AC 2010-1984: EXPLORING CONNECTIONS BETWEEN ENGINEERING AND HUMAN SPIRITUALITY

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Exploring Connections between Engineering and Human Spirituality

Abstract

The wealth of knowledge and wisdom within a diverse university community provides a rich and fertile setting for students to explore connections between their chosen discipline and their own spirituality. Multidisciplinary teams of undergraduate students and faculty explore, and wrestle with, the connections between science/engineering and spirituality as they endeavor to become whole persons. Engineering, science, and theology students team up to investigate and assess evidence of purpose from findings in science and engineering. They apply reverse engineering techniques to natural systems in an effort to assess the potential for design recovery. Psychology students help to provide a better understanding of the human condition and the role of perceived affordances in establishing purpose. Anecdotal and survey evidence suggests that undergraduate students find such interdisciplinary studies to be interesting, motivating and beneficial for solidifying personal meaning and purpose. What better place than in higher education to address such monumental and multi-faceted questions? These are the issues that students want to discuss, since the answers they uncover play a significant role in shaping and motivating their future careers and lives. The fields of science and engineering have a huge role to play in this discussion, but they need other disciplines to join them at the table. Engineering students in particular are well equipped to address such big questions, but they benefit greatly from dialogue with students and faculty in other areas. If the goal of higher education is to produce well-rounded and responsible professionals, then institutions should seriously consider addressing the issue of human spirituality as it relates to each student's field of study. This article presents one such perspective for the field of engineering.

The need for whole person graduates in science and engineering

During the summer of 2009, Sam Schurman, former Chancellor of the University of Minnesota Morris and currently Interim Dean of the Faculty at the University of North Carolina Asheville, delivered a powerful lecture entitled, "Seeing the Light: Reflections on Honors at Faith-based Colleges from a 'Sympathetic Outsider'" at the Council on Christian Colleges and Universities Honors Workshop. During this lecture, he made a radical suggestion: that we "reopen the doors of higher learning to the human spirit." He reiterates this point in his latest book, *Seeing the Light: Religious Colleges in Twenty-First-Century America*[1] where he argues that there is much to be learned by the secular academy from such institutions. Many in higher education are echoing this sentiment.

In a recent article, Alexander Astin, Founding Director of the Higher Education Research Institute at UCLA, argues that spirituality deserves a central place in higher education. In describing what he means by "spirituality," he writes that, "…spirituality has to do with the values that we hold most dear, our sense of who we are and where we come from, our beliefs about why we are here – the meaning and purpose that we see in our work and our life – and our sense of connectedness to each other and to the world around us." Based on this definition of spirituality, it is hard to imagine anyone who would not be interested in

this pursuit, or who would not benefit from discussions of how their chosen discipline interfaces with spirituality. In a new book entitled *Educating Engineers: Designing for the Future of the Field*[2], the authors call for a broadening of engineering education by asserting "…that an approach that integrates knowledge, skill, and *purpose* [emphasis mine] through a consistent focus on preparation for professional practice is better aligned with the demands of more complex, interactive, and environmentally and socially responsible forms of practice." Human spirituality is intimately related to a sense of purpose, which governs human concerns and motivations. Proper motivations are critically important for the responsible practice of engineering, as well as the successful completion of an engineering degree, and even the choice to pursue the difficult field of engineering as a career. This article begins to explore the connections between the field of engineering and human spirituality in an effort to encourage students to seriously consider careers in engineering, and better prepare engineers for a fulfilling life of meaningful and responsible service in this challenging field.

Suggestions for making the college experience more "spirit-friendly" are offered in a new book entitled *Encouraging Authenticity and Spirituality in Higher Education*. In this book, Chickering et al. note that,

> American undergraduate education is largely focused on the transmission of theories, empirically derived facts, and the disciplinary frameworks and methods used to create and interpret empirically derived information. Unfortunately, examining the ways in which students can use the information and analytic processes about which they are learning to create meaningful individual lives and positive social structures has largely been excluded. Such characteristics as wisdom, compassion, and integrity, and such concepts as justice, ethics, values, morality, virtue and character are ones that most undergraduates fail to consider because the curriculum does not encourage them to do so. [3]

In science and engineering, students are taught to be objective and analytical, and rightly so. But if their education consists solely of this approach, then is it possible that something of critical importance is being left out? Courses in ethics typically provide students with positive understandings of moral duty and professional obligation, but does this go far enough in making connections with spirituality? Recent studies are recognizing the importance of encouraging students to make connections between scientific knowledge and other ways of knowing such as direct experience, self-evident truths, and wisdom. For example, Michael Reiss at the University of London, in a recent article entitled "The Relationship between Evolutionary Biology and Religion," writes that effective teaching in this area can help students appreciate the procedures and limitations of science, "and the ways in which scientific knowledge differs from other forms of knowledge."[4] Other ways of knowing are also being discussed by educators such as P. J. Palmer, who writes,

> The mode of knowing that dominates higher education I call objectivism. It has three traits with which we are all familiar. The first of these traits is

> that the academy will be objective… Secondly, objectivism is analytic…Third, this mode of knowing is experimental…Very quickly this seemingly bloodless epistemology becomes an ethic. It is an ethic of competitive individualism, in the midst of a world fragmented and made exploitable by that very mode of knowing. The mode of knowing itself breeds intellectual habits, indeed spiritual instincts, that destroy community. We make objects of each other and the world to be manipulated for our own private ends.[5]

Chickering et al. make it clear that their "problem is not with scientific methods and research or with rational inquiries concerning human nature. Instead the problem is that we tend to assume that objective methods require us to eliminate questions of purpose, value, and meaning, and to assume that we humans are only machines, or collections of molecules or interacting subatomic particles."[6] What kind of identity do students develop under such a system? It is widely recognized that students should not be indoctrinated into a particular world view. Rather, they should receive the pertinent knowledge that will allow them to form their own view of things, and integrate the meaning and purpose of their lives into this view. Although higher education strives for this ideal, is it possible that current curricula are guilty of the following stinging accusation?

> A great irony is that while spiritual indoctrination, in particular, has been banned from our classroom, indoctrination and imposition continue unimpeded. Students aren't indoctrinated into religious liturgy but instead into dualism, scientism, and most especially consumerism. We have been indoctrinated into a severely limited, materialistically based world view. Rather than learning to nurture and preserve spirit, we learn to manipulate the world: to earn, store, and protect wealth. Rather than learning to be sensitive – understand and attend to the needs of others – we learn to want, rationalize, and do for ourselves. With the rise of a kind of "economic individualism" as our basic sense of identity has come the centralization of wealth and power, the loss of the "commons", and the ravishing of the planet. The fact is, within our schools and culture, identity is being imposed: not spiritual identity but material identity.[7]

Due to this worldview with its embedded philosophy of science, which permeates the classroom experience, students are shaped into efficient scientists and engineers who tend to focus on making discoveries and producing effective products in the absence of spiritual considerations. This is due largely to the current "academic" worldview under which they labor. While this worldview of efficiency is not necessarily bad, and is certainly the means to an often progressive end, it can lead to a dysfunctional society. This perpetuates a fragmented form of community in which members fight over resources in what Palmer calls "competitive individualism," rather than working together, using all of the talents offered, to reach a more complete and harmonious solution.

So what kind of graduates *are* needed to solve today's societal problems? Chickering et al. suggest that our colleges and universities are well poised to 'educate a citizenry able to

function at the levels of cognitive and affective complexity the problems require. They are the only social institutions that can help create the…"servant leaders" our distressed globe requires. Ten capacities of servant leaders include listening, empathy, healing, awareness, persuasion, conceptualization, foresight, stewardship, commitment to the growth of people and building community. No other educational institutions can do as much to enhance these human competencies and personal qualities. But higher education is not succeeding in these tasks.'[8] Why is higher education failing in this regard? Are not all of the tools to develop servant leaders readily available to them? What do faith-based schools offer that can succeed where secular schools have not? A focus on spirituality, as opposed to religion, is suggested. It may be helpful at this point to further clarify the distinction between religion and spirituality. Teasdale offers some insightful comments in this regard,

> Being religious connotes belonging to and practicing a religious tradition. Being spiritual suggests a personal commitment to a process of inner development that engages us in our totality. Religion, of course, is one way that many people are spiritual. Often, when authentic faith embodies an individual's spirituality, the religious and the spiritual will coincide. Still, not every religious person is spiritual (although they ought to be) and not every spiritual person is religious. Spirituality is a way of life that affects and includes every moment of existence. It is at once a contemplative attitude, a disposition to a life of depth, and the search for ultimate meaning, direction, and belonging. The spiritual person is committed to growth as an essential ongoing life goal. To be spiritual requires us to stand on our own two feet while being nurtured and supported by our tradition, if we are fortunate enough to have one.[9]

Every engineering program strives to produce graduates who are ethical. Engineering ethics is an area that potentially benefits from making connections between science/engineering and spirituality. In fact, Robert Niewoehner of the U.S. Naval Academy, in his paper for the 2008 ASEE Conference, "Must Engineering Ethics Presume a Secular Foundation,"[10] argues persuasively that a secular foundation for engineering ethics lacks the necessary robustness of a faith-based approach. Motivation is a key consideration in this regard. Is it possible for engineers, or any human beings for that matter, to simply learn a set of ethical standards, and henceforth do what is right by shear act of the will, or does ethical behavior flow from having effectively addressed critical spiritual issues? This is the crux of the matter for many faith-based institutions that would hold the latter view, instead of the former. The next section describes how faculty-directed, interdisciplinary student communities facilitate the investigation of these issues.

Interdisciplinary team explorations into engineering and spirituality

If campus leaders are calling for an exploration of ways to better integrate students' spiritual quest with their academic preparation, as Chickering et al. suggest, what might

this look like for an engineering curriculum? They argue that instructors play a key role, noting that,

> "All the disciplines and professional preparation programs have content that can help students become aware of, and examine, their own mental models, beliefs and values, metaphysical assumptions, and future plans and aspirations. But this content will not generate that awareness and enable that examination unless it is accompanied by appropriate pedagogical strategies. Most important, both the curricula and teaching practices need to be accompanied by teachers who are themselves authentic, who are open and candid, [and] who share their own searching, their own concerns, and their own struggles, past and present."[11]

However, not much is offered in terms of how an engineering curriculum might be specifically upgraded in this regard. They do mention that a unit on the confluence of science and spirituality is particularly significant for students, since we seem to be accelerating into an ever more technological age. Classroom discussions around questions such as: "How do we make meaning of transcendent spirituality in a technological age?" and "How do individuals reconcile traditional systems of belief with an increasingly complex and comprehensive knowledge of science?" are suggested.[12]

Fortunately, much has been written in an effort to bring understanding, even reconciliation, to the fields of science/engineering and spirituality. As an example, I have found some success using Guy Consolmagno's book entitled *God's Mechanics: How Scientists and Engineers Make Sense of Religion*.[13] Another valuable set of resources are the proceedings of the Christian Engineering Education Conference[14] which has been meeting periodically to discuss these issues from a Christian perspective since 1992. International conferences can be a valuable arena for learning what others are doing around the world. At the 2006 International Conference on Engineering Education in Puerto Rico, I discovered a paper entitled "Confucian Influence in American Classrooms"[15] by Jainping Yue, which helped me to better understand the world view and motivations of Asian students with a background in Confucianism. At that same conference, I presented a paper describing one of my first attempts at assisting engineering students from a faith-based university to integrate their engineering studies with their spirituality. This effort has continued and become more focused over the last four years. The remainder of this paper will describe that effort and attempt to assess its value and level of success.

The paper referred to above, "Multidisciplinary Cross-cultural University Outreach to Secular Scientists and Engineers (Why Engineers Make Good Apologists),"[16] contains ideas that sprang from interactions between undergraduate engineering students at a faith-based university and technically-oriented foreign nationals (temporarily in the United State for training) who were typically skeptical of a faith-based world view. The students were challenged to learn from (and about) our guests, and also to articulate their own world-view in an understandable and coherent fashion. These interactions were found to be very successful at motivating the students to want to learn more about the connections

between science/engineering and spirituality. One of the learning objectives of their engineering program is the practice of faith-based principles of stewardship, which was introduced in a paper on assessment using electronic portfolios presented at the 2004 ASEE Conference.[17] The development of these connections in the lives of students is seen as an important part of accomplishing this learning objective since proper stewardship of both public and personal resources depends on motivations and purpose.

One insight that was realized from the very beginning is that (just like with traditional engineering topics) students benefit from working in multidisciplinary teams. This was also necessary due to the multidisciplinary nature of the issue. Thus, opportunities were grasped to allow multidisciplinary teams of students to research and write on the connections between science/engineering and spirituality. A special topics course for upper division engineering students was introduced, regular seminars were delivered to pique their interest, new material was introduced into courses such as Philosophy of Science and The History of Quantitative Thought, and an ongoing research group for honors students was initiated. There has been no lack of interest from the students. This idea of multidisciplinary community-based research with purpose, contrary to the "competitive individualistic" approach, allows for a unique opportunity for multiple talents, as well as multiple points of view, to shed light on puzzling questions. As a result of this approach, not only are solutions discovered, which are not bounded by one worldview, but a passion for servant leadership is formed, as students work together and serve each other to achieve a goal that is higher than any of them could achieve individually. We recognize that our research group at this time is somewhat limited in that its members approach these questions from a faith-based perspective. However, one goal for future work is to deepen our connections with others who hold different points of view. We believe that this dialogue would enrich the students' experience and benefit society as a whole.

The current research group consists of a biomedical engineering student, an engineering student in the mechanical concentration, an engineering student in the electrical concentration, a student majoring in psychology, and a student majoring in theology. They are the students who have assisted with the research and production of this paper. Other students have assisted with the research and production of four other papers whose contents are summarized below. These summaries were written by student researchers, and provide a good idea of the connections they deem to be important between the areas of science/engineering and spirituality, as well as demonstrating the progress that can be made through a multidisciplinary community. The full papers can be found in the referenced conference proceedings. The students also benefit by developing and delivering oral presentations of these findings, where they engage in dialogue and learn to carefully consider and respond to difficult questions. In addition, students of the special topics course, called Spiritual Engineering, are required to engage in on-line dialogue, via the internet, with those whose spiritual views are different from their own. The students also review books that differ from a traditional faith-based point-of-view, such as Richard Dawkins' *The God Delusion*. This typically enriches the students' perspectives by motivating them to search for answers to challenging questions, or even causing them to reconsider currently-held views.

The following article summaries admittedly deal with the narrow focus of "origins", which seemed like a good place to start. There are many other areas to investigate in exploring the connections between engineering and spirituality, and we plan to continue and expand this work. In addition, this research was conducted at a faith-based institution, and therefore reflects a faith-based perspective. Never-the-less, it is hoped that this material will be helpful for all those who are interested in exploring the connections between science/engineering and human spirituality.

Summary of "The Applicability of Engineering Design Principles in Formulating a Coherent Cosmology and Worldview"[18] (American Society for Engineering Education 2008)

This paper discusses how the field of engineering influences worldview. It presents attributes of engineers that tend to facilitate their contributions in the areas of cosmology and worldview. It also investigates the idea that engineering design principles are recognized in the make-up of the universe, and the philosophical implications of this realization. The article begins this discussion with a brief explanation of why the engineering mindset is helpful in, and justly applies to, cosmology and worldview. Making the large claim that "the most coherent view of the cosmos appears to be that of an engineered system of interdependent subsystems that efficiently interact to prepare for, develop, and support advanced life, subject to various constraints," the article identifies characteristics that are found in human-engineered systems as well as the cosmos. These characteristics include: "stability, predictability, reliability, transparency, controllability, efficiency, and optimality."

Identifying the complex mysteries of nature, and the ability (not to mention desire) to unravel these mysteries, the article asks the question, "Could it be that the realm of nature and the human mind were, in some sense, made for each other; possibly for the purpose of communicating important truths?" This perspective forms the basis for a coherent worldview through the study of nature and cosmology. The article quickly identifies the engineering mindset as helpful in further developing this worldview. The engineer is able to both understand scientific knowledge, as well as, understand society's needs and has the skills to apply that scientific knowledge to meet these needs, under a banner of integrated fields of study such as philosophy and humanities.

While the typical flow of information is from abstract science to practical feats of engineering, recent engineering concepts have been influential in the process of scientific discovery. This transformation of scientific discovery, with its implications for worldview, is due to the concept of reverse systems engineering. "Reverse systems engineering can be described as a multidisciplinary endeavor to extract engineering design knowledge from a complex system consisting of multiple interacting subsystems that have been synthesized to work together as an integrated unit." Reverse engineering techniques, originally applied to man-made systems, are currently being used effectively to investigate natural systems. This ability to readily and profitably reverse engineer natural systems seems "to suggest that such systems were engineered in the first place."

However, the means and operations of this transcendent engineering influence remain largely unknown. In applying reverse engineering techniques, the recognition of order is a fundamental concept, which has proven very useful. One major reason why reverse engineering seems to be pointing to a particular worldview is the evidence of a "fine-tuned universe." Citing biologist Michael Denton, the article claims, "There is simply no tolerance possible in the design of the celestial machine. For us to be here, it must be precisely as it is."

Support for a reverse engineering mindset comes in the shape of similarities between characteristics of engineered systems and nature, as well as concepts such as irreducible complexity (i.e. bacterial flagellum), introduced by Michael Behe, and specified complexity (i.e. the DNA molecule), introduced by William Dembski. However, these concepts are still controversial within the scientific community. For example, it has been argued that irreducibly complex structures could be produced by certain natural processes. Likewise, there are those who believe that we will eventually discover how DNA formed by unguided natural processes. But no matter how these structures have come about, one cannot deny the fabulous engineering that has resulted. The article wraps up with many quotations of advantages and criteria of an engineering mindset in investigating cosmological problems, such as the origin of life. Lastly, the article recognizes that this perspective is one that provides hope. "This worldview of an ingenious transcendent engineer of the cosmos is a worldview filled with hope. It just makes sense that such an extraordinarily competent engineer who cares so much for the creation would be quite capable of completing the good purposes that are designed for its realization." However, this conclusion may be seen as a naïve approach since the problems of evil, pain and suffering, and accusations of poor design in nature remain as mysteries that are not adequately addressed. It certainly leaves one with additional questions.

Summary of "Enhancing Science and Engineering Programs to Equip and Inspire Missionaries to Technical Communities"[19] (Christian Engineering Education Conference 2008)

The role of faith in higher education, specifically in science and engineering, has received more attention in recent years. Science and faith are more commonly being examined as an integral element to producing a balanced and whole worldview. As faith receives more attention in these academic circles, it is crucial for Christian engineers and scientists to have a ready answer and defense of their faith and perhaps more importantly than a defense, a sound and coherent worldview to offer to the intellectual and educated mind.

In order to articulate such a complete worldview, scientists and engineers must understand the comprehensive aspects of science that appear to point to intelligent causation at the origin of life. Newly discovered ideas are popping up in many fields of science and are supporting a transcendent engineering influence throughout nature. Some examples include: "fine-tuning" from the fields of cosmology and astronomy, the precision of the formulation and fitness of carbon and oxygen, and the incredible features of water in physics and chemistry, the mystery of the origins of DNA, RNA, or TNA for

the origin of life, and the laws of nature that allow for the marvelous results of evolution in biology and biochemistry. A scientifically comprehensive case argues well for a beginning of the universe and a highly intelligent being at its source. However, a complete understanding of the universe cannot ignore the less quantifiable elements presented to scientists such as beauty, goodness, evil, and pain.

An investigation of such unquantifiable components is necessary both through a Christian and secular lens. Even without consideration of a creator, the laws that govern the universe seem to accommodate human life. In a Christian worldview, an extremely intelligent designer creates a whole system where even seemingly destructive individual parts are intended for the greater purpose of the whole. Thus, death and pain are seen in the scope of intentional works of a masterful engineer whose ultimate purpose is eternal love relationships. Such a view is paralleled with natural systems that have a level of complexity far surpassing man-made inventions.

Presentation is perhaps the most crucial element of being a missionary in academia. In light of the changes to well established beliefs in fields such as, physics, biology, sociology, psychology, and the arts, some have shied away from apologetics. However, apologetics are best put to use combining objective evidence and subjective experience. From this thinking arises a cumulative case for a Christian worldview that begins with scientific evidence and progresses to religious experience. One method for apologetics is modeled after systems engineering, focusing on individual parts operating optimally for the purpose of the whole. Engineers are innately equipped with traits to accommodate this thinking, known as "emergence" and thus, are particularly well-prepared to articulate a Christian worldview. A divine engineer is best observed through an emergent lens because creativity is essential in engineering many parts that may be useless by themselves, to work together for a greater purpose. Use of the Socratic questions and a strict understanding of definitions are useful for dialoging with those that are seeking the truth.

In the mission to reach educated minds, the value of apologetics must be put in perspective. Apologetics are best used in pre-evangelism, to shine light on people where they are with their questions, and to present God as a viable answer. Exploring faith and science is useful for both believers and non-believers as deeper investigation reveals the creativity and genius of God's handiwork. Christian engineers are in a prime position to use science and engineering to reach educated people and intellectual skeptics with evidence of a beautifully engineered universe and the ultimate experience of a relationship with their good and loving creator.

Summary of "The Coherence of an Engineered World"[20] (Design and Nature Conference 2008)

It is quite an interesting pursuit to note how, despite the intricate complexity of the universe, we are able to understand it. Albert Einstein once said, "The most incomprehensible thing about the world is that it is comprehensible." The more that one understands about the universe, the more it seems evident that there must have been some

engineering influence and power that formulated its design and set it into being. A popular alternate view in recent years is the idea of a multiverse, but this idea is not based on any form of scientific observation and seems to merely have the purpose of disproving the idea of a transcendent engineer by arbitrarily multiplying probabilistic resources. However, even if the multiverse proves true, the fundamental question of the origin of the universe generating mechanism remains.

A look at various systems and the incredible way in which they all work in very specific ways to make life possible is a fascinating study. For instance, water has many attributes that are quite remarkable, such as its high specific heat to help maintain fairly stable temperatures in oceans and organisms. Its thermal conductivity also allows cells to distribute heat well, and its high vapor tension enables air to hold more water, making precipitation possible. It seems that everything about water makes it ideal for sustaining life.

Through reverse engineering the structure of the universe, a better understanding of its meaning and purpose might possibly be gained. All of the universal constants such as the constant of gravitation and the laws such as Newton's laws all add to the astounding order and functionality of the universe. Any minute differences in things like the expansion rate of the universe appear to be detrimental to life. If the universal density were a mere $1{:}10^{60}$ greater, the universe would collapse upon itself, and a density lower by that same amount would cause it to expand at too rapid a rate for galaxies, and therefore life as we know it, to exist. Other things are remarkably helpful in the way in which they seem to facilitate life, such as the way in which Jupiter's gravity protects the earth from flying asteroids and other debris that could otherwise cause catastrophic damage.

Reverse engineering of biological systems has also been quite helpful in the design of many modern day technological advancements. The field of biomimetics is exploding with engineering applications based on ingenious solutions discovered within natural systems. Indeed, we sometimes find complex mechanisms within nature that have the same parts and layout as previously designed man-made systems, such as electric motors.

The way in which all of the many structures and systems of the universe work together seems to point persuasively to an engineering influence. Dr. Walter Bradley, a distinguished Professor of Mechanical Engineering at Baylor University, has said that to believe that the precise engineering of the universe could happen naturalistically would be to "believe in a miracle by another name." With such optimal properties for sustaining life, it does seem to show a degree of intentionality that points to the existence of an ingenious transcendent engineer behind the scenes.

Summary of "A Reversible Universe – Worldview by Affordance-based Reverse Engineering of Complex Natural Systems,"[21] (American Scientific Affiliation Conference 2009)

This paper seeks to investigate the value of affordance-based reverse engineering techniques for understanding complex natural systems. It is discussed in great detail, including the various views on reverse engineering, and seems to point out that there is not much material available for teaching reverse engineering at the college level. Several suggestions of possible methods are posed in this paper. Affordances (that which is made available to an end user) are viewed as a way to classify the purpose of a portion of a complex system to identify either the intended or the most optimal use. This form seems to be the most promising of the options offered. It allows for an analysis of the interaction between the object and the user (artifact-user-affordances), as well as the object and other objects (artifact-artifact-affordances). This encompasses all the possible interactions, both positive and negative, between an object, or system of objects, and its environment. This system tries to find original or optimal use of an object, which was placed there by an author or engineer, for the purpose of being used by some other party.

This type of reverse engineering and design recovery may be applied to natural systems to investigate issues regarding the origins of humanity, but is this an appropriate use of these techniques? Is the idea of a transcendent master design engineer a hypothesis that will be strengthened or weakened by the evidence that is gathered? Since this research is still in the early stages, it may be difficult to decide at the present, but these questions incite great interest among students, faculty and all those who are curious about our origin and purpose.

Lastly, the paper addresses how an investigator's worldview is inevitably affected by the application of reverse engineering to natural systems, and how it might be shaped by the process. One's views might be changed after finding substantial evidence, while at the same time evidence might be misinterpreted by looking at it in a biased manner. Overall this paper does a good job of showing how affordance-based reverse engineering could be useful, if implemented, in the search for knowledge of natural systems and their purpose. An earlier version of this paper entitled "Integrating the Concept of Affordance into Function-based Reverse-engineering with Application to Complex Natural Systems" was also presented at the 2009 ASEE Conference in Arlington, Texas.

Analysis and Conclusion: Lessons learned at a faith-based institution

One good result of this research is that it has expanded the thinking of our students and faculty, as they have searched for answers and interacted with those of differing perspectives. As a faith-based institution, many of our new students have been schooled in an environment which did not encourage them to seriously question their faith. As a result, many have not fully explored the interactions and tensions between science and faith. Researching and discussing the implications of science and engineering for spirituality provides an important vehicle for young people to sort out what they believe in this regard. The university is an excellent setting for this pursuit. Many faculty members from various areas became involved in these discussions, and students enjoyed seeing faculty members critique each other's views during oral presentations. Depth of insight was obtained through the involvement of faculty members from engineering, biology, chemistry, mathematics, physics, psychology, theology, biblical studies, history,

humanities, English, and philosophy. All of their input contributed to the success of this approach. One of the disadvantages of a faith-based institution is the lack of diverse views among the faculty since they are required to hold to a particular statement of faith, even though there is a considerable amount of freedom within this statement regarding origins. But this disadvantage is offset by the common vision, mission, and purpose held by the faculty, which forms a deeper bond for unity in the face of disagreements.

However, exploring the connections between science/engineering and spirituality as a professor of engineering at a faith-based university can be dangerous because one runs the risk of being the reason that your university is accused of not doing serious research in science or engineering. Sometimes I wonder if I am like the Dad who was relaxing at the park with his young son, both of them lying on the grass in the summer sunshine, next to a quiet pond, with empty hamburger wrappers beside them, offering evidence of serene satisfaction. The silence is broken by the boy who pensively asks, "Dad…why are we here?" His Father thinks for a second, and then recognizing the teachable moment, begins to wax eloquent on matters of existential philosophy. This naturally leads him into several minutes of expounding about spiritual truths that are vitally important for his young son to comprehend. But just as he feels like he's really getting rolling, the boy is finally successful in interrupting him and says, "No Dad, I mean why are we here when we were supposed to pick up Mom thirty minutes ago?" And the hamburger wrappers executed multiple pirouettes in the rapidly developing vortices… For scientists and engineers to not take the time to "lay back" and consider the philosophical implications of their work with their students is to miss out on the richness of a multifaceted understanding and appreciation for life.

Certainly the primary concerns of any engineering department are to teach and conduct research in engineering, but it is also good to discuss the philosophical implications of findings in science and engineering, particularly with students who are still developing their personal spirituality and worldview. And this does not detract from their engineering expertise. Although this is hard to quantify in a small engineering department, it has been my experience that students who participate in such discussions experience increased motivation for successfully completing their engineering studies. They are also better educated and better prepared for leadership because they have made important connections between the sciences/engineering and the humanities. I have seen these results in our engineering students, and many of them have personally shared this information with me. This is also confirmed by student responses to the student opinion surveys conducted toward the end of courses where connections were explored. In addition, multiple new engineering students have shared how they were inspired to pursue engineering after hearing about the connections between science/engineering and spirituality as a high school student. They were also excited to have the opportunity to pursue answers to life's big questions by making use of reason, logic, and knowledge from the fields of science and engineering. Finally, anecdotal evidence from students and graduates suggests that multidisciplinary team explorations into the connections between engineering and human spirituality can lead to a deeper understanding of personal meaning and purpose in life. It can also benefit the undergraduate engineering student by

assisting them in their spiritual quest, and illuminating how their professional career relates to their spirituality.

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