cultural setting. Technology does not progress by itself or inevitably; progress exists only in reference of goals to be achieved. And technology by itself is far from an adequate means of solving the problems of underdevelopment; it can even be counter-effective for that purpose.

The way we have presented our argument leaves room for two kinds of counter-arguments. First, one can disagree with our arguments aimed at refuting the dogmas of computing. Second, one can question our argument that the dogmas we have identified represent commonly held beliefs in computing fields and its relation to other fields of science and society. One might want to question if these sets of beliefs are actually dogmas, or point out some other dogmas than the ones we have presented. Such counter-arguments are certainly welcome. The aim of this article is to provoke discussion on the identification of the dogmas of computing and ICT in general, and we are happy if our article serves this purpose.

As pointed out in the chapter on liberation, we are not arguing that ICT-driven development would never work. Sometimes it indeed does. While we argue for an anti-determinist view at one place, we will not take another extremist position here. What we are arguing is that the reasons for failures in many ICT-driven projects can be found in the dogmatic assumptions of the discipline of computing itself. Insofar as the dogmas we discuss are not merely straw men, unwillingness to admit the existence of these dogmas will continue to haunt the field at large—some projects are influenced less, some more.

References

Bijker, Wiebe E. & Law, John (eds.) (1992) *Shaping Technology / Building Society. Studies in Sociotechnical Change*. MIT Press: Cambridge, Mass., USA.

Bowles, Mark D. (1996) U.S. Technological Enthusiasm and the British Technological Skepticism in the Age of the Analog Brain. *IEEE Annals of the History of Computing* 18(4): 5–15.

Black, Cyril (1967) *The Dynamics of Modernization. A Study in Comparative History*. Harper & Row: New York, USA.

Ceruzzi, Paul F. (2003[1998]) *A History of Modern Computing* (2nd ed.). MIT Press: Cambridge, Mass., USA / London, England.

Denning, Peter J. (Chairman), Comer, Douglas E., Gries, David, Mulder, Michael C., Tucker, Allen, Turner, A. Joe & Young, Paul R. (1989) Computing as a Discipline. *Communications of the ACM* 32(1): 9–23.

Denning, Peter J. (2007) Computing is a Natural Science. *Communications of the ACM* 50(7): 13–18.

Easton, Thomas A. (2006) Beyond the Algorithmization of the Sciences. *Communications of the ACM* 49(5): 31–33.

Feyerabend, Paul (1993 [1975]) *Against Method* (3rd. edition). Verso: New York, USA.

Forsythe, George E. (1968) What to Do Till the Computer Scientist Comes. *American Mathematical Monthly* 75(May 1968): 454–461.

Gabora, Liane (1995) Meme and Variations: A Computational Model of Cultural Evolution. In Nadel, Lynn & Stein, Daniel L. (eds.) (1995) *1993 Lectures in Complex Systems*: 471–485.

Gyekye, Kwame (1997) Philosophy, Culture and Technology in the Postcolonial. In Eze, Emmanuel (ed.) *Postcolonial African philosophy. A critical reader*. Blackwell: Cambridge, Mass., USA.

Harrison, Lawrence E. (1985) *Underdevelopment Is a State of Mind: the Latin American Case.* The Center for International Affairs, Harvard University: Cambridge, Mass., USA.

Hopcroft, John E. (1987) Computer Science: The Emergence of a Discipline (Turing Award Lecture). *Communications of the ACM* 30(3): 198–202.

Hughes, Thomas Parke (1994) Technological Momentum. In Smith, M.R. & Marx, L. (eds.) (1994) *Does Technology Drive History? The Dilemma of Technological Determinism*: 101–114.

Hume, David (1739) *A Treatise of Human Nature* (ed. Penguin Books, 1969). Penguin Books: Aylesbury, UK.

Knuth, Donald E. (1991) Theory and Practice. *Theoretical Computer Science* 90(1991): 1–15.

Knuth, Donald E. (2001) *Things a Computer Scientist Rarely Talks About*. CSLI Publications: Stanford, California, USA.

Kuhn, Thomas (1996 [1962]) *The Structure of Scientific Revolutions* (3rd edition). The University of Chicago Press: Chicago, USA.

MacIntyre, Alasdair (1984) *After Virtue. A Study in Moral Theory.* University of Notre Dame Press: Notre Dame, Indiana, USA.

Mills, C. Wright (2000 [1959]) *The Sociological Imagination* (Fortieth Anniversary Edition). Oxford University Press: New York, USA.

Moore Lappe, Francis; Collins, Joseph & Rosset, Peter (1998) *World Hunger, Twelve Myths.* Grove Press: New York, USA.

Mpogole, Hosea, Usanga, Hidaya & Tedre, Matti (2008) Mobile Phones and Poverty Alleviation: A Survey Study in Rural Tanzania. *Proceedings of the 1st International Conference on M4D Mobile Communication Technology for Development* (ed. John Sören Pettersson), December 11th-12th 2008, Karlstad, Sweden: 62–72.

Rist, Gilbert (1997) *History of Development from Western Origins to Global Faith.* Zed Books: London, UK / New York, USA.

Scheutz, Matthias (ed.) (2002) *Computationalism: New Directions*. The MIT Press: Massachusetts, USA.

Searle, John R. (1996) *The Construction of Social Reality*. Penguin Press: UK.

Searle, John R. (2001) Social Ontology and the Philosophy of Society. In Lagerspetz, Ikäheimo & Kotkavirta (eds.): *On the Nature of Social and Institutional Reality*. SoPhi: Jyväskylä, Finland

Shapiro, Stewart (2000) *Thinking About Mathematics: The Philosophy of Mathematics*. Oxford University Press: Oxford, UK.

Simon, Herbert A. (1981 [1969]) *The Sciences of the Artificial* (2nd ed.). The MIT Press: Cambridge, Mass., USA.

Smith, Brian Cantwell (1998 [1996]) *On the Origin of Objects* (MIT Paperback ed.). The MIT Press: Cambridge, Mass., USA.

Smith, Merritt Roe; Marx, Leo (eds.) (1994) *Does Technology Drive History? The Dilemma of Technological Determinism*. The MIT Press: Cambridge, Mass., USA.

Tedre, Matti (2006) *The Development of Computer Science: A Sociocultural Perspective*. Dissertations XIV, Department of Computer Science and Statistics, University of Joensuu, Finland.

Tedre, Matti & Sutinen, Erkki (forthcoming) Crossing the Newton-Maxwell Gap: Convergences and Contingencies. To appear in *Spontaneous Generations: A Journal for the History and Philosophy of Science* 3(1).

Wegner, Peter (1976) Research Paradigms in Computer Science. (IEEE) *Proceedings of the 2nd international conference on Software engineering*. October 13-15, San Francisco, California, USA: 322–330.

Wolfram, Stephen (2002) *A New Kind of Science*. Wolfram Media: Champaign, IL, USA.

Wright, Georg Henrik von (1971) *Explanation and Understanding*. Routledge & Kegan Paul: London, UK.