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Applied Scientific Ethics

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Abstract

Scientific ethics (SE) as previously defined by the author does have broad applications in other scientific fields especially those that are less theoretical and more practical. Applied science is an umbrella term to define several diverse areas of research (including but not limited to robotics, biotechnology, environmental sciences, etc.), all worthy of being the independent objects of ethical analysis. Through logic application of the already defined principles, SE can speak with authority on practical questions (like the morality of actions). After a brief introduction on the theoretical/ philosophical features of SE, each field will be assessed highlighting the most relevant advances in both current and future societal and moral issues related to those fields. Special attention will be devoted to the visionary outlook of interdisciplinary philosophical stances generally grouped under the term futurism. Two examples, and without prejudice to the other areas, are: conservation social sciences (having separate issues with respect to environmental science) and information and communication technology (ICT). The commonality with both fields is that the implications have become already situated in the very fabric of our daily lives. SE aids us in the understanding of the real impact of these applied sciences in our physical/mental lives and gives us a sound framework (moral standards) with which construct a common ethical viewpoint.

Keywords: Applied science; Ethics; Natural science; Ecology; Communications

Introduction

It was recently proposed the creation of a standardized ethics for science which was to be scientifically based on concepts that are unequivocally linked to science [1]. To the knowledge of the author, there has not been any previous attempt to merge science with ethics (or viceversa) nor any endeavour to derive ethics from science.

Differently with what is normally considered scientific ethics (SE) [2], i.e., the norms that regulate the responsibility of all members of the organizational system of science in all contexts where science is engaged with, SE is the ethical system that derives and befits science. SE was developed from fundamental science, following the experimental method and capturing many aspects essential to ethics [1].

Since ethics is also a technique of abstract reasoning about norms and values, of balancing different values, and of building moral arguments that try to justify why this is better than that [3], it comes to play in science for better or worse.

The new SE with all its sound scientific principles has been applied to a few applied sciences (namely bioethics), allowing to identify a conceivably universal position with regards to these topics. Since science is kept in such a high esteem as to value it most of every discipline, then ethics is at the same level because with SE ethics has the same foundation as science.

In the past century, science has been considered as the principle architect of the 20th century world, and the layman deems everything science hypotheses as unquestionable truth, as if it had the status of priest craft [4]. Recently, the reliability of science has morphed into a socially robust knowledge with a narrative of expertise expanding beyond the confines of science to engulf non-scientific disciplines [5][1].

Science has increased in size enormously. The Organization for Economic Co-operation and Development (OECD) has issued a ‘fields of science and technology’ (FOS) classification that can be useful to view what subfields science includes [6]. Although there are other more complex classifications systems of science [7], based on criteria like number and types of journals [8], this is chosen for simplicity. **Table 1** shows a

[1] Gibbon’s view of science as a contract with society is substantially an agreeable position. The only difference with Gibbon’s view that a new social contract involving a dynamic process in which the authority of science is legitimated by society seems to already been established. Particularly, this view focuses on socially robust knowledge being controlled by elite groups in society who then control popular consent.

modified version of the FOS for each major branch or knowledge (subfields are not shown).

Table 1: Fields of Science and Technology Classifications.

Type	Branches of Knowledge	FOS
Science	1. Natural Sciences	Mathematics (pure) Computer and information sciences (theoretical) Physical sciences (theoretical) Chemical sciences (theoretical) Earth and related environmental sciences (theoretical) Biological sciences (theoretical) Other natural sciences (theoretical)
	2. Engineering and Technology	Civil engineering Electrical engineering, electronic engineering, information engineering Mechanical engineering Chemical engineering Materials engineering Medical engineering Environmental engineering Environmental biotechnology Industrial Biotechnology Nano-technology Other engineering and technologies
	3. Medical and Health Sciences	Basic medicine Clinical medicine Health sciences Health biotechnology Other medical sciences
	4. Agricultural Sciences	Agriculture, forestry, and fisheries Animal and dairy science Veterinary science Agricultural biotechnology Other agricultural sciences
Almost Science	5. Social Sciences	Psychology Economics and business Educational sciences Sociology Law Political Science Social and economic geography Media and communications Other social sciences
Non Science	6. Humanities	History and archaeology Languages and literature Philosophy, ethics and religion Art (arts, history of arts, performing arts, music) Other humanities

Each FOS in Table 1 has multiple other subfields pertaining to its own parent.

Philosophical Basis

Science speaks about facts. Science is the quest for objective knowledge of our universe, and uses a special method of intellectual inquiry, the scientific method [9]. Scientists often tend to interpret those facts based on their preconceived ideas (bias). Science is devoid of bias because as a field of epistemology (knowledge) experimental and repeatable tests are performed to demonstrate its validity.

The discourse of science will now be turned from fundamental science as detailed by the Author previously [1], to applied science. The term fundamental is pretty recent addition to the term science as it comes from the substitution in language of pure science with fundamental research occurred in interwar period in the US [10].

Applied science is the application or utilization of theoretical science's concepts and frameworks for specific human purposes or scopes [11]. In contrast, fundamental or pure science (basic research), is the production of knowledge using the experimental method [1]. So, seen in a slightly different perspective, following pure science is to want to know better or more (to discover), while attending to applied science is a necessity to do (inventing new things) [12].

It is now clear what applied science means, notwithstanding the historical perspective of the evolving concept of a profits-driven research, as highlighted by Lucier [13]. And this is evident through the realization that the traditional boundaries between university and industrial science, between basic and applied research, are disappearing [5].

By reviewing the FOS in **Table 1**, it is possible to divide the table in two. The first section is linked to fundamental science (red highlighted), while the following 3 sections refer to applied science (green highlighted). Of course, in every FOS there are subfields or features that may be considered belonging to either applied or fundamental science. In those cases, the subfields can be appropriately reshuffled to the applicable FOS (e.g., physics and chemistry applications subfields can be re-routed from section 1 to section 2, similarly theoretical aspects of FOS of sections 2 to 4 can be reverted to section 1).

It should also be mentioned that the social sciences are arguably a branch of science, although certainly a branch of knowledge [1]. This stems from the conjecture that social sciences have failed, despite long attempts, to provide increasing amounts of cumulating scientific knowledge with technological payoff for predicting and controlling social processes [14]. This might be due to the impossibility to apply a core principle of scientific progress which is reproducibility [15,16]. However, often an experiment or a research on empirical findings may be irreproducible because of random or systematic errors, inaccurate initial conditions and data on the size of the effect, among other things [17]. Notwithstanding these considerations, and giving credence to the objection that the object of social sciences is we humans, very complicated beings, it is acceptable to tentatively allow the status of 'young science' to social sciences [14].

Thence, social sciences will be the object of a preliminary assessment by SE with the option of creating a scale of evaluation of societies.

Ethical Connection

Applied science could be considered as technology. Contemporary definitions of technology sometimes call it applied science, the application of scientific principles to solving problems [18]. Although this view (the similitude between applied science and technology) is centuries old, it has been challenged from many directions [19]. It is easier to see technology as the product of applied science. Indeed, the objects, tools, and machines that people made and the processes that made them are the technologies, i.e., the products [20].

Therefore, when talking about applied science, it is inevitable to refer also to technology.

As our society progresses through various increasingly higher scientific and technological (S&T) levels, social and ethical considerations tend to be at the forefront of public concern and academic interest [21]. Indeed, a steadily potent S&T growth is forcing individuals to re-examine how technology is viewed [22]. This occurs not simply because an increasing number of people are affected by technology but because revolutionary technology provides numerous novel opportunities never really thought out before [21].

The technology of this era has had more impact on society than any other technology change in the past [23]. This impact has to be carefully assessed.

Applied science (technology) has had and can have three main implications. Apart from the impact on humans (covered by ethical features), it has consequences on human society and the environment (human interaction with ecology) [24].

Ethics can be defined as both the science of human nature and a system of principles governing morally correct conduct. Morality is considered the confirmation of generally accepted standards of conduct.

These terms are often mistaken for one another because their definitions are so similar. Although their definitions are not exactly interchangeable or synonymous, it is relatively safe to assume that people cannot develop a system of ethics without first consulting their society's generally accepted standards of conduct. These standards of conduct and the resulting system of ethics are derived from a group's basic need to preserve its own society [25].

SE is ethics based on scientifically sound ethical principles of respect of life, truth and human dignity. The problem raised by Pennock and O'Rourke (2016) [26][2] has been more conclusively resolved in the light of an expanded set of scientifically derived principles, without the need for a virtue based approach. Bioethics is a major area of academic ethical

[2] The problem concerns the fact that ethics appear to be a set of externally imposed rules rather than something intrinsic to scientific practice.

thought because it so often deals with highly personal decisions and the nature of medical and pharmaceutical establishments [27]. Bioethics will not be discussed herewith as it has been introduced elsewhere [1].

Davis [28] divided ethics into three distinct categories of the application of ethical concepts. The author distinguished ethics as-ordinary-morality; ethics as special standards of conduct; and ethics as a field of philosophy.

Technoethics

Whatever is applicable to fundamental sciences is directly linked to applied science too. So, if the actions of agents are in direct contrast with the precepts of SE, the same occurs to agents in AS. Thence, SE can include applied ethics, as an ethics that focuses on applied science.

There are though several distinct discourses around applied ethics not seen as an ethics that concentrates on field-specific norms and values from (general) normative ethical options [29].

From this perspective, a new ethics was developed in the 1970s, technoethics [24].

Technoethics is said to be a research and practice field situated in between philosophy of technology and applied ethics [29]. Technoethics may be defined as the study of moral, legal and social issues involving technology [23]. In general, technoethics as an interdisciplinary field is concerned with all ethical aspects of technology within a society shaped by technology [24].

Technoethics then becomes of vital importance these days, as technology occupies a dominant place in a man's life [30]. This comes to no surprise as many state that man is technological by nature [9,31,32]. Moreover, the modern world is undergoing a fundamental transformation as the industrial society of the 20th century is swiftly morphing into the information society of the 21st century [33].

One of the laws of technoethics states that there is a direct proportional relationship between the technological innovations' social impact and the ethical responsibility of technology and its creators [34].

Accordingly, technology can be valuable, worthless or evil, depending on the ends it is made to serve, and consequently must be subjected to moral and social controls [35].

Technoethics is expected to continue to expand with new areas added as technology progresses in the 21st century, such as nanoethics, environmental ethics, neuroethics and other more refined and novel ethics [22,36].

Technoethics is also well situated to tackle the positions of transhumanism. Rooted in humanism, transhumanist agenda looks eagerly towards new advances in human enhancement technologies as a means to transform humanity [37]. This transformation is thought to allow humans to transcend the biological barriers of natural lifespan and well-being [38].

It is in this framework that SE can develop a discourse around applied science. By using problems and issues already tackled by technoethics, SE can provide new insights to long challenged problems.

Why ethics?

A question can be asked as to why ethics should be so important in our society, in this age. One answer could be that since science and technology enter our lives in new ways, scientific ethical issues in the use and consequences of choices regarding science naturally arise [9].

Probably the strongest calling of an intervention of ethics comes from the United Nations Educational, Scientific, and Cultural Organisation (UNESCO) with its famous declarations. The first is the Universal Declaration on the Protection of the Human Genome and Human Rights released in 1997. And the second is the Universal Declaration on Bioethics and Human Rights published in 2005.

But these are seen as global minimum standards in biomedical research and clinical practice [39], and not as universal principles. At the very least, it is seen as a valuable addition to the ethical conversation with its pragmatic approach to development and implementation of basic ethical infrastructures, especially in Countries where it is lacking [40].

At a similar level, the Universal Declaration of Human Rights of 1948 [41], the United Nations Charter, The International Covenant on Economic, Social and Cultural Rights (ICESCR) and the International Covenant on Civil and Political Rights (ICCPR) [42], all point towards a similar direction. Moreover, ethical guidelines from other authoritative international bodies are published, re-published and updated time and again. The Council for International Organizations of Medical Sciences (CIOMS), for example, published an update of its guidelines in 2016 [43]. There is a vast literature on the evolution of human rights thoughts [44,45] that cross with development ethics [46] and with bioethics that we shall not discuss. Suffice to say that if there is such pressure towards ethics, it is mostly because the consequences of actions are felt capable of impacting society as a whole.

Human dignity is considered a value [47][3]. This is different from the status type classical concept human dignity, which was linked to social status (with all the honours and respect that came from it) [48]. It is more correct to think of it as intrinsic worthiness, not dependent or the object of any subject [49]. In other terms, dignity is a metaphysical notion which implies an objective moral principle and derives legitimacy from an extra-legal sources, such as natural law [50]. But, human dignity cannot be relativistic to a cultural, philosophical social, historic or religious context [42] and are universally applicable. As already discussed in the first manuscript of SE [1], human dignity is necessarily. But human dignity does not encompass body integrity.

Consequently, human dignity must be reasserted above that of the products of AS (technology) so that the latter may not trump the former. Human dignity is thus superior to technology and any product thereof. Technology can add value to or make better the life of humans, i.e., a higher quality of life [51]. So, technology has an axiological significance though not related to human dignity but to human life.

With every technology there comes a risk, extrinsic or intrinsic. Technologies are being served to us without the proper information to safely use them not just practically but also theoretically. Being ethics a science in its own right [52], it is ideally treated together with AS.

SE can apply as a whole to all challenges without the need of several kinds of ethics depending on the there is a transition from paternalism to informed consent to informed choice. Unless we can educate citizens, the choices they make will not be informed

As it has been explained in the introduction, engineering and technology are prima facie applied sciences. A formal definition of engineering can be traced in the online Merriam-Webster Dictionary, stating: 'the application of science (of course, applied science) by which the properties of matter and the sources of energy in nature are made useful to people, through the design and manufacture of complex products' (https://www.merriam-webster.com/dictionary/engineering). This comes in combination with technology (the practical application of science: the design and manufacturing, and the products), again seen as useful to people. Products can be anything from engines, machines or structures, in the widest sense (https://en.oxforddictionaries.com/definition/engineering).

There are several different types of engineering fields, depending on the object of analysis (the products that are being manufactured). However, all of them have in common the purpose and scope of the products manufactured. Applied science's utility scopes include all non medical applications of engineering, including biological engineering (synthetic biology [53]), while the maintenance perspectives are those that tend to manufacture products for repairing, from the ecosystem (environmental engineering [54]) to humans (biomedical engineering [55] and medicine).

Some technologies have multiple scopes like nanotechnology applied to pharmaceutics and to civil engineering. Nonetheless, SE will follow and improve upon Bunge's insight on technoethics. Indeed, Bunge's maxim stated that "the technologist must be held not only technically but also morally responsible for whatever he designs or executes: not only should his artifacts be optimally efficient but, far from being harmful, they should be beneficial, and not only in the short run but also in the long term." [56]. But beneficial and/or harmful to whom or to what?

Finally, it is the ultimate scope of advanced technologies that matters the most. On this end we can distinguish three purposes of all technological applications (AS), irrespective to their age: repairment (changes from impairment to normal range), modification (changes within the normal range) and enhancement (changes outside or beyond of the normal range). This can be visually seen in Figure 1.

Applications of SE

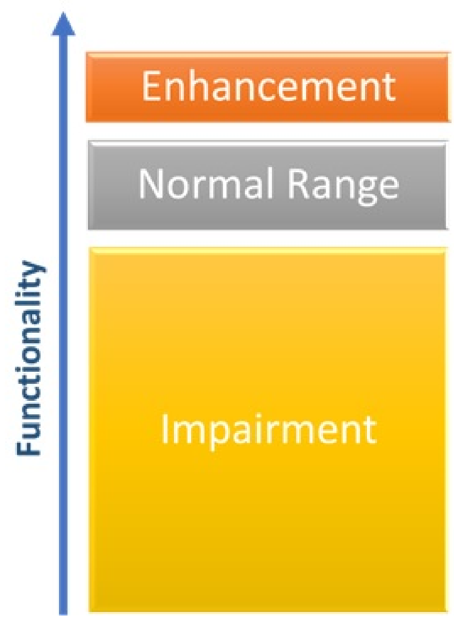

Figure 1: Degrees of Changes in Functionality.

Of course, there is much to question on what constitutes normal range, but once it is defined and agreed upon, then we can consider the other two levels: impairment and enhancement. Notwithstanding the arbitrariness of the scalar field given to functionality, the lower the level the less the functionality something has (up until complete loss). Similarly, the higher the more functionality nears the normal range, until it surpasses it. Beyond the normal range, biological living matter may encounter a setback: as one functionality surpasses the normal range another may enter the impairment

[3] The author specifically refers to value in legal terms. As such the etymological meaning of the Latin 'dignitas' is triple: worthiness, magnificence and value with respect to a subject. It is hence important for the author to understand who is the subject for which the object has a value (is 'dignus'). From here, the dignity of animals is equated, legally speaking, to a function that is served for humans. Finally, the uniqueness of each human individual is reasserted, differently from the author of this manuscript, in the notion of 'individuus' (indivisible, integral), distinct from the notion of 'persona' (the mask). The persona identifies a social creature, while individuus identifies a biologicial-spiritual creature. The two notions result in the ambiguity of the concept of human dignity. There is therefore a legal distinction between the physical and spiritual integrity for human dignity, and the physical and social identity of an individual for the dignity of a person. Contrary to this jurisdictional distinction, it is here stated to not to distinguish the two types of dignity, but only consider the first, irrespective to the latter.

level. This may occur because all functions are subtly connected and interlinked.

At that point, there is the fear that an enhancement beyond the normal biological range of functions may cause unforetold side effects. Possible technoethical issues include the following questions:

Would there really be a gain (physical, psychological, emotional, spiritual)?

Is enhancement beyond the natural biological values really promising, as post-humanists say?

Who or what can assure us that supernatural or 'biotech' values of functionality are compatible or compliant with life itself or the organism as a whole?

Are side-effects even avoidable, at all?

To these we will try to respond in the following sections:

Bioengineering and robotics

The core idea of bioengineering is the use of biomaterials (or biocompatible substances) to design or aid the reconstructions of damaged or absent living matter (definition taken from the Oxford Dictionary, https://en.oxforddictionaries.com/definition/bioengineering). Technically, bioengineering is the application of methods of physical science in an engineering approach to solving problems concerning non-functional tissues [54]. And biomaterials are any substance, organic or inorganic [57], that is similar to/compatible with living matter, from parts of a single to a collection of cells (tissues) belonging to any organism of all six kingdoms of life [58]. Indeed, cell-material interaction is the first step of biomaterial compatibility assessment [59].

Biomaterials are then used for a vast multiplicity of purposes. They are different from nanomaterials, which are not biologics themselves, but can be loaded with biologic or radioactive materials and their surface can be functionalised with antibodies, peptides, or small molecules [60]. As an example and a mix of the two, silkworm silk can now be bioengineered to produce bio-nanomaterials with incredibly versatile and sustainable characteristics [61].

As an example among many of the applications of bioengineering techniques (recombinant DNA in gene therapy [62]), is the use of biologics such as fusion proteins [63].

Bioengineering is just one of the various new technologies that can be used by medicine not just to repair anymore but also to change or enhance it. Some are already suggesting that advanced medical devices could allow the healthy to gain some new functions, not limited to physical features but also mental capacities beyond that of native human abilities [64]. Bioengineering will utilize biotechnology in order to alter the 'normal' functions of the human body and psyche – not the disease processes – and to increase or improve the innate capacities and performances of the body [65].

Another particular type of medicine is embodied medicine which uses advanced technologies (robotics) for altering the experience of being in a body with the goal of improving health and well-being [66].

It is commonly held that in this era the humanoid machine (a robot with human like capabilities) will become reality [51]. Similarly, although it is thought commonly that robots are mere machines, humanoid robots are symbolic devices, very sophisticated thinking machines, capable of helping human beings in manifesting themselves [31]. A detailed classification of possible humanoids robots and relative ethical consequences is provided by Veruggio and Operto [52].

The overarching theme permeating these concepts is that the body is malleable, viable to be modified by newest technologies, as discussed in posthuman circles [67]. In the posthuman agenda, the human body is the original prosthesis that can be extended and replaced with other prostheses [68]. In general, the ultimate goals of posthuman discourse is the overcoming (trespassing) of the limits of natural biology to attain supranatural conditions: extended life, superhuman capacities, etc. [69]. This technologically enhanced human being, sometimes called Homo sapiens + [64], is the apex of transhuman anthropology and posthuman conditions for a better life [70]. The advocates of posthumanism maintain a liberal position with respect to these newest technologies in so far as they consider "enhanced" life not only "better life" but rather the one exclusive and only right way of life [71]. No technology is too dangerous as to be limited in any way, even that of genetic engineering the future generations, e.g. by creating the most valuable genotype [72].

Given these premises, two considerations should be made from a SE standpoint. The first is the irreducible complexity of life in biological and physical terms. This translates in the scientific impossibility to obtain a better integration between natural and non-natural features (biomaterials, robotic devices, etc.). And the second is that any purported technological enhancement is doomed to impair human beings, as a whole (body, mind and spirit). It may seem to improve one single function, but this will cascade in the weakening of at least one other (when not in a multiplicity of fundamental biological) organically natural components, resulting in distress. This will occur because everything is so immensely connected to one another as not to leave freedom of enhancement without irreparably altering already established biological processes.

Several sciences have emerged to try to make sense of the outstanding convolutedness of even the simplest living matter. Complexity theory has attempted to analyse the staggeringly large number of connections between multiple interdependent subcomponents of biological organisms seen as complex adaptative systems [73]. Complexity sciences, with the use of computer power and nonlinear dynamics, gives us a hint to the behaviour of such systems that require knowledge and techniques from several discipline for a successful study [74]. Systems biology, as an integrative discipline, utilizes quantitative experimental and computational methodologies to decode information flow from subcellular components of signaling, regulatory and functional pathways [75]. Finally, among the many other fields that are flourishing, the omics sciences are just now surpassing the reductionist viewpoint to cope with the irreducible complexity of biological organisms [76].

In any case, from its inception, the idea has always been that the original living material is the best option, full-stop. Anything else is inferior in all respects. Both aforementioned concepts stem from practical analysis of biology and medicine.

The limit of biocompatibility would be the impossibility to accurately design a truly “blood compatible” biomaterial in spite of decades of research [77].

This brings us to the concept of human body. The idea springs from the antique Greek-Roman notion of a human being as in-dividuus (Lat. not divisible, integral) [47].

This highlights the ethical issues within bioengineering. SE’s view of science is that it values human dignity as a central concept of and for science itself. And human dignity is also linked to the wholeness of what is defined as human: body and mind[4] [66]. The two characteristics of humans are inextricably linked together [78], and have an impact on human health. Though the body is essentially similar in all aspects to that of other animals, biologically speaking, the resulting actions (and thought patterns) are novel, unprecedented and forever removed from the animal realm [79][5]. In other words, being biologically a kind of mammal, we are nevertheless so utterly different from all animal species [80]. Notwithstanding this, the body does not add up to the essence of man in any way. It’s more of a figurine, a symbolic representation of humans with no value. An enhancement or impairment of any kind on the human body will not modify the ultimate essence of dignity of humans, just its overall health. On the contrary: it is the dignity of man that raises the human body to a higher level so that it may not be voluntarily harmed, freely impaired, even justifiably stigmatized nor ideologically severed.

Consequently, any form of enhancement outside of the normal biological range, with any procedure that is not naturally or organically based[6], even if just for aesthetic reasons[7], is morally questionable for SE.

When using these technologies, even if just to cure, there is an intrinsic risk of constitutive resistance to such therapies [63], serious therapyrelated toxicities [62], which even when avoided become no less that adverse [81].

Technology extends the biological limits of human agency in such a way that it is often difficult to draw a clear line between the human agent and artificial creations, such as software bots, physical robots, and synthetic biological constructs [82].

Software and physical robots or any kind of artificial creations are unlike anything we have encountered yet and in them something like individual agency seem to be beginning to evolve [82].

Nanotech

Nanotechnology or nanoscale technologies is generally defined as engineering done at the molecular scale and

4 Such was the meaning of the old adage in Latin: ‘mens sana in corpore sano’ (a healthy mind is in a healthy body). In reality, King and Barrett (2017) relate that the classic Juvenal’s latin dictum was linked to the healthy lifestyle of training the body to have a healthy mind (improving cognition and verbal memory and fighting off depression and anxiety).

5 The author actually discusses the academic work (next reference), and video lecture of another biologist, Dr. Sapolsky. The bare facts are that attitudes emerge from human biological characteristics, in absolutely novel ways and are impossibly removed from the reach of other animals. Among the many examples given, are:

Ideational or ideological stances triggering biological reactions (e.g., stress physiology);

Neurologically based theory of mind (TOM), extended to encompass solely human secondary TOM;

Chimp-like empathy, but elevated to unmatched areas of abstraction where humans empathize for other species, even if only immaterially represented in artwork and even if these are unreal species;

Cultural type primate behavioural transmission, but majestically amplified in humans to include pure ideation with transgenerational transmission beyond direct contact;

Figurative language (figures of speech) is astonishingly based on human ideational abstractness (metaphors and symbols, which literally activates parts of the brain without physiological stimuli and confuses the mind to interpret them literally, physiologically or out of context;

The uncharted terrain of human capacity to believe and do in the unbelievable and the impossible;

While the first four represent common biological areas between humans and animals, where humans simply outperform all other creatures, the last two points are areas where humans are simply unique and alone.

6 Such procedures are any technique that requires body manipulations with either introduction of chemicals in non-natural ways (injections etc), or with mechanical means (implants). Hence, nutrition and body work are considered natural strategies. This explanation may not be exhaustive but serves the purpose of general information.

7 Aesthetics is a branch of philosophy (knowledge) that studies beauty and how we see beauty. In this perspective, examples of ethically acceptable non-natural alterations are aesthetic surgery for repairing damaged tissues (injury or trauma), but not tattooing (which is voluntary scarring of the body).

represents the ability to deliberately shape new structures, atom by atom [83]. Therefore, any feature relating to research and development (including the creation of new organic and inorganic materials) at the atomic, molecular or macromolecular levels is nanotechnology [84].

According to Swierstra and Rip [85], nanotechnology may refer to all those phenomena and manipulations (including a host of heterogeneous technologies, from electronics to materials and on to medical use of nanoparticles) occurring at the nanometer scale (the level of 1 order of magnitude below that of the micron). Generally, the scale is about 100 nanometers (nm) or smaller, just about the size suitable to start modifying and building anything useful [86].

Similarly, nanomaterials are those compounds that have a size comparable to that of single molecules and, as such, possess unique properties [87] (increased surface to volume ratio, nanotoxicity, etc.). The applications of nanomaterials can extend into all aspects of modern life style including the energy, biomedical, consumer, and industrial sectors [60].

It has been argued [88], in 2008, that since nanoscience and nanotechnology are still in the very early phases of development, there are no current ethical issues at hand but only a taxonomy of types of possible future ethical issues. More recently, the ethical discourse for nanotechnology has focused on the safety concerns (such as safety by design) [89] during the development these engineered nanomaterials, given the recent debate on the environmental risk posed by their large-scale production [90]. A safety debate that has partly coalesced into process-oriented (in the EU) and product-oriented (in the US) national and international fragmented regulations [87].

Though some aspects of nanotechnology are starting to materialize, most of the promising advances of the field (nanopharmaceuticals, tissue engineering, implantable nanodevices, etc.[91]) still remain in the realm of futuristic science fiction. But, features of nanomedicine (a new field of molecular medicine exploiting the properties of individual to generate complex functional drug delivery vehicles, diagnostic and analytical tools) are on the horizon [60].

It seems paramount to realize that human complexity is currently beyond science's grasp not just in comprehending it but also in fathoming it. Let us consider how many disciplines make up the Life sciences that study the human body. According to, the scientific subdisciplines are: physiology…

What is unethical or ethical is not, per se, the science but the way we 'do science'[1]. To explain, on a purely theoretical standpoint, nanotechnology has scientific concepts that can be approached on conceptual grounds that are neither ethical nor the opposite. The scientist that is conceptualizing the theory of a nanoscale phenomena is committing an ethical act, but the thought itself is a-ethical.

In the moment humans begin to think of an application of the science of nanotechnology, then ethical considerations will apply to the contemplation step, too. Hence, the development of nanotechnologies at the scientific level will certainly have ethical implications inasmuch as it concerns how will the nanotech be applied in practice.

Since Nature has perfected the science of manufacturing matter molecularly, where cells are true nanomachines [86], should we think we can do better?

Withal, we humans not able to repair us in a like to like fashion. Our best attempt so far is to minimally and imperfectly create imitations of small body parts, etc.

Futurism, as part of the transhumanist programme, would like us to believe that technology will grow to such a stage when we will be able to upgrade any part of our body, including the neurovegetative system. Indeed, the futurist vision is for a fast, controlled and directed evolution (the psychological and cognitive enhancement of human beings) brought about by human engineering and all modern technologies (nano-, etc) [92].

If we, scientists, with all our technology and knowledge cannot even replicate a simple cell, not yet a whole cell but even a tiny part of it, how could we desire to upgrade an entire human being?

How can we then possibly think to be able to get even close to creating a substitution of a system so complex that we lack the capability to comprehend it in its most essential network? There is even a lack of words to convey such complexity.

Science has shown us that nature is not easily fooled [93].

If we are to believe in evolution, then one argument against the folly of mankind to upgrade itself is the following.

If evolution is true, it took us billions of years to evolve such concerted biological systems which are so finely intertwined with themselves that they are able to autoreplicate and autorepair. It took man millions of years of evolution to adapt to an environment through which we receive stimuli we are capable of processing.

If we are not to believe in evolution, then yet another argument is the following.

Can the created become the creator? Could such superiorly created machines be even replicated by us created machines?

In either view, it is neatly beyond our reach, not just presently but forever, to be able to intelligently upgrade our body to a better one. And SE warns us of the risks.

Moreover, any attempt to perform such a transition would most likely result in monsters, incapable of adapting to the physical environment (if not to mention the psychosocial one).

Conclusions will be discussed in Section 2.3.

Environmental ethics

The outstanding task to understand how human society interacts with nature and the biosphere would alone allow us to understand the importance of the environment.

Natural ecosystems are complex entropy-fighting systems with an infinite amount of feedbacks and adaptations that contribute to resiliency [94]. Ecological engineering is a technology that both repair the damages by humans to the environment and also designs new sustainable ecosystems with human and ecological value [95]. We agree in the feasibility of the first part of the definition of ecological engineering but on the second, there are issues.

Issues involving the alteration or maintenance of ordinary human-nature relationships should be the prime subject of ecoethics [96]. Without necessarily going into the vast literature on ecological ethics, SE can simply point out that the environment is part of the nature of man. As we understand more and more how vastly important the several interactions of man with its environment are, ecoethical considerations become clearer and more prominent.

As science is devoid of second purposes (financial or other), its main resolution is the maintenance of the perfect environment for all life to prosper. Science knows all too well that an imposed change in the natural order of things will pass on to all dependent life forms like a chain reaction. And since science cannot but imperfectly copy nature, it cannot fathom of substituting it in any possible way.

Yet, bioengineering applications and new human advancement technologies continue in a progressive process to survive with little concern and responsibility for the biosphere [69]. In this understanding, SE sustains that the best action should be that which minimizes environmental impacts on a case by case basis. Using modern science as the background, SE would foster a thorough assessment of each situation and facilitate the most ideal course of action based on applicable responsibilities and accountabilities: reduction of ecological and biological stress.

The aim is to perform a rigorous examination of ethical and societal considerations implied by nanotechnology from the viewpoint of science and then briefly review a few policy concerns.

In the same way, also nature is subject to customization in the eyes of the ultraprogressives.

But if we look at the simplest technology that we had available since time immemorial, agriculture (including crop modification), we see the essence of the risks of technology. At that point in time, we may not have had the capability to understand the impact on the ecosystem of such bio- or eco-engineering feats

It seems clear that there is no need for a new kind of ethics but just the society-wide use of a universal kind of ethics. In this perspective, SE fills this void and proposes already known solutions to new problems and issues. While the technoethical issues may be new due to novel and advanced technologies, the solutions of SE can be swiftly reviewed and adapted on a case-by-case basis.

ICT

The connectedness or interwovenness of technology within human life and society is never more evident than in information and communication technology's (ICT's) seemingly unstoppable evolution [30]. ICT is an umbrella term that includes any communication device or application, like radio, television, cellular phones, computer and network hardware, etc. [34].

Notwithstanding the many research programs conducted under the communication technoethics [22] and the several issues raised by ICT's new media and web 2.0 [97], ICT has also more physical concerns.

There is a risk that ICT may be a health hazard and has thence to be used with care. Several experiments were conducted since the late 80s on hand-held radio frequency (RF) transmitting devices, from portable radios [98] to cell-phones [99-101] to other wireless communication devices [102,103]. The adoption of the specific absorption rate (SAR) as the basic parameter to establish the safety of human exposure in between 30 kHz and 300 GHz RF bands has been universally recognized [104]. Whole body exposure, penetration depth, localized and maximum permissible exposure (MPE) limits to electromagnetic fields (EMF) have been established [105].

Health risk assessments were conducted and biological effects and risk factors from lowlevel RF exposure were identified [101,106]. More recent adverse biological effects included disruption of trained work, increase in metabolic heat production, DNA double-strand breaks, DNA damage, etc. [102,103,107], while risk factors included brain tumors [108, 109]. For these reasons, RF EMF exposure is considered a tremendous public health concern [110].

Withal, there's no definite consensus in the scientific community concerning the effects of RF EMF radiation, as stated by the WHO in 2006 [111].

With that being said, SE can substantially add depth in a reflection of the status of ICT. SE would still require a series of actions to foster its standard principles. Among these actions are:

Continuous communication through all media concerning the risks and known adverse effects (awareness campaigns) – Communication duty.

Government funding for studies and awareness campaigns – Accountability, Communication duty and Fair discussion.

Any other objective measure or strategy to reduce exposure - Integrity

Manufacturers should provide accessible information on the above - Accountability

Manufacturers and Government should collaborate to reduce environmental impact – Respect for Life and Social responsibility

In the end, because notorious and important international regulatory bodies like ICNIRP, AGIR and WHO use ambiguous language not worthy of a scientific discourse [112], there should be greater adherence to ethical principles.

Social sciences

It has been shown how technology impacts humans and their society. It is now time to discuss the implications and impact of SE also on society at large.

Since sociology declares itself to be a scientific discipline, from which the name social sciences, scientific ethics can be applied to social sciences, as well. The result would be to endow this field of science with a new instrument with which societies are studied.

Sociology is the systematic study of society [113] or civilizations, and social interactions. Different interpretations of the terms "society", and especially "civilization" [114], exist and have been in modern literature since its inception [115]. Because civilization can be defined as the highest cultural grouping of people and the broadest level of cultural identity people have [116], it is comparable to society.

It is known, that different civilizations have different standards of ethics (also in the sense of definition of what is good and bad) [117]. We would not avow to the concept of social evolution [118][8], in the framework of SE. But such a paradigm could be assumed valid for a description of ethics in order to attempt a classification of societies.

It has been assumed valid for descriptions of societies evolving through different stages of economic progress. We can see this in the difference between development Countries and Westernized Countries.

We now come to the application of the scientific ethical standards to a classification of civilizations. As with the adoption of all standardized classifications [119], there are ethical considerations embedded in the cultural assumptions of the scientific ethical standards themselves. This new system of civilizational study may have, as an improvement with the other scholarly ranking models of the past [120], the advantage to produce a more accurate and complete roster (for comparison), since the use of universal principles can be applied across the board.

Classification of civilizations

Societies and civilizations have been classified in the past based on various measures, historically [121], economically [122], techno-economic [123], according to some defined standards [124], sociologically ([125], sociographically [126], culturally [127], scripturally [120], energetically [128], and religiously [114].

Not all of these methods or measures have scaled them on a defined or definite ladder.

It was recounted [124] that in the minds of the nineteenth-century international lawyers, 'civilization' became a scale by which the countries of the world were categorized into 'civilized', barbarous, and savage spheres.

This early attempt to classify civilizations would then be followed by later, more refined and scholarly undertakings.

It was noted [129] that the International Society for the Comparative Study of Civilizations (ISCSC) several times in the 1970s and 1980s tried to generate discussions on civilizations classification, their origin, and spatial and temporal boundaries. The usefulness of that approach was to foster a scholarly study of actual classifications of civilizations based on several approaches. Isaac (2015) explained that the ISCSC had the approach to naming, categorizing, ranking/classifying and assigning origin, influence, evolution, and identification of civilizations.

One of the most successful and well noted system is classification of civilizations is that of Kardashev. In 1964 Kardashev famously formulated a system to classify civilizations on their technological sophistication based on the scale of their energy supply (which could be used for intentional or unintentional radio communication) [130]. The classification of the civilizations notwithstanding its clear evolutionary character, originally containing three types of civilizations detectable, is based on the energy consumption of the society [128].

Following this approach, it makes perfect sense as it was reminded to us [131] reminds us how technology is linked to modernity, and that technological superiority is still taken as an absolute civilizational standard, at least in the West.

This could tie in quite seamlessly with the growth of a civilization [126], since energy capture is seen as the main driver of social development.

Ethical scale of civilizations

We now come to the application of the scientific ethical standards to a classification of civilizations. As with the adoption of all standardized classifications [119], there are ethical considerations embedded in the cultural assumptions of the scientific ethical standards themselves. This new system of civilizational study may have, as an improvement with the other scholarly ranking models of the past [120], the advantage to produce a more accurate and complete roster (for comparison), since the use of universal principles can be applied across the board.

We've seen that as science evolves, new technologies become available and this brings a new set of ethical issues to the forefront. We therefore need not a new set of ethical principles to deal with these but to apply those that have been identified. Ultimately, the cross-the board application will ensure that scientists, as the agents of the moral decisions, are more trained to adopt them and utilize them in a more rigorous manner.

That is, the moral compass of society should evolve upwards, as time passes, at least in order to match the

[8] The Authors would imply that there are several intellectual constructs that have gained prominence in the institutions of development. These constructs seem to obey to the paradigm of evolution. Social evolutionists deem that societies progress through stages and development means movement from tradition to modernity.

increase in science advancement or progress. By remaining behind, ethics and the morals of a society may risk to create an abyssal gap between the two. Indeed a danger of derailing science was lamented [132], if the study of ethical, and social implications does not catch up with the speed of scientific development.

The psychological evolution of a child hypothesised by Kohlberg [133] has been used as a template for the ethical evolution of societies. Kohlberg's stages of moral development for individuals is composed of 3 levels and 6 stages ([80]. The 6th and final stage of universal principles (the highest level of moral advancement where people actually abstractly think through ethical principles for themselves, and are ready to pay the consequences of disapproval and/or imprisonment for going against the rest of society in this process) is rarely achieved [134].

Using the Kohlberg's stages of moral development for people, the following phases will result, from least to most progressive:

Lower savagery (0-1): No code of morality, but basic concept of ethics mixed with law and religion, survival of the fittest by every means; the highest value is survival; language is fully developed with rudimentary forms of transmission:

Savagery (1-2): Minimal moral code based on survival of the fittest and still mixed with religion and law; Blind egoism stage.

Lower Barbarism (2-3): Struggle for existence (slavery, racism, sexism, etc. are common place). Instrumental egoism stage.

Barbarism (3-4): Self-subservient morality, Laws may or may not be codified in structured manner. Eye for eye, teeth for teeth precept is valid. Slavery is allowed and/or codified. No respect for the young or old. Literature and science are developed. Honesty and derivative values may not even be discovered. Interpersonal concordance (social relationship) stage; Lower Civilized Society (4-5): Utilitarianism supersedes human dignity although it is partly recognized. Scientific ethical principles are partly acknowledged but not followed. Laws are codified in a structured manner but imposed with force. Lighter forms of slavery are still permissible. Although honesty is noted, dishonesty runs commonly in science. Law and order stage.

Civilized Society (5-6): Scientific ethical principles are codified but have to be enforced. Tension between human dignity and utilitarianism for scientific progress. Citizens are theoretically equal although factually inequality still persists. Slavery is rejected but may run underground. Dishonesty is not limited in science. Social contract stage. A civilized society.

Enlightened Society (6-7): All citizens are equal and follow the golden rule. Human dignity supersedes utilitarianism. There is limited dishonesty in science.

Puritanism (7-8): Scientific ethical principles are incorporated into law and all citizens follow it naturally, freely and spontaneously. There is limited dishonesty in society at large.

Utopian Society (8-9): Individual human dignity is at highest place of respect. All citizens love each other like themselves and hold the scientific ethical principles to the highest esteem. Laws are not necessary. There is no more dishonesty in society.

Similarly to Kohlberg's 6 stages of moral development for individuals, the above ethical scale emphasizes the development of morality and ethics in a society based on the scientific ethical standards [1]. The more a society discovers these universal percepts and applies them in every aspect of social structure, the more it progresses through the levels of moral advancement. In this framework, the lowest would coincide with cannibalistic societies (anthropofagic), those social groups that have no respect for truth, life or human dignity.

Should we be ready to apply the scientific ethical principles outlined above to the whole of society, we would then be able to construct a graphic to represent the moral status of a civilization based on the universal values of science serves this purpose.

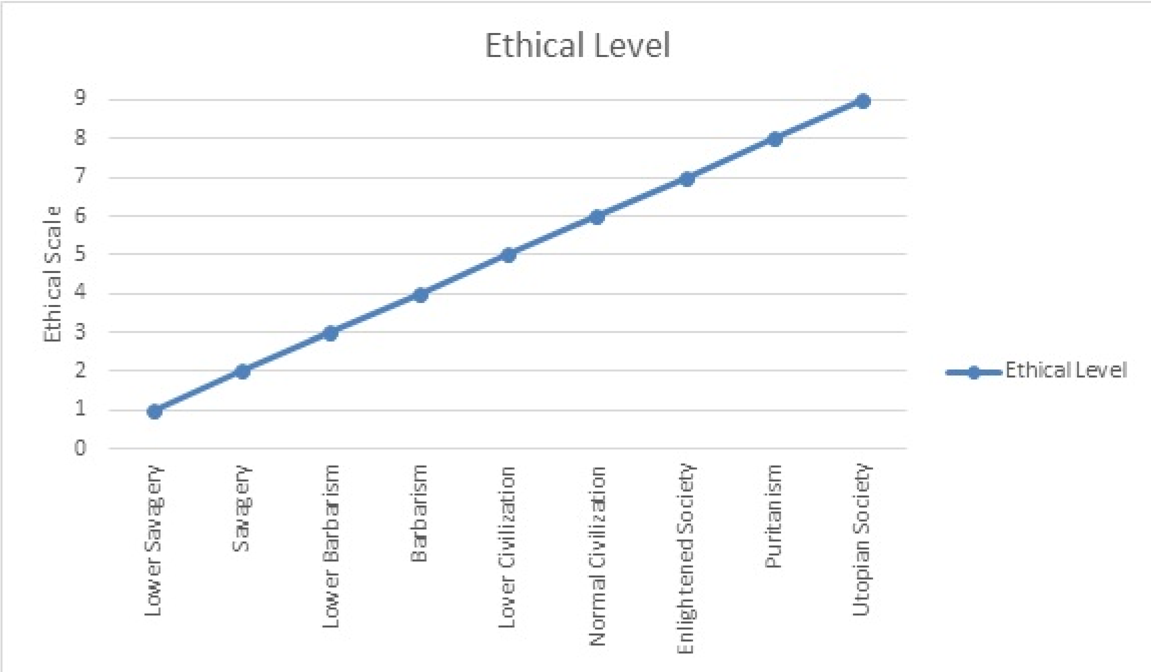

Figure 2: Ethical Civilization Scale.

By plotting the advancement of science on the x axis and the advancement of ethics on the y axis, as science advances through time periods (t1, t2, etc), the adherence to moral standards should increase to keep up with the new challenges imposed by scientific progress.

This is shown in **Figures 2 and 3**.

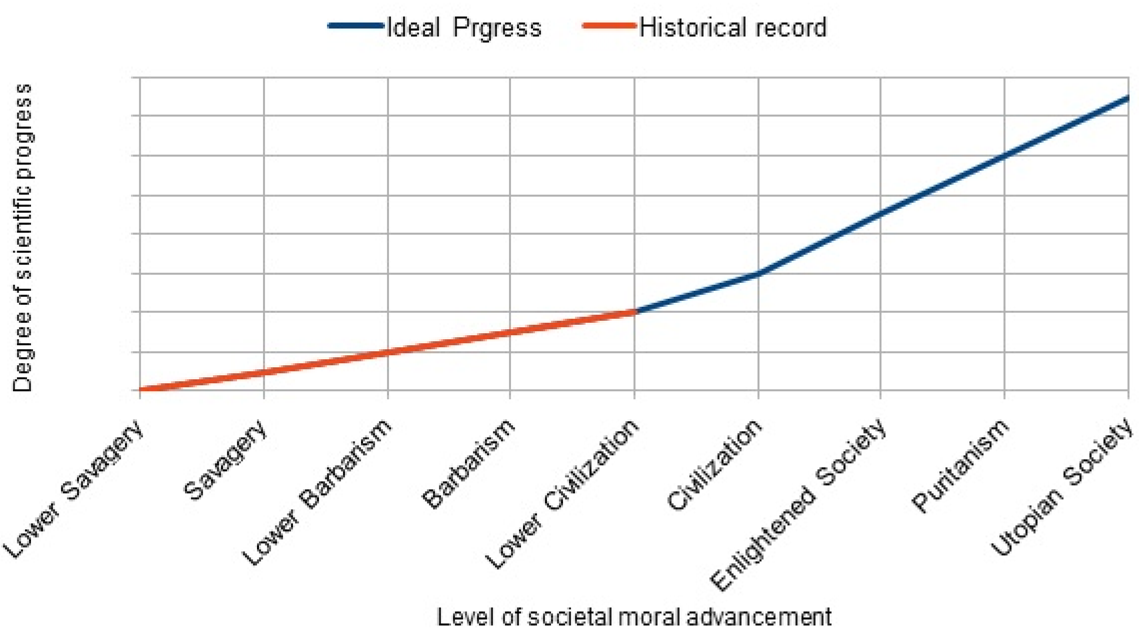

Figure 3: Theoretical advancement of morality with science.

The demoralization of western society is shown in Figure 4 with a red, curved line. Indeed, western culture is currently undergoing a reversal of universal values which undermines not just personal morality but also the moral fibre of social ties between individuals that make up the community [135].

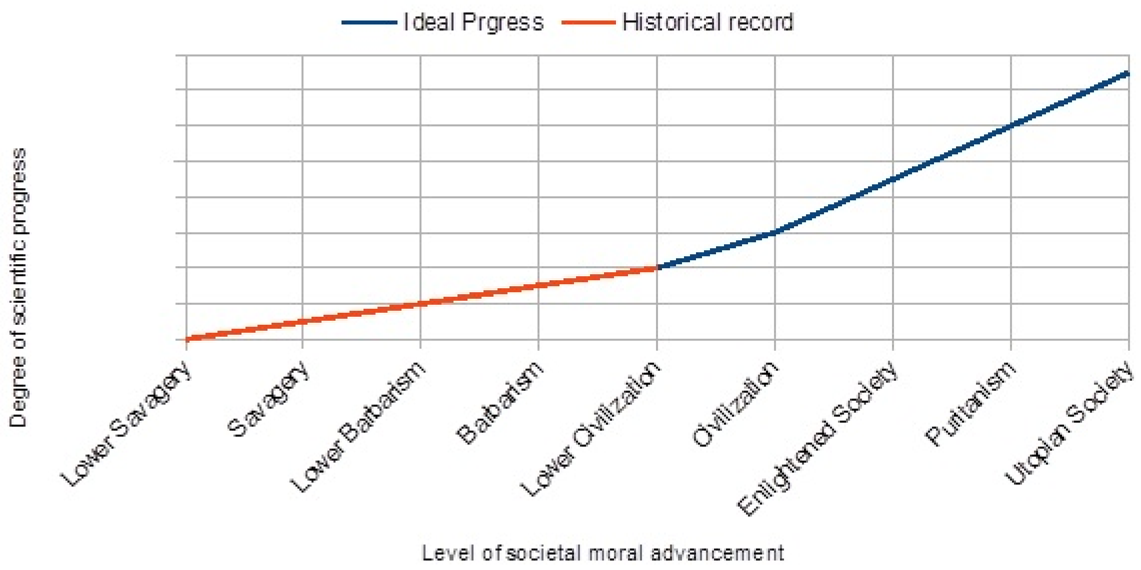

Figure 4: Scientific and Ethical Progress to Civilization Scale.

Whichever pathway western societies are taking, it is not following the science and the ethics of science. This pathway will have serious consequences for all humanity as the gap between ethics in society and science increases.

Conclusion

Rather than belonging to the middle standpoint (where the dialectical relation between capitalism and medicine concerning biotechnology is perceived as allowing access to better social positions [69]), SE could be seen as bioconservative.

We have seen that non-biological contamination (robotics and nanotech) cannot impact human dignity (as to increase or diminish it), although, visibly, it will affect the body's integrity.

Any intervention that involves man or its environment, should be carefully reviewed by SE.

Any action that puts man or its environment in danger of being negatively altered, including any feedback loop, is liable to be evaluated by SE. Restoration of the normal balanced processes of the eco-human-biosphere (the biosphere with humans interacting with nature) is always seen positively by SE. The opposite, negatively the nexus of the newly presented (techno) ethical issues with ethics or technoethics is easily resolvable in the perspective of primary agency. As recognized by SE, the problems are not new, nor do they need new solutions but just application of the universal ethics to a wider audience (agents). In this respect, we can identify three agents in technoethics: the creator of the technology, the intermediate agent (the manufacturer or distributor) and the end user. All three have their own specific responsibility relating to the object of technoethics (a product to be used). Hence, in order to close the gap between the science and ethics in technologically advanced applications [136], SE should be spread to the whole of the population. Are ethical implications of technological (AS) advances really a problem of today's ethics? Or were these already a problem of the past? In the end, we are to realize that our uniqueness is also because of a long processes and multiple steps that were crafted in such perfect ways that imitation is not a viable option. In the perspective of technoethics and SE, the pleasures and uses of technology or applied science should never be at the detriment of our health (physical, emotional, psychological, mental or energetic).

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