The Interface

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The Interface

Another New Start

Remembering Professor William (Bill) Sayle and *The Interface*

I remember the first time that I saw *The Interface*. I did not recognize its true value and dismissed the fact that I had received it for quite some time. Sometime later, Professor Ed Jones at Iowa State University saw some of the articles that I had written for our IEEE student section at Iowa State University, and suggested that I contact one of the education leaders, Bill Sayle. I had never met the professor, but I trusted Ed Jones, so I followed through with his suggestion. Bill requested to see my work and within a few days asked me to send him a picture as well. He told me that he was going to use one of the short articles titled "Are You Being Educated?" in the next issue of *The Interface*. I sent him the picture and started to look to find out more about this publication. I definitely knew *The Interface* was interesting and important. I also realized I had several issues of it next to my copies of Spectrum and IEEE Transactions on Education, yet I had never really paid much attention to it. Before the next issue containing my article reached me, I managed to read more than a few articles of the collection that I had. After few hours of reading the articles I went to Ed Jones's office and told him, "Wow, *The Interface* is fantastic! It is like an old friend that I needed and never knew I had!" Ed smiled and told me that when I meet Bill, I will say the same thing about him as well.

This statement was as true as anything Ed Jones had ever told me. I first met Bill on a Monday morning at an ASEE conference. I was a first-time attendee and did not know what I was doing. Bill and I talked; he listened to me and encouraged me to stay active and participate to shape our field for the better. Later he told me that he had not been feeling well but he hoped to see more of the members or ECE and educators. We had the privilege of getting to know Bill much better for a short time, a much too short amount of time, and then we all lost him forever.

Bill's contributions in the IEEE Education Society and ECE Division have been unique and greatly valued by all of us. *The Interface* has been one of the legacies of his hard work, vision, hopes, and deep belief in an ongoing dialogue between all educators. Every time that I see any issues of *The Interface*, I begin to experience a deep melancholy in thought of our lost friend Bill, but memories of his vision and smile then begin to induce a feeling of great hope and energy to do better for our field. I believe I am not the only one who feels this way; there are more than a few of us.

The Interface: The pedagogical platform for ideas and discussions in engineering education.

We owe it to Bill, and to many past, present, and future leaders of IEEE and ECE to continue our history of rigorous efforts to shape a new dialogue. *The Interface* should be the flagship that allows us to bring new ideas, hopes, visions, and pedagogical discussions forward. This publication is the medium in which we mold our efforts to confront diverse, exciting, new, and ever-changing challenges that are facing the future of Engineering Education. You may say, "There are many ongoing discussion groups, Facebook pages, sites, journals … why do we need a new one?" I agree that these all exist in many forms and in many places, but, there are many of us that believe *The Interface* is a unique and necessary piece to tackle future challenges!

The Interface has a rich history and a can have a hopeful, lasting, and visionary reach that could stand the test of time and the demands for constant change. So, everyone is invited to think, share, start constructive dialogues, participate with our ideas, and shape the future of *The Interface*. At this particular point in time, *The Interface* needs us more than we need *The Interface*. However, there are many of us who believe that with the ever-changing faces of engineering education in the near and distant future, we definitely have a need for *The Interface*. I hope that our enthusiasm, visions, hopes, and educated dialogues are the spark that leads to a bright future. Our goal with *The Interface* is to create a vivid, passionate, and radiating platform for all engineering educators.

Shape the future with your ideas and participation!

With the goal of creating a short issue we invite everyone to provide ideas to the editorial board. We are looking for ideas, thoughts, and articles that initiate progressive and constructive discussions. We are seeking a new form/format for *The Interface*. This is simply the starting point. With everyone's participation, and a more dynamic format for *The Interface*, we can and will be the leading flagship that is a serious, creative, innovative, and progressive fuel for the needed pedagogical dialogue in engineering education.

- *Dr. Mani Mina*

A Look Ahead, A Look Behind

This writer returned recently from the First World Congress on Engineering Education, sponsored by Texas A&M University—Qatar (TAMUQ) and the Maersk Corporation. The conference venue was the Qatar National Convention Center in Doha, a beautiful and very functional new facility. The conference was held in conjunction with the 10th anniversary of the founding of TAMUQ, which is a very important success story in international engineering education. This new engineering program, part of Education City in Doha, blends in a most productive way the academic climate and campus life of the main campus with the culture of Qatar, and the students graduate knowing a lot about their world and their homelands, and ready to work anywhere in the world.

The attendance at the conference was about 400 educators from approximately 17 countries on five continents. The conference general chair was Dr. Hamid Parsaei, Associate Dean of Engineering at TAMUQ. The topics were similar to those of all engineering education conferences—accreditation, retention of highly qualified students, continuing education, faculty development, the role of technology. These questions have been discussed at engineering education conferences around the world and over the years. The questions remain, but as we advance, the answers change, and change dramatically! This is one of the major reasons for having such conferences—to learn the new answers to age-old questions. And the conferences complement each other, and help us share new ideas.

This writer was really pleased to learn that Mani Mina has agreed to serve as Editor of *The Interface,* this joint newsletter of the IEEE Education Society and the Electrical and Computer Engineering Division of ASEE. Mani himself is an innovative and successful academician and teacher. EEs in our readership will be interested to learn that Mani wins student-driven teaching awards when teaching electromagnetics, teaching it well, but not making it "easy." Few can do this. He also teaches technological literacy to students from across the campus, and shows us ways technology and the humanities can and should interact.

This writer actually edited the first year of newsletters, when we used mimeograph machines, typed the addresses on labels, staples, and glued moistened stamps on the documents. Bob Fontana, Floyd Cash, Don Kirk, and Bill Sayle built on the foundation, to ever increasing heights. Mani, thank you for undertaking this assignment, and we look forward to reading your articles and those you get others to write. This will be an important use of the web.

-Dr. Edwin C Jones, Jr.
President, IEEE Education Society, 1975-76

Why Philosophy

Since 2007 there has been a flurry of papers and books on philosophy and engineering and attempts to develop what some authors call a philosophy of engineering education [1]. Because engineering educators, indeed most educators tend to ignore the philosophical basis of their work it is appropriate to ask-why this new found interest in philosophy? It is tempting to answer because there is no escape. It is part of human nature to philosophise at some level or another if philosophy is taken to mean the activity of reflective thinking. For some of us the fundamental questions that have occupied the persons we recognize as philosophers are not considered either fundamental or for in-depth reflection; for others questions such as "Why do we exist?" or "what is the purpose of our existence?" or "what is truth?" are of profound importance. Nevertheless the opinions and values that we have inform our behavior and our reactions to the behavior of others. Moreover as Sherren and Long pointed out long ago in *Engineering Education* they inform our teaching [2]. Our beliefs and values are our drivers and to understand them and how they are formed is at the heart of philosophical urge in human thinking. The method of philosophy takes us out of the realm of casual opinion on which much educational policy and action is based into disciplined reflection. That is – why philosophy.

At the present time, for a variety of reasons some engineers and engineering educators are questioning whether the philosophical premises that have driven the structure and content engineering curriculum since the end of the second –world war are appropriate for the 21st century. They ask questions about the purpose of engineering education and more generally about higher education. They are being driven by changes in employment patterns horizontally (employment availability at any time) and vertically (employment persistence in a particular job) caused by developing technologies. Their impact on social structure and social mores is profound, so questions have to be asked and are being asked about the purposes that higher education will have to accomplish in the future, how it will be delivered, and how it will be afforded [3]. In the first place they are philosophical issues and philosophers of education have shown in the past that they are highly competent to deal with them as they effect general education. Now is the time for engineering educators to join with them in a reconsideration of the aims of higher education and within that context those of engineering education. It cannot, however, achieve this goal without interaction with subjects from the social sciences that are themselves spin-offs from philosophy [e.g. sociology-[of knowledge], psychology- [of development, the mind), and the humanities [e.g. historical context]). One topic that is pressing is the relationship between liberal and vocational education and the necessity or otherwise for liberal education that is highlighted in a 2011 report from the National Governors Association [4].

It is customary to try and express aims in terms of behavioral outcomes. Often these require interpretation, and as Yokomoto and Bostwick showed some of the statements in ABET 2000 were ambiguous [5]. One of the lessons of twentieth century philosophy is that it can help us clarify meaning and ensure that statements are understood similarly by those we wish to respond to them [6].

But a discussion of aims is meaningless if there is no agreed understanding of what engineering is and what it is that engineers do. It is surprising how little is known about what engineers do and how they feel when they are doing engineering. In these recent discussions much attention has been given to the differences between engineering and science.

Two books and a paper that may be regarded as seminal were published in the early years of the 21st Century. In the same year (2003) Koen linking philosophy and engineering illustrated how the theoretical and practical can merge to form real-world practical solutions [7]. He generalized the engineering method to become a universal method based on heuristics. Bucciarelli set out to show that philosophy mattered to engineers and in so doing asked important questions about the nature of engineering knowledge [8]. Since then epistemological issues have occupied much of the debate that has been generated. To Bucciarelli, perhaps more than any other writer, is owed the understanding that design is a social process, and from that comes a major contribution to our understanding of the aims of engineering education namely- that engineers have to have a good understanding of social processes. Ethnographic studies by engineers who are also qualified philosophers and sociologists associated with the University of Grenoble in France give powerful illustrations of this need that have implications for the curriculum [9].

In the following year Goldman in a paper set out the argument for a philosophy of engineering as distinct from a philosophy of science [10]. Among his arguments is that because engineering couples values and knowledge to *"the world engineering practice should enable the exploration of experience "as itself a source of values"* which may be read as a call for students to be trained in reflective practice, and coincidentally what it is 'to be' an engineer. This links in with authors like Davis who have taken the teaching of ethics beyond a simple the understanding of codes of conduct and whistle blowing into what it is to be a professional engineer [11]. Such studies have to be placed in the context of engineering decision making. Like Vincenti he underlines the importance of understanding what it is that engineers do [12].

In a significant departure from the general run of discussions in ethics Bowen argues that engineers have forgotten their major role which is to promote human well-being because they "*have not engaged* *sufficiently in ethical analysis of their activities*"[13] In pursuit of what he calls an "aspirational ethic" he draws on the work of Buber and MacIntyre, two twentieth century philosophers with quite distinctive views. In contrast to those who have argued that too much emphasis is placed on comparisons with science in these discussions Bowen draws on the philosophies of business and medicine for comparison.

Finally, there has been much debate, most of it informal, about the role of philosophy (other than ethics) in the undergraduate curriculum. Smith and Korte, for example would argue that the application of the philosophical method to engineering learning enhances that learning [14]. While not disputing this view I argue that students need to be confronted with the perennial questions that have occupied philosophy, and that taken together society will gain the reflective practitioners of profession and life that it so badly needs.

So where does one start? One begins with the self as agent and asks what is my philosophy of engineering education and how does it influence my attitudes toward teaching and the curriculum? When that is answered find out what the philosophies of your students are in order to choose an educational theory that is compatible with your philosophy and those of your students. Maybe you will have to do some reading, which is not a bad place to begin a philosophical journey!

- *Dr. John Heywood*

[1] Since 2005 two groups have held regular sessions. The first group was founded in Denmark has run conferences that have produced several books. The First was *Philosophy in Engineering* (2007) edited by S. H. Christensen, M, Meganck and B. Delahouse (Academica, Denmark). The second group developed out of committees of the National Academy for Engineering, Royal Academy for Engineering and the Dutch equivalent. There first conference was published as *Philosophy and Engineering: An Emerging Agenda* (2010) edited by I van de Poel and D. Goldberg (Springer, Dordrecht and New York). The third group has organized special and paper sessions at the Frontiers in Education Conferences, and members have contributed to ASEE annual conferences. Their focus has been on philosophy and engineering education. The IEEE Ed Soc together with the ASEE ERM division and NSF sponsored a symposium at the 2011 FIE Conference. They produced a review and bibliography that are published in the FIE Proceedings. Heywood, J., Carberry, A and W. Grimson. *A Select and Annotated Bibliography of Philosophy in Engineering Education* (34 pages), and Heywood, J. *A Historical Overview of Recent developments in the Search for a Philosophy of Engineering Education* (24 pages)

[2] Sherren, D. C. And T. R. Long (1972). The educator's dilemma. What makes Clyde want to learn? Engineering education, 63, (3), 188 -189.

[3} See for example (a0 Sparks, E and M. J. Waits (2011). *Degrees for What Jobs? Raising Expectations for Universities and Colleges in a Global Economy.* Washington, DC. National Governors Association. (b) A polemic that looks at what it considers the harmful influence of the UK and USA on higher education, and Irish higher education in particular among other matters. Gallagher, M (2012*). Academic Armageddon. An Irish Requiem for Higher Education.* Dublin. Liffey Press.

[4] Heywood, J (2012) Engineering at the Crossroads: Implications for Educational Policy Makers. Plenary Lecture. ASEE Annual Conference. Pamphlet. Available electronically from ASEE or the author.

[5] Yokomoto, C. F and W. D. Bostwick (1999). Modelling the process of writing measurable outcomes for Ec 2000. *Proceedings Frontiers in Education Conference*, 2, 11b1 pp 18 – 21.

[6] for a comment on analytic philosophy in education see Noddings, N (2007) *Educational Philosophy*. 2nd Edition., Cambridge, MA, Westview Press. She draws attention to the work of R. S. Peters and notes his distinction between Aims and Purpose. In this article they are confounded. Her book is a good introduction to the philosophy of education.

[7] Koen, B. V (2003). *Discussion of THE Methiod. Conducting the Engineer's Approach to Problem Solving*. New York, Oxford U. P.

[8] Bucciarelli, L. L. (2003*). Engineering Philosophy*. Delft, DUP Satellite.

[9] Vinck, D (ed) (2003) *Everyday Engineering. An Ethnography of Design and Innovation*. Cambridge MA. The MIT Press. The studies does not deal specifically with the education of engineers but the implications are both clear and profound.

[10] Goldman, S. L (2001) Why we need a philosophy of engineering. A work in progress. *Interdisciplinary Science Review*, 29, (2), 163 – 176.

[11] Davis, M (1998) *Thinking Like an Engineer. Studies in the Ethics of a Profession*. New York, Oxford UP.

[12] Vincenti, W. G.(1990) *What Engineers know and How They Know It. Analytical Studies from Aeronautical History*. Baltimore. The Johns Hopkins University Press.

[13] Bowen, W. R (2009). *Engineering Ethics. Outline of an Aspirational Approach*. London, Springer.

[14] Korte, R and K. Smith (2009) Developing engineering student's philosophical inquiry skills. *Proceedings Frontiers in Engineering Conference,* T4B, 1 – 2.

Engineering, Philosophy, and the Will to Act

What is engineering? What does it mean to be an engineer? For those studying engineering these are important questions. College is more than the knowledge gained in a succession of classes. Since for many students college is the first truly independent step in a process of growing and becoming, it is wise to understand where you may end up before taking a journey will change the course of your life; or in the words of Bilbo Baggins, "*It's a dangerous business…going out your door. You step onto the road, and if you don't keep your feet, there's no knowing where you might be swept off to.*" [1]. While you often hear engineering described as the application of science—and engineering does build upon science—most engineers would say their job is much more than applying others' discoveries. This essay starts from common definitions of engineering and explores the surprising role that philosophy, morals, and belief play in engineering.

There are over one hundred definitions of engineering, but perhaps the most common comes from the Accreditation Board for Engineering and Technology (ABET), the organization that monitors the quality of engineering degree programs. ABET defines engineering as "*… the profession in which a* *knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize economically the materials and forces of nature for the benefit of mankind*" [2]. While this definition has evolved over time, the original idea can be traced back to the very start of engineering as a formal profession at the start of the 19th century [3]. A second, related definition comes from an engineering philosopher, Dr. Billy Koen, who defines the engineering method as "*...the use of state-of-the-art heuristics to create the best change in an uncertain situation within the available resources*" [4]. The word "heuristics" can best be described as "rules of thumb" that aren't precisely provable but help one arrive at a solution; engineers constantly use such heuristics in decision making. Both of definitions fit very well with our current ideas of how engineering should be taught since they focus on experience, making things, technical knowledge, and the need to work within constraints. Both the ABET and Koen definitions give guidance on teaching engineering since they imply that one becomes an effective engineer by gaining state of the art knowledge, experience, and effective heuristics.

To explore whether there more to engineering than technical knowledge and the ability to apply heuristics, I introduce an idea popular in thought experiments of past centuries by imagining a "demon" with superhuman powers capable of taking specific actions not possible for humans. LaPlace imagined a demon that predicted the future from knowledge of the position and momentum of all particles. Similarly Maxwell's Demon operated a small trap door to show that the second law of thermodynamics was probabilistic. Let us imagine a "professional demon" with superhuman perception who aids you in your professional tasks. While your professional demon can answer any question or perform tasks with superhuman skill, they need to be given a heuristic, or direction, to act; they are incapable of making choices that we ourselves are unable to. In other words, the Demon lacks independent volition and can only act if its actions can be defined before-hand.

One example of how to construct such a demon is suggested by the economist Milton Friedman's article "The Social Responsibility of Business is to Increase its Profits" [5]. Here the corporate executive demon, or Friedman's Demon, suggests actions to maximize the profits of a business as long as the actions are not deceptive or fraudulent. While the actual amount of data the demon must understand to make such decisions is overwhelming, the heuristic is simple- analyze all incoming data and take the action that maximizes profit. Similarly one can imagine Hippocrates' Demon in medicine that has keen perception of diagnosis and chooses a treatment that has the highest probability to cure an ailment while minimizing harm to the patient. Clearly such heuristics can't fully define a profession—Friedman's Demon cannot motivate employees and Hippocrates' Demon cannot comfort the sick. Nevertheless, identifying a profession's habitual actions—those that could guide our demon—sheds light on values and how performance is measured. The CEO that increases the profit made by a company is valued by shareholders and the doctor who cures a higher fraction of patients is a judged a better physician.

Of course not all human endeavors or professions can be fit so neatly into heuristics; it is difficult imagine the instructions given to Picasso's Demon for example. What about engineering? From the prior definitions of engineering ABET's Demon would supply the knowledge of mathematical and natural sciences, nature's forces and material, and access to others' judgments, leaving the engineer merely the task of deciding what most benefits mankind. Similarly Koen's Demon provides state of the art heuristics, available resources, and probabilistic calculations of uncertainty so that the engineer simply needs to decide what change is best. Here, however, even the best technically trained engineer confronts a potential dilemma. Unlike Friedman's Demon—maximize profits—and Hippocrates Demon—cure the sick—there is no heuristic to determine what is the best change (Koen) or what most benefits mankind (ABET). Technical competence alone is insufficient to guide action; definitions of engineering seem to *assume* either the engineer knows how to best serve the greater good, or will be told how by someone else. This is an important realization; to be able to act as an engineer requires us either to relinquish our judgment to our employer or to develop a moral philosophy that allows us to determine how to bring about a greater good.

Isn't this then the role of ethics in engineering? In a broad sense, yes, but not in the way ethics is commonly taught. Engineers have developed their own code of ethics to avoid the harm that comes from poor engineering decisions. In philosophy such ethical codes are broadly known as *deontological*, or rule, ethics. While deontological ethics provide broad guidelines for avoiding harm, they generally offer little practical advice on how to act for good. Such codes of ethics are also normative—they state how things *ought* to be or an individual *ought* to behave—and thereby may limit the right of an individual to determine for herself what is good. Alternatively one can look to the branch of ethics called *consequentialism*, where actions are judged by their consequences rather than whether they conformed to some predetermined rules. Consequences, however, can be very difficult to predict. The former president of the National Academy of Engineering, William Wulf, identifies ethics as a significant challenge for the engineering profession in the 21st Century since today's complex engineering projects, large teams, and the unpredictable effects of the aggregate of many small, sensible decisions make it increasingly difficult to predict the consequences of engineering actions [6].

If doing good is central to engineering, yet good can't be defined by rules or predicted from consequences, then engineers seem to require more than technical competence in order to be able to act. The engineer must be able to articulate and defend why their action benefits humanity even in the face of uncertainty. The question of how an individual acts when faced with uncertainty was addressed by the American pragmatist William James more than a century ago in his essay "A Will to Believe" [7]. James argues that belief as well as knowledge support action, and that basing behavior on one's beliefs need not lead to a completely relativist world. James recognized that to make completely rational decision we require proof. While for many problems it is possible to wait until sufficient proof is accumulated, moral issues—"*a question not of what sensibly exists, but of what is good, or would be good if it did exist*"—cannot always wait for rational decisions. In these cases one should be guided by one's beliefs. James distinguishes between true beliefs and fantasies by arguing that real belief is living (you care about it), forced (you must make a choice), and momentous (unique, irreversible, and with high stakes).

As engineers we are trained to think rationally in the way of scientists, and James eloquently explains why it can be very difficult to argue an engineering decision from personal beliefs:

> *When one turns to the magnificent edifice of the physical sciences, and sees how it was reared; what thousands of disinterested moral lives of men lie buried in its mere foundations; what patience and postponement, what choking down of preference, what submission to the icy laws of outer fact are wrought into its very stones and mortar; how absolutely impersonal it stands in its vast augustness, then how besotted and contemptible seems every little sentimentalist who comes blowing his voluntary smoke-wreaths, and pretending to decide things from out of his private dream!*

Yet I argue that it is in belief the differences between engineering and science emerge. Where science seeks truth, engineering seeks change. One of James' major claims is that when fully rational decisions are not possible we should be guided our beliefs, when science cannot guide action then truth becomes what you are willing to stand behind. Engineers make uncertain decisions and must be prepared to stand by them. Belief is implicit to being an engineer; what you believe directly influences the outcomes of a project. By being willing to stand by our belief, by having faith in certain outcomes, we help make these outcomes possible. Since beliefs guide actions and the actions of engineers affect others we must both acknowledge, yet be wary, of the power of our belief. Bridges built only from belief collapse, planes designed without the best rational science behind them fall from the sky, and engineering done even for the right reasons is often later seen to cause harm.

How then should an engineer walk the invisible, ever-shifting line between belief and rational decision making? First, do not substitute belief for the empirical methods of science when they are available. Second, practice humility, not hubris, by recognizing that what you know is only a small part of what is known. Seek knowledge as well as change, and realize that the social sciences, humanities, and philosophy have much to offer about how to do good in the world. Finally to trust your beliefs you must be willing to actively develop them and change them at need. Seek to understand where your beliefs originate and test them against the beliefs of others by becoming an active member of an intellectual community. James argues that we have the right to believe what we will, at our own risk, as long as our belief is living, forced, and momentous; but that we must respect the freedom of others to believe as they will. I would add to this that engineers also need to understand that the consequences of their beliefs are real, significant, and may be impossible to predict. As another famous engineer has stated, “The bottom line is that the things engineers do have consequences, both positive and negative, sometimes unintended, often widespread, and occasionally irreversible” [8].

In conclusion, this essay argues that implicit to definitions of engineering is not just technical prowess, but the assumption that the engineer knows how to work for the good of humanity and thus has a keenly developed moral philosophy. Given the complexity and interconnectedness of today’s world, it is becoming harder through rational means to know with certainty the outcomes of one’s actions, to make ethical engineering decisions, and address moral questions. Yet the problems faced by the world that will be solved by tomorrow’s engineers are fundamentally moral in nature, cannot wait for rational certainty, and thus must be guided by a living, forced, and momentous moral philosophy. To be able to act, except in the most narrowly technical fashion, requires that engineers develop a personal philosophy that is grounded in community since our actions affect others. The role of the university is not just to provide vocational training, but to serve as this community to hone one’s philosophy and discover our shared humanity. Wrapped in our own technological hubris and rational mindset engineers often fail to understand the extent to which our beliefs affect our actions and thus the lives of others. Although all actions have consequences, still we must act and in the final analysis engineers can make human choices because we are human.

-*Dr. Alan Cheville*

"The thought manifests as the word;
The word manifests as the deed;
The deed develops into habit;
And habit hardens into character;
So watch the thought and its ways with care,
And let it spring from love
Born out of concern for all beings…
As the shadow follows the body,
As we think, so we become."

- *Dhammapada (The Sayings of the Buddha)*

[1] J. R. R. Tolkien, *The Lord of the Rings*. New York: Ballantine Books, 1954.

[2] Accreditation Board for Engineering and Technology, "Criteria for Accrediting Engineering Programs " Engineering Accreditation Commision, Baltimore 2008.

[3] C. Mitcham and E. Schatzberg, "Defining Technology and the Engineering Sciences," in *Philosophy of Technology and Engineering Sciences*. vol. 9, A. Meijers, Ed., ed Amsterdam: Elsevier, 2009.

[4] B. V. Koen, "Quo Vadis Humans? Engineering the Survival of the Human Species," in *Philosophy and engineering: an emerging agenda*, I. van de Poel and D. Goldberg, Eds., ed New York: Springer, 2010.

[5] M. Friedman. (1970, September 13) The Social Responsibility of Business is to Increase its Profits. *New York Times Magazine*.

[6] W. A. Wulf, "Engineering ethics and society," *Technology in Society*, vol. 26, pp. 385-390, 2004.

[7] W. James, *The Will to Believe and other Essays in Popular Philosophy*. New York: Longman, Greens, and Co., 1912.

[8] N. R. Augustine, "Ethics and the Second Law of Thermodynamics," *The Bridge*, vol. 32, pp. 4-7, 2002.