Proceedings of the International Symposium on Sustainable Systems and Technologies, v2 (2014)

Understanding Sustainable Technology and Human Behaviour: Adolescence to Adulthood!

Suman Devadula, Indian Institute of Science, devadula@cpdm.iisc.ernet.in
Amaresh Chakrabarti, Indian Institute of Science, ac123@cpdm.iisc.ernet.in

Abstract. Understanding how technology and humans interact continues to be dominated by the tool-impact view under which only impact assessments can be done after the fact leaving questions of how the process of humans come about with technology in the first-place unanswered. Urgent concerns of unsustainability are attributed to be the consequence of anthropogenic use of technology since the industrial revolution. If technology is seen to expand human capabilities, the fact that the consequences of its use result in unsustainability (identified as technological adolescence) requires clarification. In an attempt to clarify, this article argues for distinguishing abilities from capabilities and defines technology generally to be the context of extension of human abilities to capabilities. Also, if sustainability is an anthropocentric concept, what 'sustainable technology' means, rather than 'sustainable human development' requires clarification. The extension of ability to capability, the definition of technology as a context of such extension and the end goal of free and full realization of human personality indicate at humans becoming capable in using their own embodiment as the tool to realize self-actualization as the eventual capability. Within such a limiting condition, technology and sustainable technology are withdrawn into (being) human being and sustainable human being, indicating that technicity and anthropocentricity are synonymous. This in turn supports the view that humans and technology co-constitute each other in an ongoing process motivating further research in this direction. Problems of unsustainability are those of requirements of various stakeholders (humans) not being met or insufficiently met. A profile of these requirements is generally based on those arising out of human needs that are hierarchical according to Maslow. Design is a process of arriving at specifications, which if implemented meet requirements and thereby, satisfy human needs. However, based on differences in available resources and individual design ability to meet needs progressively people have come to value needs differently. This article juxtaposes Maslow's hierarchy with models of design ability and levels of leverage for systemic intervention to situate problems of unsustainability systemically and identify the requirement and the necessary design ability to design to meet the profile of needs. The journey of the designer in every individual meeting needs progressively up the hierarchy, is claimed as the required transition to sustainability, from 'technological adolescence', to what can be called, 'technological adulthood'.

Keywords*: ability, sustainability, design ability, capability, technology, skill development, systems thinking*

Proceedings of the International Symposium on Sustainable Systems and Technologies (ISSN 2329-9169) is published annually by the Sustainable Conoscente Network. Melissa Bilec and Jun-Ki Choi, co-editors. ISSSTNetwork@gmail.com.

Cite as: Understanding Sustainable Technology and Human Behaviour: Adolescence to Adulthood!
Proc. ISSST, Suman Devadula, Amaresh Chakrabarti. Doi information v2 (2014)

Introduction. Though stated as grand challenges of sustainability science, questions like, "What should be the human use of earth?" (Kates, 2001) are praxeological and answering these with rigor and repeatability of method is still in its infancy (Gilberto, 2004) (Wang, 2011). It is arguable whether such methods can at all answer normative questions involving judgment about the contingent raising doubts about calling sustainability a science prematurely (Funtowicz & Ravetz, 1993). Concerns of unsustainability are frequently attributed to the consequences of anthropogenic use of technology since the industrial revolution (IPCC). If technological competence is considered fundamental to human existence and enables human development (Burke & Ornstein, 1995), the fact that consequences of the use of technology result in unsustainability requires clarification. This brings us to question whether sustain*ability*, in the context of being technology-led, is actually a (technological) capability that we should be wary of wielding or an ability that resides more equitably, i.e. innately and universally, with all members of humanity.

Motivated primarily by the consequences of using technology to earth's habitability, current opinion of how technology is related with human behavior can be largely categorized under the tool-impact view (Postman, 1993) (Verbeek & Kockelkoren, 1998). This approach considers technology as a given/fact already and hence falls short in answering questions of, 'How do we come about with technology?', 'How did we end-up with the technologies we have now?', 'How could we not have developed better ones then?', etc. Participating scientists of the Fifth IPCC report are of the opinion that we can no longer claim ignorance of the consequences of our actions (Dechert, 2014). This necessarily requires steering focus away from impact assessments of technology done after the fact to understanding how technology and human behavior co-constitute each other in an ongoing process. This brings the process of humans coming about with technology, i.e. design, into question. Hence, this article situates the phenomenon of 'design' central to such co-constitution and attempts to understand it phenomenologically hoping to disclose the technology/human relationship at an ontological level. Such phenomenological understanding of world-hood is also the context of sustainability, as its concerns are frequently earth-scale mentions of warming climates, depleting resources, acidifying oceans, retreating forest-covers etc.

In the context of global problems on earth foreboding collapse and the offer of promise for the future of humanity, it is said that the quest for extraterrestrial intelligence is next to no other and a single message from space will show that it is possible to live through technological adolescence (Sagan, 1978). More recently, in the context of the promise ICT offers to governance and public administration, its misuse and consequent mistrust is considered an aspect of humanity's technological adolescence (Huffington, 2011). Technical education literature mentions the progression from technological knowledge, technological skill and to technological will is considered being technological literate (Autio, 2011). Scientists and technologists alike were remorseful at the uses to which technology, created unmindful of the possibilities of human use/mis-use, could be put to (Einstein, 1954). Contrarily there are notable others believing that science and technological innovation is directed to solve particular problems and that it should be detached from the possible misuses it could be put to (Valiunas, 2006). In this connection, a humanity knowing and following developmental pathways that avoid technological disaster is considered to have reached maturity (Sagan, 1978) or technological adulthood. Sustainability as a human ability, refers to the possibility and belief in conducting ourselves in ways that avoid technological disasters and, more importantly, steer us towards a known desirable future. However, originally, sustainability is an anthropocentric concept and what 'sustainable technology', means rather than 'sustainable human development' also requires contextual clarification.

Research objective. The objective of this research article is to understand how humans and technology co-constitute each other interactively in design in the context of management of technology-led transitions to sustainable human development.

Method. An inquiry into the interaction of technology, human behavior and sustainability which spring from the most diverse disciplines of science, psychology and rights based developmental studies requires interdisciplinary knowledge. Consequently this article presents an interdisciplinary exploration of interaction of three classic models (pyramids in Figure1) from learning theory, psychology, and systems thinking. Common to the three models is the positive humanist outlook. The models are juxtaposed as follows. In the middle is the classic Maslow's hierarchy of relative pre-potency of human needs (Maslow, 1943). To its left is the model for levels of design ability design ability (Dorst, 2008) based on the path-breaking phenomenological critique of AI (Dreyfus, 1992). Beyond self-actualization, transcendence is defined as the power to see the influence of one's own worldview and that of others in tolerance. To the right are levels of leverage for systemic intervention (Meadows, 2009). These two models, flanking the upright Maslow's pyramid, are represented as inverted pyramids to indicate the increasing scope of change they effect, upwards. A corresponding description of the levels in these two models is given in Table 1. The proposed framework of 'Transcedence by Design' can be used to inform pro-active and reactive intervention into real-word systems to effect change for tackling unsustainability.

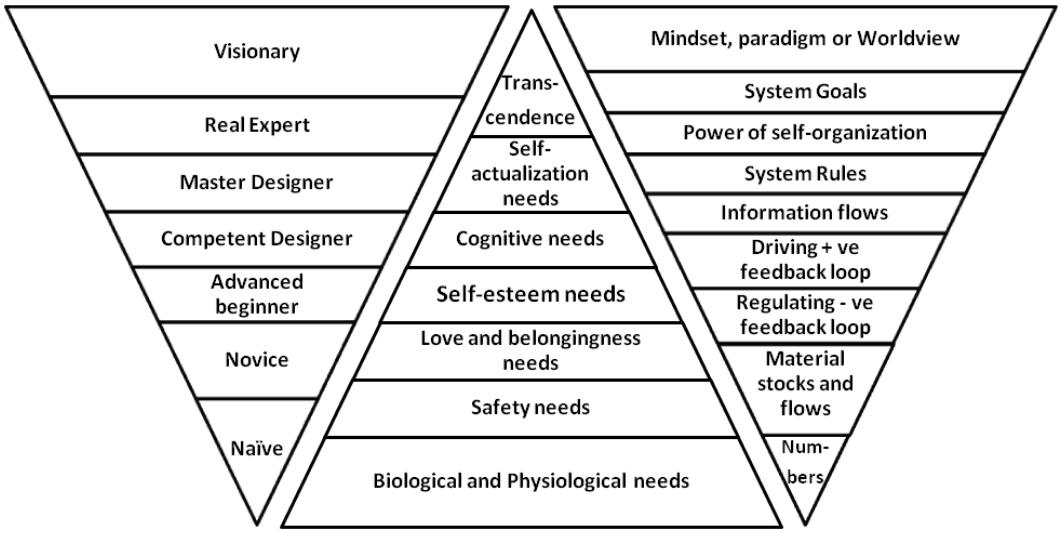

Figure 1: Communicative requirements for the design of systemic interventions for sustainability
(Note: The horizontal lines within any pyramid are used to indicate levels and do not mean the existence of clear divisions between skill levels, needs or leverage points)

Ability and Capability. Ability is the agent's potentiality for capability (explained further in this section). It is mere existence or being(ness) separated of any processes of consciousness, due to which, the event of the agent realizing its capability is plausible. An agent's substantiality affords this potentiality. Agent's responses that are reflexive like knee-jerk responses to certain stimuli are also abilities by definition as these are primarily required for securing that very substantiality of the agent from other prying agents. Capability (shared etymology with 'capacity') presumes an organ extending in space for eg. length, area, volume etc. providing opportunity. Capability is extended ability. Tools, as means of extension, can be substantial like a crowbar, car, stone etc. and can also be insubstantial like language, knowledge, institutions

etc. Capability is realized in the agent's acts of volition which afford the fathoming of tools (naturefacts (Hilpinen, 2011 quoting Oswalt 1973) and tool-use, for e.g. a Bonobo using a piece of available wood as a club for breaking nuts (Mammals by David Attenborough), and tool-making for e.g. the Caledonian crow creating a hook off a piece of available wire to create a hook (Weir, Chappell, & A, 2001). Capability is generally attributed to active entities, like animals and individuals, equipped with tools. However, within anthropomorphic teleological explanations capability is also attributed to non-living entities, for example, the capability of a metal to be fused (Idictionary, 2014). Anthropomorphic and teleological accounts of tools suggest their ontological status to be comparable with that of agents. Observing further examples of the use of ability (Oxford Learners Dictionaries, 2014) and capability (Oxford Learners Dictionaries, 2014) it can be proposed that agents (active embodiments) are constitutionally, just able and when externally equipped with tools (passive embodiments) they assume capabilities i.e. they become capable. Being capable to do more than one could ably do increases opportunities for achieving a life one values and can also accelerate this very process of achievement. Consequently, realizing one's full potential seems more plausible.

Technology and Design. Tools extend our limited abilities to unlimited capabilities. The context of such extension is technology and tools are the means to extend. Technology is not a thing as is mentioned liberally in literature. Technology does not stand-alone and it is always mentioned in relation to something as in 'technology-to-crystallize at room temperature', 'technology-to-fasten passengers safely', technology-led development etc. These examples indicate artifacts (tools) that are the means to extend our abilities but not the technology itself. The process of specifying the process of extension and the means i.e. tools is design. Design, generally, is synonymous with intentional action. Intent, as a nascent *artifact of the mind* (Thomasson, 2007), serves as a specification motivating the agent to effect change. The process of intending starts the extension of ability to capability when the agent's *being* or mere existence

Technology and Sustainability. Inquiring into the consequences of technology to since the industrial revolution climate scientists at their release of the fifth IPCC report equivocally state that we can longer claim ignorance to the consequences of our actions (Dechert, 2014). Sustainability is a belief in our ability to conduct in full awareness of the consequences of our actions. Though the belief may have arisen from our technical capability to intervene into systems of the scale of the earth's systems for example, climate engineering, geo-engineering etc., the degree of control that can reside with us post an intervention of such global magnitude is something that the intellectual circles are very uncertain of (Matthews & Caldeira, 2007) (Silver, et al., 2010). This brings us to question whether sustain'ability', in the context of being technology-led, is actually a capability that we should be wary of wielding or an ability that resides more equitably with all members humanity spanning the developed, developing and undeveloped.

Table1. Description of the various levels of models juxtaposed in Figure1

	Design expertise model Hubert Dreyfus', as quoted in (Dorst, 2008)	**Maslow's hierarchy of relative pre-potency of needs** (Maslow, 1943)	**Leverage points for Systemic intervention** (Meadows, 1999)
Active creation of design situations	**Visionary**: A level of designing that develops new ways of being, defines issues, extends and creates new domains. Focus on other domains, their boundaries with others, marginal practices and anomalies that hold promise for a new vision of the domain or the world altogether	Transcendence	The power to transcend paradigms
	Master designer: A level of designing with an acute sense of context and openness to subtle cues. Focus on producing ideas, within areas formerly thought well-understood, that can potentially change the rules by which systems operate. This could be deemed 'practice based research'.	Self-actualization	The mindset or paradigm out of which the system – its goals, structure, rules, delays, parameters - arises
	Expert: Level of designing where distinction between problem solving and reasoning collapses as designers, with their years of experience, recognize high-level patterns in design situations and respond to a specific situation intuitively, and perform the appropriate action, straightaway	Cognitive needs	The goals of the system
	Competent designer: A level of designing where design situations are strategically created by choosing relevant aspects of situations and plans that provide opportunities to achieve desired goals.	Self-esteem needs	The power to add, evolve, change and self-organize system structure
Reaction to design situations	**Advanced beginner**: A level of designing questioning strict rules to be replaced by maxims. Focus on situational aspects leading to the acquisition of schemata i.e. design prototypes, at the minimum		The rules of the system (such as incentives, punishments, constraints)
	Novice: A level of designing dealing with design as a formal process by following strict rules. Focus on situations identified based on their objective features, i.e. situating *that*	Love and belonging needs	The structure of information flows (who does and does not have access to what kinds of information)
			The gain around driving positive feedback loops
		Safety needs	The strength of negative feedback loops relative to the impacts they are trying to correct against
			The lengths of delays relative to rate of system change
	Naïve: A level of designing for everyday use in conventional situations involving not just design professionals but ordinary people also. Focus on mimicking existing objects only, i.e. that	Biological and Physiological needs	The structure of material stocks and flows (transport networks, population age structures)
			The sizes of buffers and other stabilizing stocks relative to their flows
			Constants, parameters, numbers (such as subsidies, taxes, standards)

human abilities to capabilities, thereby allowing the situation of technology and the process of design in the context of human development. The concern for sustaining human development, then becomes a requirement, the tools for meeting which need to be designed.

Discussion. The spine of the juxtaposition in Figure 1 Maslow's model reflects the rights basis of the concept of sustainability that humans should be enabled to lead a full life i.e. are provided enough opportunity to realize their full potential. While the ability of sustainability is the design ability to know how to affect change to meet one's own needs progressively, opportunity is the access to learning required to acquire the design ability and the access to means for implementation. Technology is the context in which individuals, who having identified their

needs and having been provided with opportunity, design and implement solutions to satisfy needs. The question of technology being sustainable or not lies in the state of distribution of people bereaved of opportunities as a result of which they are dependent on others who are more opportune. Hence ensuring that opportunity is accessible to all appropriate to their situation of needs is the path towards making human development sustainable.

The proposed framework of 'Transcedence by Design' can be used to inform pro-active and reactive intervention into real-word systems to effect change for tackling unsustainability. Pro-actively a profile of human needs that will have to be met in the future given the current progression is drawn. Based on the different levels this profile is spread across the corresponding design abilities are identified. For knowing how best to accommodate the build-up of design ability necessary the rightward model for systemic intervention can be read correspondingly. This allows for planning skill development or design manpower development. The profile of needs drawn also determines the extent to which state action is necessary over individual action. This is further dependent on the goals which governance sets for itself in the short and long-term. Reactively, problems faced within existing institutions and systems in addressing contemporary issues are really observed. These are then posed as problems inhibting their design ability. The appropriate constructs to be dealt with is determined in combination of the left and right pyramid suggesting what of the system needs to be changed and how respectively.

Inadequacies of such a system of situations can be further identified as systemic problems requiring intervention at appropriate levels of leverage based on Figure1. Figure1 also aids to situate the design skill required for controlling unsustainability.

Technicity, or the process of designing and developing technology, is arguably the central philosophical question forgotten over since the Greeks (Stiegler, 1998). This article highlights that centrality of design as the process by which humans coming about with technology and argues that technicity is synonymous with anthropocentric sustainability.The extension of ability to capability, the definition of technology as a context of such extension and the end goal of free and full realization of human personality indicate at humans becoming capable in using their own embodiment as the tool to realize self-actualization as the eventual capability. Within such a limiting condition, technology and sustainable technology are withdrawn into (being) human being and sustainable human being, indicating that technicity and anthropocentricity are synonymous. This in turn supports the view that humans and technology co-constitute each other in an ongoing process.

Sustainability is the ability to meet our needs without compromising the ability of the future generations to meet their own (Brundtland, 1987). Though mentioned as a collective ability it is primarily an individual ability to act in a way that does not consume opportunities that afford others, co-existing and to come, to act similarly. Action, as response to requirements, can be voluntary or involuntary. When voluntary it can be attributed to the being's volition and when involuntary it can be attributed to instincts and the self-organizing processes adapting to changing environments. In connection with evolution of artifacts and contexts this can be compared with the propositions of Petroski (Petroski, 1992) and Schlossberg (Schlossberg, 1977) respectively. Such adaptation effects populations through to the individual's constitution. Volition is a recently evolved ability in comparison with evolved features. Volition, for this reason, can be an offshoot of the extremely high interconnectedness of our constitution that the course of self-organization has resulted in and continuing. In this sense volition might be privy of humans. Self-organization is considered to be the character of all life, and thermodynamically,

of all open systems. Entropy is the exhaust of the evolution engine and consequently all involuntary activity of life increases the disorderliness of the universe that provides for our larger cosmic being. The universe, taken as an isolated system comprising open systems, is progressing towards increasing its disorderliness, both through voluntary or involuntary action that is possible of its constituents. In such a scenario of both avoidable and unavoidable activity increasing the rate at which opportunities will be consumed, the prescription for sustainability as a human ability is to avoid as much voluntary activity as possible so that more opportunity is afforded for the co-existing and to come. As this should be the agenda of all humans and in a situation where such a prescription may not be fathomable to all, our constructive discontent should be directed to ensuring successful communication of this prescription to all. Beyond whatever that is necessary for self-maintenance and self-replication, this alone should determine the direction for all voluntary action. This is purposive action and hence meaningful. In a situation where everyone understands this and behaves accordingly, contented acceptance replaces constructive discontent. When the nature, variability and spontaneity of the processes of earth shift the balance of opportunities, it is our responsibility to adjust between such constructive discontent and contented acceptance to restore balance. With this basis of the argument, it is appropriate to refer to our interventions as 'tackling unsustainability', in a Sisyphean sense, which involves more time and effort rather than a vainglorious phrase of 'achieving sustainability' which is only momentary. Hence, sustainability as a human ability requires us to be able to mutually inform ourselves successfully of purposive action; the particular purpose being the affordance of purposive action in others. The more such a purpose is afforded in people, the more such people afford similar affordances in others (Withagen, de Poel, Araújo, & Pepping), thereby sustaining habitable and enlivening conditions, longer.

Communication is a natural consequence evolved of mutual necessity between animals. While the needs may be reproduction, surveillance, leadership etc. not all of these need necessarily occur within a single species. Communalism and mutualism are some phenomenal examples. With time, species evolve depending on other species for the benefit of themselves and in extension, of the whole community. One essential idea of such dependence is the way animals read other animals and their environment in general. The study of emotions and expressions in animals has been of interest since a long time (Darwin) and from the perspective of information theory, studying them as signals has led to insightful results recently. Research findings here have implications for empathy (Rizzolati & Craighero, 2005)(Fogassi, et al., 2005), egalitarianism (Gavrilets, 2012) and hence as a binding force for group action when necessary against a common cause/threat. Once initiated, the expressions (Levenson, 1991), gestures and vocalizations, as involuntary (Corbalis, 2003) signals of animals, deteriorate or go viral based on an evaluation based on shared understanding implicit to the community. Consequently, this serves as a pan-personal mechanism for the benefit of community. The initiation and reciprocation of expressions happens based solely on evidence, at the sight of a predator for example, and involuntarily so.

As can happen voluntarily or involuntarily between animals, an object does not reciprocate to the expression of the animal. The expressing animal then has the following possibilities to construe: one, that the object is an animal without response and hence possibly life-less; two, to doubt the evidence causing its own expression as the object has not responded. Such mistrust in one's own senses can potentially afford disbelief in oneself and belief in an object. Further, the belief in the object has the potential to motivate the animal to fashion it more and more like itself . The story of the advent, growth and the future of technology may fundamentally be a follower of this human condition. Fascination with technology has become a phenomenon.

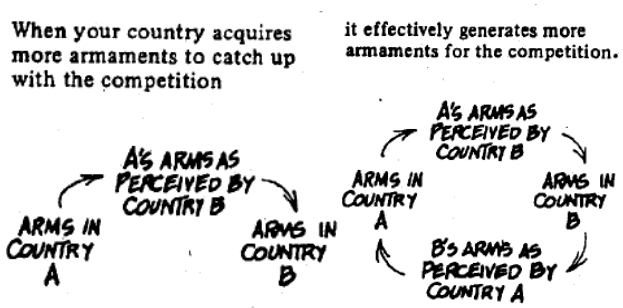

Figure 2: Arms race as a consequence of positive feedback (Meadows, 1982)

Technology, as a context in which ability extends to capability, has the potential to set-in a positive feedback loop into which humans voluntarily enter when engaged in 'design' to realize the context. The truth in an object being incapable of response coupled with a subject's ability/necessity for instilling subjectivity into it due to its perception of itself being objective and incomplete is the context in which technology is to be perceived in society. Consider the example of arms race (Figure 2) and as to how the author feels that the participating nations become helpless puppets. This is a consequence of the 'human condition' or to put in more general terms as the author, "But the most powerful aspect of the feedback concept, a truly profound and different insight, is the way you begin to see that "the system causes its own behavior". Country A perceives the arms race as caused" by country B and vice versa, but one could equally well claim that country A causes its own arms buildup by stimulating the buildup of country B. Or, more accurately, there is no single cause, no credit or blame. The relationships in the system make an arms race inevitable, and A and B, are helpless puppets (until they decide to redesign the system)" (Meadows, 1982). Technology begets more technology through humans i.e. by reducing humans to devices that further technology (Heidegger, 1977). More importantly, given this human condition, this sets limitations on what an activity 'design' should be, as it can be both positivist as well as negativist. Further, if this is considered along with the consequences of the industrial revolution in the context of sustainability , design philosophy can potentially provide the answer for what should the human-use of earth should be (Robert, 2001).

In another example such fascination is termed illogical by Dawkins, as follows: "Incidentally, why does this impress us so? If we forced ourselves to think in a detached way we surely ought to be more impressed by the architecture of the Caddis' eye, or of its elbow joint, than by the comparatively modest architecture of its stone house. After all, the eye and the elbow joint are far more complicated and 'designed' than the house. Yet, perhaps because the eye and elbow joint develop in the same kind of way as our own eyes and elbows develop, a building process for which we, inside our mothers, claim no credit, we are illogically more impressed by the house" (Dawkins R. , 2006).

Conclusion. As the hierarchical Maslow's needs are progressively satisfied the requirement for material to meet needs decreases (though seeming to increase at the self-esteem needs temporarily). This progression culminates in the individual using his own embodiment to self-actualize, be aware of his/her worldview and transcend worldviews. In this condition the object of necessity and the means are drawn inwards from an otherwise outward emphasis on means to be acted upon by the designing individual as a separate entity. This condition is synonymous with co-constitution though it happens at all levels of designing to meet Maslow's needs. On comparing the progressive levels of design expertise and Maslow's hierarchy it is observable that the focus on material objects of the naïve through to the focus on extending domains of the visionary indicates at an increasing trend of less and less material requirement. Eventually, on knowing that the self is the means as well as the object of necessity the individual transcends

this whole process by design requiring minimal design and hence minimal material means any further. It may be observed that the constructs dealt by the designer designing at this level are indeed conceptual largely dealing with which individuals will be in a position to effect systemic change with the maximum leverage. This is the condition wherein 'communicating more of less' is required progressing gradually from 'communicating less of more'.

Acknowledgement

The authors like to thank the organizers of ISSST 2014 for having been kind to consider our reservations in registering, not being able to attend ISSST 2014 and for nevertheless arranging for presenting our work as per schedule.

References

Brundtland, H. (1987). *Our Common Future.* Oxford University Press.

Clark WC. (2003). Grand Challenges of Sustainability Science, William Clark, . *International Conference on Science and Technology for Sustainability 2003: Energy and Sustainability Science* (pp. 16-19). Tokyo: Science Council of Japan.

Corbalis. (n.d.). *From Hand to Mouth.*

Darwin, C. C. (n.d.). *The origin of species.*

Dawkins, R. (2006). *The Selfish Gene* (30th Anniversary edition ed.). OUP.

Dechert, S. (2014, March 31). UN authors: 'We can no longer plead ignorance' on climate change. Retrieved April 10, 2014, from http://digitaljournal.com/news/environment/un-authors-we-can-no-longer-plead-ignorance-on-climate-change/article/379030

Dorst, K. (2008). Design Research: a revolution waiting to happen. *Design Studies, 29*, 4-11.

Einstein, A. (1954). *Ideas and Opinions.* New York: Crown.

Gavrilets, S. (2012). On the evolutionary origins of egalitarian syndrome. *Proc Natl Acad Sci USA 109:14069–14074*.

Gilberto, C. G. (2004). *Sustainable Development: Epistemological Challenges to Science and Technology.* ECLAC, Santiago, Chile.

Heidegger, M. (1977). *The Question Concerning Technology and Other Essays.* New York: Harper Torchbooks.

Huffington, A. (2011, June 16). *The Internet Grows up: Goodbye messy adolescence*. Retrieved April 30, 2014, from http://www.huffingtonpost.com/arianna-huffington/the-internet-grows-up-goo_b_878157.html

Levenson. (1991).

Maslow, A. (1943). A Theory of Human Motivation. *Psychological Review, 50*, 370-396. Retrieved from http://psychclassics.yorku.ca/Maslow/motivation.htm

Meadows, D. (1982). Whole Systems: Whole Earth Models and Systems. *The CoEvolution Quarterly*, pp. 98-108.

Meadows, D. H. (1999). *Leverage Points: Places to intervene in a System.* Sustainability Institute.

Petroski, H. (1992). *The Evolution of Useful Things.* New York: Random House.

Petroski, H. (n.d.). The Evolution of Artifacts. *American Scientist*, pp. 416-420.

Postman, N. (1993). *Technopoly: The Surrender of Culture to Technology.* New York: Alfred A Knopf.

Rizzolatti, G. (n.d.). A mirror to the self: Understanding actions, intentions, emotions and others .

Robert, W. K. (2001). Queries on the Human Use of the earth. *Annu. Rev. Energy, Environ, 26*, 1-26.

Sagan, C. (1978). The Quest for Extraterrestrial Intelligence. In C. Sagan, *Cosmic Search* (Vol. 1 No.2). Smithsonian Institution. Retrieved April 30, 2014, from www.bigear.org/volno2/sagan.htm

Schlossberg, E. (1977). For my father. In J. Brockman, *About Bateson.* NY: Dutton.

Stiegler, B. (1998). *Technics and Time, 1:The Fault of Epimetheus,.* Stanford: Stanford University Press.

Valiunas, A. (2006). The Agony of Atomic Genius. *The New Atlantis: A Journal of Technology & Society, 14*, 85-104. Retrieved from http://www.thenewatlantis.com/publications/the-agony-of-atomic-genius

Verbeek, P.-P., & Kockelkoren, P. (1998). The Things That Matter. *Design Issues, 14*(3), 28-42.

Wiener, N. (1989). *The Human Use of Human Beings: Cybernetics and Society*. London: Free Association Books.

Withagen, R., de Poel, H. J., Araújo, D., & Pepping, G.-J. (n.d.). Affordances can invite behaviour: Reconsidering the relationships between affordances and agency. *New Ideas in Psychology 30 (2012) 250–258*.