AC 2010-911: WHAT FUZZIES MIGHT LEARN FROM TECHIES

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What Fuzzies Might Learn From Techies

Introduction

Almost all those in academia agree with the value of liberal arts subjects are to "round out" an engineering education in order to make a "whole person" of the graduate. Engineering faculty largely agree that engineering students (and faculty) can learn a great deal from liberal arts faculty and their publications, particularly in the valuable area of "soft skills." Through our interactions on campus and the ABET 2000 Criteria we have certainly seen that engineers benefit from interaction with arts/humanities faculty and the materials they develop. Examples include dealing with team members and clients, interpersonal communications, understanding one's abilities and growth areas, communicating concepts to a wide audience, understanding ethical theories, wrestling with ambiguity in those situations which are not clearly black and white, and understanding social impacts of design. Is there a way to return the favor? Not so much consideration has been given to the opposite issue, which is that of helping liberal arts majors to understand some of the technical aspects of our society. Some technical concepts can be communicated with a relatively slight dependence upon mathematical understanding, and these concepts may even be helpful to liberal arts professors in their teaching of liberal arts courses. While there is definitely value in engineers learning something about the liberal arts there is also definitely value to liberal arts majors in learning something about engineering.

Are there some things that "fuzzies" (a nickname heard on National Public Radio for humanities people, apparently popularized at Stanford) might learn from "techies" (NPR's nickname for engineering and technical people)?

Techies tend to be computer gurus, becoming more helpful to fuzzies as our society becomes more dependent on computer technology. In addition to computer assistance, there are also a number of other technical concepts that may be helpful, such as thermodynamic principles involved in economic situations, an understanding of the relative sizes of numbers, and some basic concepts, fundamental to those of an engineering discipline, which can be applied to everyday life. Fuzzies could also benefit from having familiarity with the popular concept of the Singularity (including the controversy that surrounds it) and with Billy V. Koen's "Method." The following pages outline these concepts.

1. Everyday Concepts – Feedback

Our society is continually becoming more technically oriented in all aspects of life. Technology may seem mysterious to fuzzies. There is, however, a certain set of basic, easily understood information that "techies" can help fuzzies understand.

Some basic concepts, fundamental to those of an engineering discipline, can be applied to everyday life. For example, a person concerned about his or her weight can use the concept that “measurement precedes control.” This concept comes from the engineering principle of a feedback loop. If the output of a system is used to control the input, the whole system may become stable or unstable. Feedback also occurs when a microphone is placed too close to a speaker at a rock concert. The loud noise produced is due to the instability of too much positive feedback. To control weight, a person may simply count calories daily and record the calorie count on a graph. The individual could also maintain a daily weight record on the same graph. A relationship should arise between these two graphs, and the intake can be adjusted appropriately. Similar thinking occurs in blood sugar control. The individual acts as the feedback loop. Other examples from engineering might include everyday tradeoffs (as in speed/power), “bandwidth”, “signal” and “noise” in communication, personal multiplexing (multitasking), opposing forces in society, and reaching “steady state” activity after wild oscillations.

2. Reality and Murphy’s Law

Fuzzies would benefit from an understanding of real – world imperfections, so that they would not hold unrealistic expectations of technology.

RWG writes:
Many students today live in a “different reality” than I did. Their “reality” has been influenced by so much TV, video, and computer games that some actually think that these things represent real life. It’s as if they had grown up in “the Matrix”. They have been immersed in a world in which they have very little experience with reality as dictated by the laws of probability, physical principles, and Murphy’s Law. They have learned to expect “miraculous interventions”, superhuman strength, and magic. They have not experienced the laws of probability, because very improbable things have become commonplace to them. When I first saw “Mission Impossible”, having been trained as an engineer, I had to laugh out loud, as a complicated device, built without having been tested, functioned perfectly the first time! My sophomore students have to be retrained in the way they build projects, so that they test each part of the device individually before incorporating it in the overall project. This is now necessary in order to overcome their expectation that everything will work perfectly the first time they try it. In other words, they need to learn, by experience, “Murphy’s Law”. One of the projects I assign in lab is to build a Rube Goldberg machine, which is a long string of energy transfers, like the “Mousetrap Game”. The main purpose is to show them that in real life, something will probably go wrong, since real components follow Murphy’s Law. Simply explained, Murphy’s Law says that” if anything can go wrong, it probably will.”

3. Mathematics and Economics

There are some misleading concepts that fuzzies may hold regarding mathematical principles. One example is "Fibber McGee's law of probability", which is, "the less you win, the more you gotta." The radio show, "Fibber McGee and Molly" was popular in the 1940's. This misconception, that the more often you lose in a game of chance, the higher the probability is that you will win the next time you play, may explain why a large number of people play the lottery, believing that they are investing in their retirement. The problem is due to a lack of familiarity with large numbers and some basic ideas about probability: In a set of independent trials, such as lottery ticket purchase, each round begins anew, so that the probability of winning is the same as it was when you started. If a person "invested" a dollar a day in a lottery that might pay a million dollars, and the odds were a million to one that they would win, then at the end of 40 years they would have lost about $14,600. The probability that they might have won the million dollars at some time during those 40 years is still only one in 68. (proof: multiply 365 days per year by 40 years. Divide by 1,000,000 to obtain .0146, which is roughly one in 68).

Engineers deal with numbers, probabilities, and practical logic, but everyone should be able to manipulate numbers, so that they can make change in a store (without a calculator), or figure out a budget. It is also important to know about the mathematical properties of exponential functions, since almost everything changes up or down at an exponential rate. One also needs an intuition for numbers, so that he or she can make realistic estimates of everyday changes. An easy way to familiarize oneself with the exponential nature of natural systems is the "rule of 72", which follows, with an example of its use.

The number 72 can be factored in several ways, as 6 times12, 3 times 24, or 2 times 36. Any way you factor it, one factor gives you the per cent compound interest, and the other gives the time it takes for your money to double. For example, if you put your money in the bank at 6% interest, it will double in 12 years. This also works for inflation, in reverse. If the average inflation rate in a country in 6% per year, your money will be worth half as much in 12 years. An engineering analysis of compound interest reveals that the unbridled practice of its use (as debt) can wreak havoc to a society. For instance, one dollar, invested at 1% interest for 2000 years, will yield about 230 million dollars; If the rate is 2%, the yield will be about 50 quadrillion dollars (that equals 50,000 trillion), in that same time period. One can see from this illustration that large inflation rates, or high interest rates, can doom a society. Such was the case in the Weimar Republic before WWII, where inflation became so high that it was cheaper to burn money for heat rather than buy wood with it. A student of the Bible might notice that there was virtually no inflation from the time of Joseph, (who was sold into slavery in Egypt around 1800 B.C. for 20 shekels of silver, roughly 8 silver dollars) to the time of Jesus, (who was "sold" around 30A.D. for roughly the same amount (30 pieces of silver; equivalent to around 12 silver dollars if the pieces are shekels). This is because usury, which is the practice of charging excessive interest, was forbidden in the Jewish Law. We know that "excessive interest" was defined as "the hundredth" (one per cent?), because it was specifically condemned by the prophet Nehemiah (Nehe.5:10,11), in the Old Testament.

4. Engineering Thinking

Computation and scientific thinking may come easily for some students, but many freshman-engineering students don't automatically think like engineers. It takes a few courses to undo some habits learned earlier, so that one can help students consider realistic requirements and constraints, estimate answers rather than blindly accepting calculator answers, and plan out a project instead of jumping too quickly to a supposed solution.

It might help fuzzies to understand the thinking styles involved in engineering design. Engineers typically ask 5 questions at the start of every project:

1. What is required?
2. How can we do this?
3. What will it cost?
4. How long will it take?
5. How will we verify that we have met the goals?

Engineering design requires alternating between divergent thinking (generating many possible ideas towards a solution) and convergent thinking (narrowing down to the best solution.) Engineers also adopt at least four basic thinking styles or "thinking hats" in design work. Two of these "hats" are positive and creative ("What could be done?"," How could we do it?"), and two are more negative and restrictive ("Should we do this- are there ethical problems here?", and " Is this even possible, given the finances and technology available?")

5. Understanding Engineering Concepts

What would it help fuzzies to know? If we were creating a course for non-engineers, we might include such topics as basic principles behind most devices, mathematics as a modeling language (not as frightening as many think); planning, organizing, considering constraints, and testing as part of everyday life.

RWG writes:
During my time at Drexel, I taught a course in engineering for non-engineering majors, an overview of electrical principles. In that course, I was able to communicate the basics of practical circuit theory and engineering concepts, while I myself learned some basic tenets for communicating technical ideas to a non-technical audience. One of the main approaches is to use analogies to relate engineering concepts to concepts in everyday life. One of the basic foundations of engineering is that physical principles can be modeled mathematically, because they obey the logical laws of physics; however, a person need not be a mathematician to understand the physical principles. Engineers learn to make the relationship between the mathematical model and the physical system. When addressing students who are not familiar with mathematics, the physical principles simply have to be related to other things, which are more familiar to the students. The students need to develop a basic vocabulary in order to begin to understand concepts, such as voltage, current, inertia, mechanical advantage, and similar terms. When I taught this course in 1970, the emphasis was on electrical engineering, and at the end of the quarter, the students understood frequency, wave propagation, feedback, oscillation, basic electronics, transformers, and broadcasting fundamentals[1]. Since I taught that course I have learned more about how students learn, and there is a marked difference between the abilities demonstrated then and now. Students tend to be more calculator dependent, less familiar with mathematics, and not as able to focus, now[2, 3].

There are a few very basic electrical engineering concepts which I teach to general engineering students for which a hydraulic analogy is helpful. Since fuzzies may find electrical gadgets puzzling (as do most of our mechanical majors), I have devised a laboratory experiment, to be performed by all members of the Circuits class. In this two-period lab, water is used to demonstrate the difference between current and voltage. The experiment also demonstrates the properties of a resistor and a capacitor. An inductor is more difficult to make cheaply, so that it is left as a thought experiment[4]. Electric current is like water current. If you have ever siphoned water from an aquarium, you find that once the tube is filled with water, the water runs out until the level in the tank is even with the level in the receptacle. In fact, the distance between the level in the aquarium and the end of the tube outside determines how fast the water runs out through the tube. This explains why towns have high water towers. The water coming through the faucet to homes comes with high pressure. High water pressure, analogous to high electrical voltage, produces high water current, in gallons per minute, analogous to high electrical current. The difference between the hydraulic and the electrical quantities only exists in the units, gallons per minute versus amperes. Resistance is represented by a slight pinch in a siphon hose; the tighter the pinch, the bigger the resistance. In your home, the resistor is your water faucet. When it is turned off, you have infinite resistance to water flow. In a siphoning exercise, you can turn off the water flow by either pinching the hose tight, which applies infinite resistance, or by raising the end of the siphon hose to the level of the water in the aquarium. This action reduces the water pressure, or voltage, to zero.

In the first of two lab sessions, the students measure water current flow, in milliliters per second, for various tube constrictions, based on a given height of water "head." "Head" becomes the distance, in inches, of the source water level to the end of the tube. Since some students have never siphoned water, this gives them all a "feel" for voltage, current, and resistance.

There are only three basic elements of concern, presently, in the electrical field, the resistor, the capacitor, and the inductor. (No, I haven't forgotten the memristor, but that is not used much, yet.)   At the end of the first lab session, the students understand the resistor. The other two elements are related by differential equations, but the equations are not necessary to explain what they do. You can't suddenly change the voltage on a capacitor, and you can't suddenly change the current through an inductor. Capacitors are becoming very important because of their ability to store energy, now that hybrid and fully electric vehicles are being built. They act like batteries for a short time, and are able to deliver power at a much faster rate than a battery can. The first lab session of the course serves to familiarize students with voltage, current, and resistance. The second session introduces the properties of the capacitor. The water capacitor, or, "wacapacitor", which I designed for the lab, consists of two chambers separated by an elastic membrane, with separate entrance tubes to each chamber. If you fill one chamber, the input chamber, with red water, and the other, output chamber, with blue water, then you can set up the following "magic trick". As you siphon red water into this device, blue water comes out the other side. This happens because the chambers are separated by the elastic membrane, "charging up" the capacitor. A regular electric capacitor can retain its charge for hours, and acts like a battery, for a short time. Thus, for that short time, it acts much like a battery, with which most fuzzies are already familiar. That explains their increased importance in the design of electric vehicles. The second lab investigates how a wacapacitor discharges through a waresistor, which is my nomenclature for "a pinched tube." [5]

6. Constraints and boundary conditions

Real life deals with boundary conditions at all times. Some things are possible, and some simply are not. It would be a good thing for fuzzies to be able to determine which things are, or are not, possible. The three basic factors that determine this are economic, physical, and technological constraints. Economic constraints involve projects that are possible to develop, but unaffordable within the budget. Physical constraints exist because the implementation of a device would involve a violation of the first or second law of thermodynamics. The final constraint is that the technology to implement a certain design simply has not been developed yet.

Why don't perpetual motion machines work? It is because, by definition, they break the second law of thermodynamics. In common terms, that law translates to "there is no such thing as a free lunch." What are the limits of technology? At what point do we go from science to science fiction; or, vice versa? Many of our present technological advances were predicted in older science fiction stories, and may have even inspired these advances. Some advances did not even seem possible at the time the stories were written. Technological breakthroughs led to their implementation. A great majority of Sci-Fi may never be realized unless faster-than-light travel is possible. So far, it is a scientific limitation. These technical limits can be understood without any technical training.

7. The Singularity

An important concept which fuzzies should understand is that of "The Singularity". This can be the point at which a computer or robot becomes self-aware. Numerous movies have portrayed, or hinted at, this concept. "Bicentennial Man", "Short Circuit", and "A.I." are examples of such Hollywood inventions. It was even the focus of a recent episode of the popular television series, "Numbers". A test, known as the Turing Criterion, has been devised to determine whether or not a robot has achieved self-awareness. If achieved, science declares, we will have reached "The Singularity".

Ray Kurzweil, inventor of the Kurzweil reading machine, has popularized this concept of "The Singularity," a point in time in which standard laws break down. The popular definition of the Singularity has become the point at which computers overtake human minds or human minds are understood so well that they can be uploaded to computers, thus preserving the individual.

Kurzweil makes his case based upon these assumptions:

1. Computation is growing exponentially
2. We should have the hardware to recreate human intelligence within twenty years
3. Our knowledge of how the brain works is growing exponentially
4. The brain is characterized by a genome of only 23 bytes
5. We should have a complete map of the human brain within thirty years
6. Technology itself is an exponential evolutionary process

Kurzweil writes, “if you follow these trends further, you get to the point where change is happening so rapidly that there appears to be a rupture in the fabric of human history; some people have referred to this as the ‘Singularity.’ This is a term borrowed from physics, meaning a point of infinite density and energy that’s kind of a rupture in the fabric of space-time.” [6]

Since the IEEE dedicated an entire issue, *Spectrum*, June 2008, to the concept of singularity, it must be worth the effort to address problems associated with the singularity.Koch and Tononi begin their IEEE article with this statement:

> “Would you sell your soul on eBay? Right now, of course, you can’t. But in some quarters it is taken for granted that within a generation, human beings – including you, if you can hang on for another 30 years or so – will have an alternative to death: being a ghost in a machine. You’ll be able to upload your mind – your thoughts, memories, and personality – to a computer. And once you’ve reduced your consciousness to patterns of electrons, others will be able to copy it, edit it, sell it, or pirate it. It might be bundled with other electronic minds. And, of course, it could be deleted.” [7]

> “Across cultures, classes, and aeons, people have yearned to transcend death. Bear that history in mind as you consider the creed of the singularitarians. Many of them fervently believe that in the next several decades we’ll have computers into which you’ll be able to upload your consciousness—the mysterious thing that makes you you. Then, with your consciousness able to go from mechanical body to mechanical body, or virtual paradise to virtual paradise, you’ll never need to face death, illness, bad food, or poor cellphone reception. Now you know why the singularity has also been called the rapture of the geeks. The singularity is supposed to begin shortly after engineers build the first computer with greater-than-human intelligence. That achievement will trigger a series of cycles in which superintelligent machines beget even smarter machine progeny, going from generation to generation in weeks or days rather than decades or years. The availability of all that cheap, mass-produced brilliance will spark explosive economic growth, an unending, hypersonic, technoindustrial rampage that by comparison will make the Industrial Revolution look like a bingo game.” [8]

Philosophical Problems of the Singularity

Engineering reasoning and boundary analysis (including the issue of the “duplicator” machine) can demonstrate the difficulties inherent in this concept. Consider the problem, illustrated by Spock (of "Star Trek" fame) and Calvin (of "Calvin and Hobbes" fame): Calvin devises a duplicator to make another of himself, then argues with this duplicate as to which one is really himself. Spock beams himself down to a planet's surface, so that all of his atoms are rearranged exactly the same as they were before leaving the ship. His body and memory are exactly the same as before, but is Spock's self awareness the same?

Technically, the singularity can be understood by reducing the human being to three parts – the body, the memory, and the self. This third quantity, the self, is the most elusive to definition. Depending upon one's Basic Worldview Category (BWC), it may be the soul, the spirit, or simply self-awareness (see Appendix A for an explanation of worldviews). Self-awareness consists of that that which remains after accounting for the body and the memory.

> "Specialists in real rather than artificial brains find such bionic convergence scenarios naive, often laughably so. Gerald Edelman, a Nobel laureate and director of the Neurosciences Institute, in San Diego, says singularitarians vastly underestimate the brain's complexity. Not only is each brain unique, but each also constantly changes in response to new experiences. Stimulate a brain with exactly the same input, Edelman notes, and you'll never see the same signal set twice in response. 'This is a wonderful project--that we're going to have a spiritual bar mitzvah in some galaxy,' Edelman says of the singularity. 'But it's a very unlikely idea.'…
>
> A healthy adult brain contains about 100 billion nerve cells, or neurons. A single neuron can be linked via axons (output wires) and dendrites (input wires) across synapses (gaps between axons and dendrites) to as many as 100 000 other neurons. Crank the numbers and you find that a typical human brain has quadrillions of connections among its neurons. A quadrillion is a one followed by 15 zeroes; a stack of one quadrillion U.S. pennies would go from the sun out past the orbit of Jupiter." [9]

Neuroscience Problems of the Singularity

Several of the problems in the purely materialist approach to the mind are developed in the book, *The Last Superstition*:

> 1. The underlying assumption is that the mind is strictly the brain and that biochemical reactions account for all of human thought.
>
> 2. "Individual thoughts, (then), are just physical symbols in the brain –like words or sentences, only encoded in the form of neural firing patterns."

3. "(However), nothing counts as a 'symbol' apart from some mind or group of minds which interprets and uses it as a symbol."

4. "No physical system can possibly count as running an 'algorithm' or 'program' apart from some user who assigns a certain meaning to the inputs, outputs, and other states of the system."

5. "The suggestion that the meaning of the symbols purportedly encoded in the brain derives from their causal connections with things in the external world is incoherent…It requires identifying certain points in a chain of causes and effects as having a privileged status, in particular as counting as 'the beginning' of the chain and 'the end' of the chain; yet objectively speaking no points in the chain have any such status."

6. The ''computer model'' of the brain "is incoherent...insofar as it undermines the very possibility of rational argumentation, including any argument a materialist might want to give in support of his own theory." The meaning of all symbols is, in fact, absolutely relevant to all forms of logical thought and computation. [10]

8. Koen's Method

While philosophers may actually despair over our inability to know anything completely or even with certainty, engineers are used to working with heuristics and sets of assumptions. A key book discusses this approach in detail, showing how the engineer differs from the pure skeptic.

There is a distinct difference between the thinking and learning processes of techies as compared to those of fuzzies. It is rare to find someone who can see both sides clearly. Dr. Billy Vaughn Koen, UT Austin Mechanical Engineering Professor, is truly a "Renaissance Man", a "philosopher-engineer-scientist". His book bridges the gap between "techie" and "fuzzy".

Different types of techies exist, as do various kinds of fuzzies. Individuals of both groups are willing to explain things, as well as those who look for an opportunity to display their expertise as they overwhelm others with information. Koen is willing to explain things.

In 1990 Billy V. Koen published his treatise *Discussion of The Method*, (11) which explained the author's presentation of the Engineering Method. Koen's goals in writing the book were to define a philosophical base for what an engineer actually does and to generalize engineering to a universal method. . Koen's insight into both sides is clearly evident as he summarizes the extremes of both points of view. He sees the extremes as thinkers or skeptics on one side of the spectrum, and doers, or engineers, on the other side.

The following principles define The Method (Koen deliberately underscores the letter):

1. "Engineering is the use of heuristics to cause the best change in an uncertain situation within the available resources."By "heuristic", the author means something helpful that is based upon experience but not necessarily justified. Rules of thumb and principles for resource allocation are examples of engineering heuristics.
2. A particular set of heuristics associated with a specific label and time stamp become the SOTA, or "state-of-the art."
3. "Evaluate an engineering design against the SOTA that represents the best practice at the time the design was made." In engineering, "best" is typically related to optimizing a particular quantity, such as energy efficiency. [12]

The extension of The Method is Koen's "audacious philosophical claim" that "All is Heuristic."

Koen shows that all of mathematics and science that we depend on breaks down. (1) Koen cites Godel's proof, claiming that mathematics, arithmetic, or any axiomatic system, for example, "is either incomplete or inconsistent." (2) Logic has limits. (3) Causality is in question based upon the Einstein-Podolsky-Bell experiment (EPR) or Bell's Paradox. (4) Human perception is in question, because the senses can be deceived and hypnotism can trick the mind. All of practice, whether engineering, math and science, art, or writing therefore involves the use of heuristics.

Koen terms this conclusion "The Universale Organum", or universal method, underscoring the letter h to indicate that it is based on heuristics. Since there is no way to prove , absolutely, that anything exists, even ourselves, the engineer (or, Techie) simply uses his best estimate of the conditions (the state of the art, or "SOTA") in order to come up with the best solution of the problem. Thus anyone who accomplishes a change is an engineer, in that he or she uses the engineering method to do this. This would mean that the writer, journalist, farmer, physician, and plumber all use this universal method, the engineering method, which is:

Use heuristics.

In practice, we don't spend our lives worrying about whether our desk and pen really exist. We assume that they exist, and proceed from there. The skeptic concludes that life is meaningless, so that there is no point in doing anything. The engineer sees that one cannot prove anything exists; however, knowing the state of the art (SOTA), anyone can accomplish something by doing the best they know how at the time.

Jerz writes:
"Koen claims that everything in engineering is a heuristic. Heuristics are simply levers that offer paths of progress towards a solution. An engineering project has ***objectives***, and there are ***limiting factors*** that conspire to prevent the project from reaching its objectives. The engineer must understand all of this, and use heuristics to maneuver around (or through) the (perceived) limiting factors so that the project can reach its objectives. When one path is blocked around a limiting factor, we must select another path." [13]

In the extreme, the skeptic concludes that life is meaningless, and it is pointless to attempt to do anything. The engineer sees that one cannot prove that anything exists. The engineer determines that by knowing the state of the art, a person can use his or her knowledge and abilities to actually accomplish something

Conclusions

We have attempted to suggest a few areas in which technical concepts can be explained in ways easily understood and applied by the more left-brained students and faculty. Numbers, probability, and the exponential quality of nature were discussed. Electricity, mysterious to many of the mechanically inclined as well as to fuzzies, was, hopefully, made clearer. Many of the present technical advances have been spurred on by science fiction, and technical knowledge helps one to understand the difference between what aspects of sci-fi are attainable, and those that are not. The singularity concept illustrates this tension. Dr. Koen's insights form a bridge for us, since he is expert in both technical and philosophical fields. We find that we are all engineers, if our aim is to produce change.

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Appendix A:

The Gospel According to Carl Sagan

RWG writes:
I love science fiction. Sometime during junior high school, I discovered science fiction magazines, and began to devour them. My love for science fiction motivated me to learn math and science, and, eventually, to become an electrical engineer (because, I figured, if I was going to discover anti-gravity, I would probably have to learn about electromagnetic fields).

Between my junior and senior years at Purdue, however, I discovered that Jesus Christ died for my sins (which were many), and my life was turned upside down. I had to rethink everything. I took a class in modern physics, talked with lots of people, both Christian and non-Christian, discovered the writings of Francis Schaeffer and Josh McDowell, and discovered that miracles actually do happen. So, how does all this information fit together? I still love science fiction; I also developed a love for teaching electrical engineering, and eventually wound up teaching in a Christian university, where I now continue to teach.

Eventually, I watched "Contact", a movie based on Carl Sagan's book of the same name. I loved the movie, so I got the book and read it. I was amazed to find that this die-hard proponent of humanistic thought ("The Cosmos is all there is…") believed in intelligent design! Let me explain.

In the movie, Ellie, played by Jody Foster, is the only passenger to travel, in a machine dictated by aliens, to a distant star system. In the book, there are five passengers, but the focus is still on Ellie. The basic concepts are the same in both the book and the film versions. The book, however expands the discussion, which is the point of the story, of how the universe began.

Carl Sagan was a great scientist and a deep thinker, and my father (also an engineer) adored him. He mentioned him more than once in our vehement theological discussions.

However, what a person writes in fiction reveals what he really thinks about life, death, and the universe; and in the book, more was revealed than what was in the movie. Many naturalists believe that it is possible to build a robot complicated enough to house a person's consciousness, so that a person could transfer himself into that robot and live forever. The time for this technological breakthrough is hoped to be in the near future; the event at which a machine becomes conscious is called "The Singularity". A whole issue of a respected scientific journal, the "*IEEE Spectrum*" (June, 2008), was devoted to this concept, called "The Rapture of the Geeks".

One version of the "Singularity" suggests that at death one's entire memory may be uploaded to a computer while the body decays permanently. This is contrary to the Judaeo-Christian concept of a soul that survives death and is rejoined to a resurrected body. Other options suggested after death: wandering around as a disembodied spirit – a ghost- with or without memory, because the existence of Alzheimer's disease gives reason to think there are those two options. If you believe that after death you simply cease to exist, then your attitude toward morality (if you think logically) may eventually be that morals are simply a construct to keep the society orderly, so that you might as well do anything for your own benefit that you can get away with. It all depends on which of the three Basic Worldview Categories (BWC's) is actually true. One is, and the other two are not. The engineer understands the principle that only one is really true, because he is trained to deal with real systems and make them work. In this case, the options are as follows.

There is no supernatural realm, no spirit, and no soul. When you die, you simply cease to exist; it is as if you went to sleep, and there are no dreams. This is BWC #1

There is a self-awareness, or soul, or spirit, and this is transferred to another living being; a human, animal, or spirit being. This is BWC #2.

Same as number 2 above, except that there is a judgement, so that the soul experiences justice: reward and/or punishment for moral actions performed in his life (in BWC #2, justice may come during reincarnation, but the source of a justice standard is vague).

Actually, the latter two of these BWC's each have two more options, depending upon whether or not the memory is retained.

Science fiction stories have been written about this dilemma as early as the 1950's (remember, science fiction is what motivated me to enter the engineering field). What if you developed a matter transmitter and the soul did not follow? What if Spock was beamed down to a planet and he simply ceased to exist (if BWC#1 is true), and another being with his memory appeared on the planet? Or, he might find himself in an animal, or being born as a baby somewhere, with no memory of his previous existence (if BWC #2 is true). If BWC#3 turns out to be true, he might either be standing before God to be judged, or have gone on, in a soul-less body, to do whatever soul-less things do.

If Sagan's book reflects his conclusions, he believes that the "rapture of the Geeks" is possible, that the universe is teeming with life, and that many species have been "raptured" in this way, and have been living for perhaps billions of years, so that they have achieved nearly godlike characteristics. But, in the discussion with our heroine, Ellie (Jody Foster in the movie), something is revealed in the book that was not portrayed in the movie.

The ages-old alien tells her to go back and check pi, the ratio of the circumference to the diameter of a circle. He says there's a message hidden in it. After she returns to earth, she puts her computers to work in order to calculate pi to an extent never before attempted, and finds the message.

What has Sagan done, here? He has, maybe without realizing it, revealed that, in spite of his declaration that "the Cosmos is all there is", and all has come into being through random processes, there is more. He has been driven to conclude that the fundamental constants of the universe must have been engineered by Someone. He basically is stating a case for "intelligent design."

I am reminded of the astrophysicist Sir Fred Hoyle's statement:

"A common sense interpretation of the facts suggests that a superintellect has monkeyed with physics, as well as with chemistry and biology, and that there are no blind forces worth speaking about in nature. The numbers one calculates from the facts seem to me so overwhelming as to put this conclusion almost beyond question" [1]

Bibliography, Appendix A:

1. Heeren, Fred, "*Show Me God*", Day Star Publications, Wheeling, IL, 1997

Appendix B

Steps Toward the Death of Science

Lynn White, professor of history at UCLA, in his lecture and subsequent lecture in 1967, said: “From the thirteenth century onward, up to and including Leibnitz and Newton, every major scientist in effect explained his motivations in religious terms. Modern Western Science was cast in a matrix of Christian theology”. [1]

Are we seeing a movement towards the loss of true science in our culture? A number of recent trends highlighted in the news suggest that we may be on a downward slope in terms of our science.

We will lose real science when:

1. We lose objectivity among some scientists.

2. Science becomes politicized.

3. Science becomes a lucrative business.

4. Results are falsified for the sake of publication/career, political correctness, continued funding, or one’s pet theory.

5. The general public rather than the scientific community votes on what is worth studying and funding.

6. The public loses trust in scientific research.

7. The scientific method is abandoned because the results are “obvious.”

8. No one cares how things really work.

9. We move to an age of magic and mysticism.

Lewis wrote:
“Men became scientific because they expected Law in Nature, and they expected Law in Nature because they believed in a Legislator. In most modern scientists this belief has died: it will be interesting to see how long their confidence in uniformity survives it. Two significant developments have already appeared—the hypothesis of a lawless sub-nature, and the surrender of the claim that science is true. We may be living nearer than we suppose to the end of the Scientific Age.”[2]

Bibliography, Appendix B:

1. White, L., “The Historical Roots of our Ecological Crisis.” *Science, vol. 155, p.1203-1207, 1967.*

2. Lewis, C.S., *Miracles: a preliminary study,* Collins, London, p. 110, 1947.