

# PROCEEDINGS

*of the*

**3<sup>rd</sup>**

Christian Engineering Education Conference

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at the

JAARS Facility of Wycliffe Bible Translators  
Waxhaw, North Carolina

# CEEC-99

The Mission of Christian  
College Engineering Programs  
for Y2K and Beyond



## **PREFACE**

The first Christian Engineering Education Conference was held in 1992 at Calvin College in Grand Rapids, Michigan. The second conference was held in 1996 at Messiah College, in Grantham, Pennsylvania. The 1999 Christian Engineering Education Conference brought together a diverse group of dedicated Christian engineers. It was a distinct pleasure to hear the wonderful ways God is working in the various programs and schools represented at our meeting. The Jungle Aviation and Radio Service (JAARS) facility of Wycliffe was a fantastic location for our conference, and we are very thankful to our gracious hosts. A special thanks goes to Carol Weaver, the JAARS conference coordinator.

The goal of these conferences is to glorify God, to foster community among Christian engineering educators, and to encourage and challenge each other in our work of kingdom building. Abraham Kuyper, one of the great thinkers within the Reformed tradition of Christianity, has said that there is not one square centimeter of the creation that is not claimed by Christ. As Christian engineering educators of whatever tradition, we seek to stake that claim in our discipline, exploring how our faith impacts our teaching, our profession, and the technological products we design. In this proceedings you will find seven papers that span several areas of interest: philosophical questions as well as practical matters, changing ABET requirements, and mission statements, to name a few. We hope you find these papers encouraging and challenging. May God be glorified through this work.

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The next Christian Engineering Education Conference is tentatively being planned for the summer of 2001 in Albuquerque, New Mexico. If you are interested in serving on the planning committee, please contact the CEEC-99 chair, Steve VanderLeest, Calvin College, 3201 Burton SE, Grand Rapids, MI 49546, or by email at [svleest@calvin.edu](mailto:svleest@calvin.edu).

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## **CHRISTIAN ENGINEERS AS FAITHFUL WITNESSES TO GOD'S REDEMPTIVE PURPOSES FOR CREATION**

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Some of the best advice I ever heard about choosing a vocation didn't come from a guidance counselor or a minister, or my parents, but from a famous golfer, Jack Nicklaus. He is reported to have suggested the following: "Find something that you love so much and you're so good at, that you'd do it for nothing, and then find someone who will pay you to do it." That's good advice, as far as it goes (I will soon argue that it doesn't go far enough). I have at times quoted this advice in discouraging parents from pushing their son or daughter into a college major where they can easily "make a living" (e.g., business), when what John or Susie really loves to do and is really good at, is to create works of art. I personally think it's better to be a struggling artist, loving what you do, than a well-to do business person who dreads the sound of the alarm clock on Monday mornings.

But surely something is missing in Nicklaus' advice. To love to do something and to be good at it may be necessary conditions for a wise vocational choice, but they are not sufficient conditions. So Nicklaus' advice is incomplete, from my perspective. I illustrate with an outlandish counter-example that makes my point. As a kid in Brooklyn, I may have loved and been good at stealing hubcaps off cars and selling them for a nice profit (not that we would ever think of doing that). But my love and gifts for such an activity hardly justifies it. I have to ask whether the activity is worthwhile. Is it important? To rephrase the question in terms of my Christian commitment: "Is the activity important in light of God's redemptive purposes for creation?"

But that question raises a prior question: What are God's redemptive purposes for creation?

I was brought up on a narrow view of redemption, which was accompanied by a narrow view of what it means to witness as a Christian. I have since rejected that narrow view, and have embraced a broad view of God's redemptive purposes. My explanation of this change in perspective will reveal my understanding of the ways in which Christian engineers can be faithful witnesses to God's redemptive purposes for creation.

The view of redemption I was brought up on in my pietistic Lutheran church was that individual persons need redemption. And that is certainly true. As individuals, we need to embrace the good news of the gospel that God loves us as we are, not as we hope to be. And we need to appropriate for ourselves the redemptive work of Jesus Christ that reconciles us to God.

This initial view of redemption clearly defined what it meant for me to be a witness to God's redemptive purposes. In terms of my witnessing as a Christian engineer in the aerospace industry in the late 1950s, such witnessing included the following:

- Striving for excellence in all my work, as if I was working for God; not just for other people (Col. 3:23).
- Developing caring relationships with my co-workers; trying to be sensitive to their needs and seeking to be a help to them in any way that I could.
- As opportunity presented itself, bearing witness to the good news of the gospel, pointing my co-workers to a loving God who desires their redemption.

I want to state clearly that I wholeheartedly embrace these aspects of witnessing and the underlying view that individual persons need redemption. But is there more to redemption and witnessing than this; in addition to, not in place of? I now believe that there is.

The nature of the addition is best introduced by my noting questions I never asked myself as I tried to witness as an engineer, in the ways I just described. Is the work itself important? Is the product produced by this aerospace company, or the services rendered by this company important in light of God’s redemptive purposes for creation?

A major product of the company I worked for was a guidance system for ballistic missiles. Was it important for me as a Christian to contribute to the development of a guidance system for ballistic missiles? I don’t want to suggest that there would have been a simple answer to that question, had I asked it. My point here is not to try to answer that question. My point is the absolutely amazing, and alarming fact that I never asked myself the question: Should I be contributing to the development of a guidance system for ballistic missiles? Is such work important in the light of God’s redemptive purposes for creation?

And why did I not ask myself that question? Because at that time in my pilgrimage, I had a very truncated view of redemption, that only individual persons need redemption, and a corresponding truncated view of what it means to be a Christian witness.

I would now like to tell you what I believe is “the rest of the story” (to borrow a phrase from Paul Harvey).

I must now return to that prior question: What are God’s redemptive purposes for creation (in addition to the redemption of individual persons)? In other words, what does God consider to be important?<sup>1</sup>

Far be it from me to give you a definitive word on that. I invite you to join me in an exploration I began some 30 years ago, when this question of importance first pressed itself on my mind and heart and I began dissecting the pages of my Bible looking for explicit and implicit hints as to what God considers to be important.

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<sup>1</sup> I often use the phrase “biblical values” to refer to my understanding of what God considers to be important. But, I am not using the word “values” here in the anemic sense so prevalent today, referring only to “personal preferences.” What I am referring to as “biblical values” has solid ontological status; they are important, whether I prefer to think so or not.

Without wanting to truncate your exploration of what God considers to be important, here is my partial list, expressed in terms of my understanding of the work to which God calls those who profess commitment to the Christian faith, in addition to the redemption of individual persons.

- God calls Christians to be *agents of peace and reconciliation* between persons and groups in conflict, from the farthest ends of the world to our places of employment, to our churches, to our own homes. Situations of conflict groan for redemption.
- God calls Christians to be *agents for justice*; to work tirelessly for a more equitable distribution of goods and rights to the marginalized, the poor and the oppressed of the world. Unjust societal and political structures groan for redemption.
- God calls Christians to be *agents for the flourishing of the natural creation*, the inanimate world, by wise stewardship of natural resources and concern for a healthy physical environment. A polluted earth groans for redemption.
- God calls Christians to be *agents for beauty*; showing appreciation for beauty, both in God's creation and in the artistic creation of humans, and fostering the further creation of such beauty. Ugliness groans for redemption.
- God calls Christians to be *agents for knowledge*, for greater understanding of all aspects of the created order, that we may live in proper relationship with that order. Ignorance groans for redemption. Inadequate perspectives on the academic disciplines groan for redemption.
- God calls Christians to be *agents for the growth of other people*, with each person growing in accordance with his/her special gifts and abilities. Persons whose growth is stifled through neglect or abuse groan for redemption.

The truth of the matter is that all of God's creation groans for redemption. This large view of redemption was eloquently captured by the Dutch statesman and theologian Abraham Kuyper, when he said "...there is not a square inch in the whole domain of our human existence over which Christ, who is Sovereign over all, does not cry, 'Mine!'."<sup>2</sup>

I propose for your consideration this large view of redemption. The associated large view of witnessing to God's redemptive purposes is that I must go beyond working for the redemption of individual persons, as important as that is. I must commit myself to being an agent for various facets of God's redemptive purposes, in accordance with my particular gifts and abilities.

If you accept this large view of redemption and this large view of witnessing, there are significant implications for engineering education at a Christian college or university. I will

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<sup>2</sup> Quoted from "Sphere Sovereignty," the speech with which Kuyper opened the Free University of Amsterdam in 1880. For a complete translation of this speech see James Bratt, *Abraham Kuyper: A Centennial Reader* (Grand Rapids, MI: Eerdmans, 1998).

now propose some concrete suggestions for your consideration, including some curricular proposals, recognizing that you may have to adapt these to your particular college situations.

- Create venues for your engineering students to struggle with the following question: What types of engineering services and products are important in light of God's redemptive purposes for creation?

I was never encouraged to deal with this question in my own engineering education. This question should be posed early and often during the student's college career.

In my idealized engineering curriculum this question would first be posed in a first year engineering seminar class, which would also include a healthy dose of dealing with worldview issues, including struggling with the prior question: What are God's redemptive purposes for creation? (Recognizing that my proposal to you is only one possible response to that prior question).

- Create venues that will enable your engineering students to take the giant step from knowledge to wisdom.

I am using the word "wisdom" here to refer to discernment as to how to use knowledge in light of God's redemptive purposes for creation.

Christian engineers must avoid like the plague the common, rampant "technological fallacy," which is the idea that if we have developed the capability for doing something new, that is sufficient reason for doing it.

For example, to have the capability to build the next generation of automobiles is not sufficient reason for doing so. The discerning Christian automotive engineer will ask the prior question: For what purpose are we building the next generation of automobiles?

The discerning Christian automotive engineer will distinguish between automobile design and production programs intended to provide more expensive toys for the rich and famous and programs intended to minimize pollution for the redemptive purpose of creating a healthier natural environment.

Although I believe the discernment that I call wisdom is better caught than taught, by exposure to mentors who exhibit such discernment, engineering students must also understand the discipline of ethics, which if properly taught, can provide students with a framework for making discerning choices.

Therefore, my idealized engineering curriculum would include a junior level course in ethics, but not the common course on ethical theories taught by your philosophy department, as good as that might be. Rather, this should be an interdisciplinary course in ethics that reflects the ABET 2000 standards. Christian engineering educators should especially embrace the "criterion 3" expectation that "Engineering programs must demonstrate that their graduates have...an understanding of professional and ethical responsibility...[and] the broad education necessary to understand the impact of engineering solutions in a global and societal context;" as well as the "criterion 4" standards that "students must be prepared for engineering practice through the curriculum culminating in a major design experience based

on knowledge and skills...that include most of the following considerations: economics; environmental; sustainability; manufacturability; ethical; health and safety; social; and political.”

These ABET criteria suggest the need for a well chosen set of regular general education courses, selected on the basis of the stated considerations that should inform the major design experience, which will lead up to my proposed junior level course in ethics. These criteria also suggest some of the interdisciplinary aspects that should be included in this required ethics course. In order to distinguish this ethics course from the usual fare, I might retitle it “Engineering Decision-Making in Societal Context.”

- Create opportunities for students to have a significant service internship (6-10 weeks during the summer between the junior and senior years) that focuses on your collective departmental understanding of God’s redemptive purposes for creation (which may differ from my understanding).

If I were developing such service internship experiences, I would focus on addressing the needs of the poorest and most marginalized peoples of the world.

This internship should be a credit-bearing experience which includes major reflective components, such as reading, writing papers and journaling, in addition to hands-on experience.

In my idealized engineering curriculum, this would be a requirement for all engineering majors, so that they get first hand exposure to pressing needs of the world prior to making career choices. A portion of my proposed junior level ethics course could be devoted to preparation for this service internship.

One of you posed the following question in a recent email message to me: “Many of our programs saw the ABET 2000 criteria as vindication of our broad, strong liberal arts approach. However, now everybody’s doing it, so how do we remain distinctive?”

The service internship proposal I just made could be distinctive if it focuses on addressing God’s redemptive purposes for the poor and marginalized of the world.

Likewise, my final proposal could be distinctive. It is patterned after the opportunity faculty in TIAA-CREF now have to direct their retirement investment into companies classified as “socially responsible.”

- Conduct a major job fair for your senior students, to which you invite companies that you judge to have a special commitment to provide engineering services and products that significantly foster the various facets of God’s redemptive purposes for creation.

You have by now detected my underlying assumption that all Christians are called to be agents for God’s redemptive purposes for creation, broadly defined. I believe that is the calling of Christian engineers.

My prayer for you as Christian engineering educators is that you will first model that calling in your own life and then create optimal educational structures that will best prepare

your engineering students for a lifetime of devotion to that high calling of being agents for God's redemptive purposes for creation.

# THE IMPACT OF WORLDVIEW ON THE ENGINEERING DESIGN PROCESS

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## INTRODUCTION

As Christians working within the discipline of engineering design we are routinely faced with questions which have answers strongly influenced by our worldview. What do I mean by *worldview*, and what are some examples of these kinds of questions?

A simplified definition of worldview is the set of presuppositions through which all of life is filtered. This worldview may be one which is held consciously or held by “default”. Whether one knows or admits it or not, each person has a worldview. It is the set of beliefs called upon when facing day-to-day questions or decisions.

The questions faced in the day-to-day life of a design engineer which must be informed by one’s worldview range from decisions about what job to accept to decisions between potential solutions to a design problem. We may choose to ignore the deeper issues behind these decisions and just “do our job”, but the renewed mind (Romans 12:1,2) requires more than this.

The design engineer is required to draw on knowledge of history, economics, creativity theory, ethics, management, and even some engineering science and engineering design. Thus, it can be an overwhelming task to find the *origins* of dominant and accepted approaches to problem solving. The engineer is often “forced” by lack of time for reflection and research to conclude that the present, dominant approach to engineering design is compatible with a Christian worldview.

A major goal of this paper is to present examples of the worldview(s) which often impact engineering design and creativity and compare and contrast these with a Christian worldview. This should provide a useful starting point for the student or professional who recognizes that there are important questions to ask, but does not know where to begin. Some of the critical questions for the engineering designer (and also for others in design-related fields) are

1. What does God call us to do in His world?
2. What overarching standards set the agenda for the helping professions?
3. What standards govern our work as engineering designers?
4. Who is the “customer” when doing design work?
5. By what yardstick do we measure success in engineering design? (What is the “best solution”?)

## DOES WORLDVIEW MATTER?

Before investing time and energy in the consideration of the questions of worldview and presuppositions, it is worth considering what difference this will or should make in my

life. Hasker, in “Faith-Learning Integration: An Overview”, presents three strategies for faith-learning integration: the compatibilist, the transformationist, and the reconstructionist strategies. The compatibilist strategy is to recognize and exhibit the compatibility which already exists, using the presuppositions of the discipline with absolute comfort. The transformationist strategy is to transform basically valid disciplinary assumptions in its weak points. The transformationist would seek to transform the discipline at some basic, although not radical, level. The reconstructionist finds the existing discipline beyond any hope of transformation, and so constructs a new “Christian” discipline. While not accepting Hasker’s description as being fully consistent with a scriptural view of post-fall man, his outline does at least provide a basis for asking critical questions about one’s discipline. If one seriously considers the motivations for actions of individuals and not only the results, then questions of worldview become some of the most important.

### **THE FIRST QUESTION – WHAT DOES GOD CALL US TO DO IN HIS WORLD?**

Ask the average first-year engineering student in any college why they are pursuing a degree in engineering and you are likely to hear at least one of the following responses.

- I was good in Math and Science, so my High School guidance counselor recommended engineering.
- Engineering salaries are good (and the more spiritual student might add, “so I can help support the work of the church.”).
- There are lots of engineering jobs available.
- I’ve always enjoyed building (taking apart) things.
- A career guidance profile showed engineering as the best fit for me.

Anyone who has served as an academic advisor has heard these answers, along with some as unsatisfying as a shrug of the shoulders, and the occasional serious, well-researched response. What is it that leads to these responses, and are they appropriate for those who are to have the mind of Christ? (I Cor. 2:16) As a starting point, let us examine some of the prevailing assumptions about the *need* for engineers and the *motivation* to work in engineering design.

To begin this discussion, an operating definition of engineering design is necessary. There are many definitions in the design literature, but for now I will list a pair of definitions which capture most elements of the process.

Engineering design is the systematic, intelligent generation and evaluation of specifications for artifacts whose form and function achieve stated objectives and satisfy specified constraints. (Dym and Levitt, as cited in Dym)

A creative act of selecting, combining, converting, constraining, modifying, manipulating and shaping ideas, scientific facts, and physical laws into a useful product or process. (Harrisberger, p. 2)

These two definitions point out the many uniquely human abilities required for engineering design. These include true creativity, intelligence, ability to communicate symbolically, concern with physical laws and science, and the production of artifacts.

The obvious, though often unstated, prevailing assumption among engineers is that engineering design is something worth doing. Otherwise we would not be involved in it or seeking to advance the state of the art.

Engineers have traditionally had a service orientation. This is evident even in the history of engineering societies. The first engineers to form professional societies were civil engineers (see Florman, p. 51), those concerned with public works for the public good. This is also reflected in the Codes of Ethics, which place public service as a higher priority than service to employer.

The satisfaction resulting from such service is not due to public recognition, but is the satisfaction of a job well done. If desiring public recognition, the engineers of this century would have become physicians or lawyers, but they chose to work on the seemingly small pieces of large projects without great public acclaim. A famous quote from Herbert Hoover illustrates this engineering view:

Engineering is a great profession. There is a fascination of watching a figment of the imagination emerge, through the aid of science, to a plan on paper. Then it moves to realization in stone or metal or energy. Then it brings jobs home to men. Then it elevates the standards of living and adds to the comfort of life. That is the engineer's high privilege.

The great liability of the engineer, compared to men of other professions, is that his works are out in the open where all can see them. His acts, step by step, are in hard substance. He cannot bury his mistakes in the grave, like the doctors. He cannot argue them into thin air or blame the judge, like the lawyers. He cannot, like the architects, cover his failures with trees and vines. He cannot, like politicians, screen his shortcomings by blaming his opponents and hope the people will forget. The engineer simply cannot deny he did it. If his works do not work, he is damned...

On the other hand, unlike the doctor, his is not a life among the weak. Unlike the soldier, destruction is not his purpose. Unlike the lawyer, quarrels are not his daily bread. To the engineer falls the job of clothing the bare bones of science with life, comfort, and hope. No doubt, as the years go by, the people forget which engineer did it, even if they ever knew. Or some politician puts his name on it. Or they credit it to some promoter who used other peoples' money. But the engineer looks back at the unending stream of good.

Engineering is thus seen as an important human function which serves our fellow man. Is this general viewpoint in accord with the teachings of the Bible? I would claim that this view of engineering service is compatible with, but inferior to, a biblically-based view.

That God intended for man to do more than just maintain a static garden is clearly seen. In Gen. 2:15 (KJV) man's pre-fall job description is given. "And the LORD God took the man, and put him into the garden of Eden to dress it and to keep it." This was not the job of keeping things just as he found them; he was to *dress* the garden. Even in the pre-fall condition, with no toiling against thorns or losing battles with Japanese beetles, man had a task of developing God's creation as a servant of God. This task continues after the fall, but now includes the ongoing battle with the effects of the fall on all creation. This battle with the effects of the fall will continue, but it is not futile.

Jeremiah 33:9-18, Zechariah 1:16,17, Isaiah 49:8, and Acts 3:21 show God's promise to "restore the fortunes of the land". Note the direct reference of Acts 3:21 to the prior promises. The promise of the King in Jeremiah 33 is being fulfilled as Christ is ascended and sitting at the right hand of God the Father (Acts 2:33). God's people are privileged participants as the blessings of the covenant overflow to the nations. The engineer, as a doer,

plays a special role in the outworking of God’ plan in history. The engineer “evokes the wisdom of God” [Gidley] as he or she works for the good of mankind. As Gidley points out, “Good engineering makes real provision against real evils, bringing by God’s common grace longer life, ease of toil, and pleasurable recreation.”

In *Philosophy, Science and the Sovereignty of God*, V. Poythress provides an introduction to philosophy of science, and constructs detailed terminology to aid in the statement of problems and provide a framework for investigation. In this effort to organize our thinking he identifies the *official* functions (having to do with *office*) of man (p. 35ff) as Prophetic, Kingly, and Priestly, and the *ordinantial* functions (having to do with the creation *ordinances* of the Sabbath, of labor, and of family) as Sabbatical, Laboratorial, and Social. He then interprets human personal functions on a matrix formed by these. This is just the beginning of his definition of structure, but this most basic element is extremely helpful in viewing our human activities. A summary form of his table of personal functions is found in Table 1, with a few examples filled in to illustrate its utility.

Table 1. Human Personal Functions (Poythress)

	Prophetic	Kingly	Priestly
Sabbatical	Pray, preach	Worship	Bless, curse
Social	Greet, tell	Serve, rule	Punish, buy
Laboratorial	Remember, think, plan	Build, weigh	Expect, appropriate

The doing of technology has mainly laboratorial and kingly/priestly aspects, but obviously there are individual engineering tasks which may cross these lines. The important point for the moment is that the doing of technology does fulfill the Christian’s duties in terms of God’s creation ordinances and in terms of office.

God calls people to be workers, as those created in His image. Humans can imitate God’s works in daily life. Sherman and Hendricks address the ideas of work and calling in *Your Work Matters to God*. On pages 81-83 they illustrate from Genesis how man was created to be a worker, and a **coworker** with God. They point out that the Bible views work as a gift.

Then I realized that it is good and proper for a man to eat and drink, and to find satisfaction in his toilsome labor under the sun during the few days of life God has given him--for this is his lot. Moreover, when God gives any man wealth and possessions, and enables him to enjoy them, to accept his lot and be happy in his work--this is a gift of God. (Ecc1 5:18-19 NIV)

The Bible also teaches us to use our gifts and abilities in service to God and our fellow man.

Jesus replied: “‘Love the Lord your God with all your heart and with all your soul and with all your mind.’ This is the first and greatest commandment. And the second is like it: ‘Love your neighbor as yourself.’ All the Law and the Prophets hang on these two commandments.” (Matt 22:37-40 NIV)

Love for my neighbor involves doing all within my power for his good. This includes the development and refining of life-improving and life-saving devices and technologies.

Our service to God involves all of life, as is shown clearly in the following passage, which is set in the context of the work and duty of slaves to masters, but certainly applies also to vocations chosen voluntarily.

Whatever you do, work at it with all your heart, as working for the Lord, not for men, since you know that you will receive an inheritance from the Lord as a reward. It is the Lord Christ you are serving. (Col 3:23-24 NIV)

We are to work at the jobs we are placed in by God as service to God.

Sherman and Hendricks provide a practical framework for the goal of work in Chapter 6 of their book. Their five main points are

1. Through work we serve people.
2. Through work we meet our own needs.
3. Through work we meet our family's needs.
4. Through work we earn money to give to others.
5. Through work we love God.

Although I would probably list these in a different order, they do address the breadth of the reasons we should work.

It is evident that engineering design is one way of serving God and fellow man in stewardship of the gifts God has given us. Thinking carefully about worldview can lead to a more satisfying career, knowing that my efforts are not futile, but are making use of the gifts God has given to all of mankind, and the special skills and abilities he has given particular individuals.

Recognition of the richness of God's definition of appropriate human work can also lead one to witness to others of God's gracious provision in this part of life. We have an opportunity to tell others the end goal of our work, even when things are not going perfectly.

### **STANDARDS FOR THE HELPING PROFESSIONS (AND ENGINEERING DESIGN IN PARTICULAR)**

The prevailing worldview (at least among engineers) and the biblical model already presented both see engineering design as a task which meets human needs, so it is appropriate to include engineering among the "helping professions". Are there standards which help set the agenda for these professions (For example, what efforts should have the highest priority), and what are these standards?

The engineering profession's most universally recognized set of standards is presented in the Engineering Code of Ethics (see Appendix for the Fundamental Canons). The Code of Ethics gives a commonly-held moral code, but is subject to revision to meet changes in the society (this is discussed at some length in the introduction to an ASME tape series on ethics intended to be presented to students). The moral code is therefore something externally imposed and not tied to any absolutes other than man's absolute right to self-determination (essentially secular humanism).

...engineering ethics is not, or should not be a medium for expressing one's personal opinions about life. Engineers do not have the responsibility, much less the right, to establish goals for society. (Florman, p. 95)

Florman's "ethics" is that which leads to care, diligence, and conscientiousness, which will, according to Florman, result in good. "Practically speaking, people who start out to do a good job and people who start out to do good often end up in the same vicinity." (p. 106)

He feels that "healthy competition" (see p. 113) coupled with political decisions carried out in a republic will lead toward good solutions. "An abstract devotion to 'the good of humanity' is no substitute for devotion to real human beings". He feels that working on a dynamic team will produce the healthy environment required to move toward a goal which will usually be honorable.

We see then a pragmatist approach to defining good and bad, right and wrong, but also a respect for the present laws of the land. Although not believing in true absolutes, his relativism is at least *temporarily* stable and founded in the opinion of the perceived majority. This leads the engineer operating in this society, with laws still somewhat connected to the intent of the founders of our country, to act in apparently "good" ways, but not necessarily out of proper motivation.

From a practical, everyday point of view, many of Florman's observations do help the engineer to maintain a proper focus. For example, Florman, p. 99, draws the parallel of judicial restraint for the practice of engineers.

It is not the engineer's job, *in his or her daily work*, to second-guess prevailing standards of safety or pollution control, nor to challenge democratically established public policy. (emphasis mine)

The practicing engineer, once satisfied that he or she is working in a reasonably well governed society, should practice within the constraints of the law. If changes must be made in the law, one should act through the proper channels, and not initiate designs which violate accepted standards as a form of protest.

Florman states clearly that he does not consider the code of ethics to be part of a worldview, but *only* a moral code. He sees this code as externally imposed rather than an internal code based on a consistent system of beliefs.

Others (Moriarty, Jones) do bring worldview issues more directly to bear on moral and ethical issues. According to Moriarty, engineering design work has content and context, and the recognition of context can help engineers fulfill their responsibilities in a balanced manner.

The economics, ethics, and politics of engineering, coupled with environmental concerns, encompassed by and understood within a philosophical and historical framework -- all this, bound up in a complex web of interactions, seems essential for a full discourse on the context of engineering design.

What Moriarty is saying is that our worldview does affect what we do and how we do it. He points out that we can often function without thinking explicitly about worldview issues, but they are still there, and must eventually be addressed. This context ties the engineer to the society he or she serves.

Jones is getting at the same sort of idea when he outlines the levels of designing (p. 31) as Community, Systems, Products, and Components.

The design engineer operates within a social context. He or she cannot radically change society, but he can challenge society, and present new ways of doing things, from

banking to telephone communications. This social context is what makes engineering challenging and also rewarding. Technology is not carried out in a vacuum, and it is not what controls or predetermines social movement, as Ellul would have us believe.

The views of Jones and Moriarty are not widely known or held, but they do provide a starting point for discussing worldview in the context of engineering design.

As we look for a biblical basis for standards, several important guiding principles are seen. The designer, whether acknowledging it or not, is responsible for his or her actions and is held accountable by God (Romans 2:15). The Creator God has established unchanging moral laws, summarized in the Ten Commandments, and summarized yet further in Matthew 22.

Jesus replied: “‘Love the Lord your God with all your heart and with all your soul and with all your mind.’ This is the first and greatest commandment. And the second is like it: ‘Love your neighbor as yourself.’ All the Law and the Prophets hang on these two commandments.” (Matt 22:37-40 NIV)

God has even given clear examples of the application of moral law to everyday situations. A good example is the positive application of the law (almost a building code) regarding safe building practices:

When you build a new house, make a parapet around your roof so that you may not bring the guilt of bloodshed on your house if someone falls from the roof. (Deut 22:8 NIV)

Other examples abound, but the basic approach is that of following God’s “Love Commands” (the ten commandments and all that flows from them).

Another important biblical principle which helps set standards for our work is that we are to work as unto the Lord (Col. 3:23). There are many aspects to this, but several points can be clearly illustrated.

One aspect is how we work. God has given each of us gifts, to be used in our calling to serve Him and our neighbor.

So we rebuilt the wall till all of it reached half its height, for the people worked with all their heart. (Neh 4:6 NIV)

God’s people are often charged to work with all their heart, or praised for doing so, or chided for sloth. The Christian engineer should use all of his or her abilities, and maintain and develop those abilities, so that he or she may serve God well.

Another part of this is working humbly, giving credit to God and fellow workers as appropriate.

The fear of the LORD teaches a man wisdom, and humility comes before honor. (Prov 15:33 NIV)

When pride comes, then comes disgrace, but with humility comes wisdom. (Prov 11:2 NIV)

Humility and the fear of the LORD bring wealth and honor and life. (Prov 22:4 NIV)

Do nothing out of selfish ambition or vain conceit, but in humility consider others better than yourselves. (Phil 2:3 NIV)

Recognize, as many of those who have been blessed by God have clearly reminded us, that the ability, the wealth, the resources, all come from God, and we are but His stewards.

A good example of a Christian who continues to work humbly, depending on God for his strength, is Wayne Alderson. In the book *Stronger Than Steel*, R.C. Sproul chronicles a portion of Alderson's life and work spent in bringing workers and management together. In all of this, Alderson did not depend on technique or publicity, but on the Lord.

As with the previous question, the generally accepted view and a Christian worldview do not lead to radically different *practical* outcomes, but the view not informed by God's word is somewhat deficient, lacking richness, clarity, and consistency. Rather than a "quasi-equilibrium" system of morals (which are currently based on Judeo-Christian standards) and an assumption that man (and evolutionary process) is basically good, the biblical worldview sees God as the source of all good and man as fallen. The potential outcomes of a worldview not informed by the Bible could be disastrous, if not moderated by God's hand.

The Christian should have a greater dedication to upholding standards, not out of self-interest, but as an act of service to God.

## CONCLUSIONS

One can extend this search for disciplinary presuppositions to many other aspects of engineering design and find that the prevailing worldview of engineering designers does not often lead to radically different engineering *practice* when compared to that resulting from a Christian worldview. This raises some important questions of its own. How is it that Christian and non-Christian engineers can agree that engineering is an important endeavor, that we do need moral standards, and why do they reach similar final designs when several presuppositions about the nature of the world and the nature of man are quite different?

Why is it that non-Christians are capable of doing "good" work?

Every good gift ..... comes down from the Father... (James 1:17)

Do you see a man skilled in his work? He will serve before kings; he will not serve before obscure men. (Proverbs 22:29 NIV)

For an act to be good in the sight of God, it must "externally conform to the demands of the law" and must proceed from correct motivations [Sproul, *Ethics*, p. 32]. Man sees only the outward, so these *outwardly* good acts are not the sole domain of the regenerate. If man is radically fallen (totally depraved) as the scriptures clearly teach, we are left with the question, Why do we see any good in human life? Berkouwer summarizes the historic answers which lead to the concept of "Common Grace" in Ch. 5 of *Man: The Image of God*. He summarizes Calvin's teaching on common grace as follows:

And therefore it was possible for Calvin also to portray corruption in radical terms. Man was indeed endowed with outstanding gifts, but these have been so corrupted by sin that "no trace of purity is left," and we must thus seek all righteousness *outside* ourselves (*Commentary* on Acts 15:9). But it does not follow from such statements (and their number could be multiplied) that Calvin fails to appreciate the gifts of God to man... There is no reason to wonder what sort of contact the godless, wholly alienated from God, have with the Spirit; for though the Spirit of sanctification dwells only in the believer, still God achieves and moves all things through the power of His Spirit, in accord with the uniqueness of each thing, given it by Him in the law of creation.(Berkouwer, p. 150)]

It is important to not confuse common grace with the concept of the image of God, which we sinners often do as we try to make it easier to look at ourselves in the mirror. Berkouwer, on pp. 127ff stresses the complete disobedience and enmity brought about by the fall, as does Rushdoony in Ch. 7 of *By What Standard?*. Van Til also points this out in *In Defense of the Faith* in the Chapter on common grace.

All men have not only the ability to know but actually know the truth. This is so even in the case of those who do not know all the truth that they would need to know in order to be saved. All men know that God exists and is their judge. Secondly, all men have become sinners through Adam's fall. All men therefore suppress the truth that they know.... Common grace is not a gift of God whereby his own challenge to repentance unto men who have sinned against him is temporarily being blurred. (p. 174)

Men know (Romans 1) yet they are not capable of doing the good on their own.

Thus, God grants common grace to restrain man in his efforts to complete the effects of the fall, and to work out His plan in history. Man, left to his own, would greatly accelerate the outworking of the effects of the fall.

Or, as North states it, in down-to-earth terms [*Dominion and Common Grace*]

“Law does not save men's souls, but partial obedience to it does save their bodies and their culture.” (p. 173)

It is important to note that these good works are possible NOT because man has some “spark of divinity” (a common misinterpretation of what the image of God is) but because of God's common grace, manifest toward sinful mankind. As North so clearly puts it “Common grace is not common ground” (p. 191).

We see then that it is not surprising that God would make it possible for engineering design to produce results which are useful to people. But we must also recognize the ultimate end of all work done out of improper motivations. Looking at Hasker's three strategies (compatibilist, transformationist, and reconstructionist), it appears that these approaches miss some important distinctions which are of practical importance. It seems that Christians must in some sense always be reconstructionists, since truly good works can only be performed out of proper motivation, and any false presupposition corrupts motivation. On the other hand, common grace tells us that humans will do useful and apparently good things, even if not properly motivated. Poythress, for example, points out that the results of “pseudo-study” may be genuine (p. 138), but the flawed approach to God's Creation is still flawed. The Christian must be prepared to put these results to use, and this use looks like that of the “compatibilist”, BUT the Christian should probably not use such terminology without great caution, since the word compatible may imply acceptance of more than we are really prepared to accept. I thus reject these classifications as not consistent with a Biblical view of post-fall man.

A better approach is presented in seed form by Brian Walsh in “Worldviews, Modernity, and the Task of Christian College Education”. He drives home the point that worldviews are *pretheoretical*, that those presuppositions are items of faith. We cannot change the dominant presuppositions in our field, but we can speak prophetically and “erect signposts”. This involves teaching students “not only...to *think* Christianly, but in dynamic relation to that thinking, to *live* Christianly.”

We are, then, interested in “transformation”, but that transformation comes about through “reconstructed” *individuals*, working in legitimate “compatible” endeavors made possible by God’s common grace. Truly Christian engineering design does exist, but is carried out in service to all men by Christian engineers involved in their society.

How, then, am I to use what I learn by studying the dominant presuppositions in my field? I see at least three important applications.

1. I can use what is learned to bring my **personal** practice of engineering design into closer conformity to God’s will.
2. I can learn by studying failures in engineering design, not only by considering the failures in process and results, but by probing the presuppositions which may have led to failures in process.
3. I can use my own considerations of worldview as opportunities for discussion with others. This can lead to improvements in my own practice of engineering and my walk with God. It can also help others to look, maybe for the first time, at their own pretheoretical assumptions.

A major goal of this study is to encourage each reader to take the time to think about his or her own presuppositions and the source of those presuppositions. By these few examples I hope to have stimulated each person to occasionally step out of the routine practice of engineering design and to consider the origins of day-to-day practice.

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## **APPENDIX**

### **FUNDAMENTAL CANONS OF ENGINEERING ETHICS**

#### **THE FUNDAMENTAL PRINCIPLES**

Engineers uphold and advance the integrity, honor and dignity of the engineering profession by:

- I. using their knowledge and skill for the enhancement of human welfare;
- II. being honest and impartial, and serving with fidelity the public, their employers and clients; and
- III. Striving to increase the competence and prestige of the engineering profession.

#### **THE FUNDAMENTAL CANONS**

1. Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties.
2. Engineers shall perform services only in the areas of their competence.
3. Engineers shall continue their professional development throughout their careers and shall provide opportunities for the professional development of those engineers under their supervision.
4. Engineers shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest.
5. Engineers shall build their professional reputation on the merit of their services and shall not compete unfairly with others.
6. Engineers shall associate only with reputable persons or organizations.
7. Engineers shall issue public statements only in an objective and truthful manner.

# **DEVELOPMENT OF A MISSION STATEMENT**

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## **PREAMBLE AND INTRODUCTION**

As the conference steering committee explored possible themes for the 1999 CEEC, we thought it desirable for participants to have opportunity to share something of their own institution's stated views on the meaning and purpose of their educational programs. It was hoped that in sharing experience from various campuses in developing their mission statements or in revising their engineering curricula on the basis of expressed statements of purpose, not only would we learn more about a process which has become increasingly important in this era of assessment-oriented accreditation, but just as importantly, we all would learn and appreciate more about each other as co-laborers in higher education dedicated to the Kingdom of Christ.

A well thought-out and carefully-crafted mission statement is critical to the successful functioning of a Christian engineering department, but only if such a statement has living biblical roots and is kept alive by conscientious effort of its members. This paper discusses the development of the Dordt College Engineering Department Mission Statement and the associated curriculum objectives which have guided our recent program revision (to be phased in with the coming freshman class.) It begins the discussion, however, by raising some matters of more general interest related to the formulation and value of mission statements.

## **MISSION STATEMENTS - PASSING FAD OR POSITIVE TREND?**

Some of us have perhaps become tired of the "fad" of making mission statements. We've seen them everywhere it seems: in business advertising and correspondence, academic brochures and annual reports, and even in our church bulletins. Perhaps you know a family that has one too. Sometimes catchy and succinct, and sometimes not, these proclamations of vision and goals can either inspire us or make us feel cynical and weary.

As stand-alone statements, many of them (especially the shorter ones) seem too broad or vague to offer clear direction in critical cases. Those of us who have been involved in writing them may have grown jaded of seemingly endless discussions to sort out the common ground and the central purpose and then to state it concisely and usefully. I recall an elder on our church council asking how the statement we were working so hard to produce was actually going to affect the way we made decisions and accomplished things in the congregation and around the neighborhood. At times like this, we may wish for a pastor, a company president, an academic dean or a department chair to simply tell us what our mission and objectives are, and then we'll get on with it and quit wasting time on the elusive goal of a concise, yet meaningful and effective mission statement with which everyone fully concurs.

Christians and their institutions might be inclined to ask "what more do we need than the 'great commission' of Matthew 28 as a mission statement?"

All authority in heaven and on earth has been given to me. Therefore go and make disciples of all nations, baptizing them in the name of the Father and the Son and the Holy Spirit, and teaching them to obey everything I have commanded you. And surely I am with you always, to the very end of the age. (Matt. 28:18-20)

Yet we realize that a school is not a church, a family, a business, or a political party, all of which are called to bow themselves to the authority of Christ and work for the coming of his Kingdom throughout the world. But we do have different roles and gifts to use in our areas of responsibility. So Matt 28 is good, but we need more specificity to define our educational task. Perhaps academics could cite Phil. 4:8, which was and still is the motto of the University of Alberta:

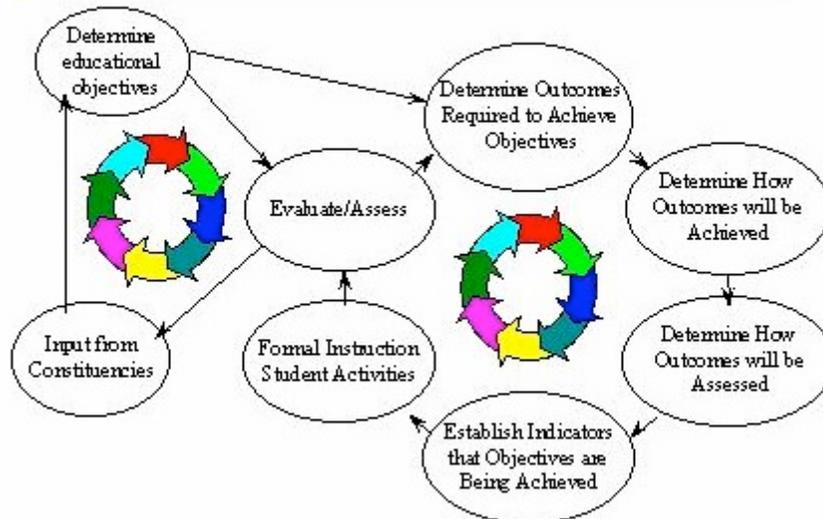
...whatever is true, whatever is noble, whatever is right, whatever is pure, whatever is lovely, whatever is admirable -if anything is excellent or praiseworthy- think about such things.

Christian educators may want include verse 9, Paul’s advice and benediction:

Whatever you have learned or received or heard from me, or seen in me- put it into practice. And the God of peace will be with you.

Here we have a statement that academics can warm up to, haven’t we? It urges both thought and action, theorizing and practice, with good curricular breadth and due respect for authority of experts, along with the assurance of divine favor as we do our work. We certainly can’t say it is too long, or staid, or boring! The whole constituency can agree on this, and who could argue that it isn’t scriptural enough?

## The Two Loops of EC2000



**Figure 1**

Ah! But here someone may nervously ask “what would ABET think?” We do need a statement that includes some more obvious reference to educational objectives that can be translated to measurable student learning outcomes. This is certainly part of the point of ABET’s “two loops’ assessment diagram, shown in Figure 1.

Thus, the faculty of an engineering department like yours may indeed desire to write an appropriately worded mission statement, but not want to be hindered by the (time consuming!) advisement of the administration, or by the critique of other departments, or of students and alumni. It also requires time and effort to arrange for input from the supporting community, perhaps represented by the board of trustees, and from the employers of graduates, possibly represented by an industrial advisory board. While it seems to me that the faculty are perhaps the ones called (by virtue of their roles as scholars and teachers) to lead this effort, they must certainly not neglect considering the larger constituency which they serve. Note again that ABET also recognizes this. In its Engineering Criteria 2000, ABET requires accredited programs to document that they provide for input from a wider variety of stakeholders, and that they act upon that input. But more on that a bit later...

### **MISSION STATEMENT FORMATS AND FUNCTIONS**

Let's step back for a moment. In itself, perceived pressure from an accrediting agency can not be sufficient reason to do something that isn't necessary or desirable for more fundamental reasons. Why should we be careful about developing and using our mission statements? It may help to review why companies make the effort to write mission statements. Corporate rationales and styles vary. Some statements appear to express particular quality or performance goals in order to impress or reassure customers. Or they may state some competitive operating strategy to direct and guide the employees and to communicate a positive corporate image to others. However, "an authentic mission isn't a bronze plaque in the office lobby," according to Allan Cox, writing about corporate mission statements in a article titled "Linking Purpose and People" in the March 1996 issue of *Training and Development*. Rather, he says, "an authentic mission statement is drafted by top management, using information from teams throughout the organization that have engaged in guided introspections in order to identify hidden, positive root values that the organization does live by." Its main message is for the people who work there daily.

Cox quotes the work of professors Collins and Porras of the Stanford Business School, who suggest that "high performing companies are distinguished by being in touch with their own authenticity - a quality one might call 'soul.'" Organizations that function well, and that are adaptable to and resilient in a changing environment, have a "soul-based mission" that highlights root values and names a shared purpose for all members of the company. These companies can then quickly determine the "core competencies" and an overall strategy.

He recommends that a mission statement "should be a brief but compelling statement of purpose, uniqueness, and method – 75 crisp words or less. And most critical is that the first sentence be short, inspiring, and memorable." Next, the statement should answer questions about how the organization understands the needs of the customer, the products and services it offers, and how it provides these to customers. Fairhurst, Jordan, and Neuwirth (1997), researchers in the area of organizational communication, seem to concur. Their article in the *Journal of Applied Communications Research* cites others who suggest that most mission statements are composed of three parts, namely purpose, principles (or values), and future path (or vision).

Others suggest that two separate statements make sense: a vision statement and a mission statement. One example of a firm with both of these is AMBAC International of Columbia, South Carolina. As reported by B.P. Sunoo in April 1996 in Personnel Journal, this company's vision statement is "Working Together, We Can Do Anything." Now this

sentence is certainly bold and succinct. What does it tell you? Perhaps, this firm has focused on its need for teamwork as the priority issue to be reminded of as it does whatever it does day in and day out.

But we don't yet know what it really does. That is revealed in its "mission statement:"

We are a full-service precision manufacturing company oriented toward the supply of fuel injection systems, equipment and peripheral devices. We will continually improve our products and services to meet our customers' needs. We will also ensure a rewarding work environment for our associates, and provide a fair return for our investors.

Here we see a mission statement that answers all of the questions posed by Mr. Cox. We now have an idea of the company's product lines, we hear about its explicit orientation to quality improvement, and we hear its stated commitment to fair rewards for the workers and the investors. However, the short, inspiring, and memorable part is the vision statement.

In the same *Personnel Journal* article, John M. Noel, president of Noel Group in Stevens Point, WI, is quoted as saying he thinks that many corporate mission statements provide little inspiration to employees. He does feel they become valuable if everyone in the company understands them or is involved in their formation. He too distinguishes between vision statements and mission statements. The vision statement is "big picture thinking with a little bit of soul," indicating the direction of the firm and giving daily inspiration. "Mission statements should articulate the principles that will guide the corporation to grow, advance and prosper." Answering questions akin to those suggested earlier, each department in the Noel Group has worked on its own mission statement (with feedback from others) to direct its relations with customers, co-workers and suppliers, and to clearly explain its products and services.

### **KEEPING MISSION STATEMENTS ALIVE**

There has been, then, much evident optimism about the role of mission statements, as expressed by industry executives such as those quoted previously. Yet, among those who research organizational development issues, there is apparently a broad sense that the development and implementation of such statements has, for the most part, failed. Fairhurst, et al. (1997) state that many researchers, including the Stanford Business professors mentioned earlier, conclude that most mission statements are boring and essentially worthless, having little or no real impact on organizational performance. While they also cite one mission statement<sup>3</sup> as exemplary, and suggest that such positive expressions can serve as a balance for other more restrictive corporate codes of ethics, they conclude that many mission statements may "lack clarity, relevance, salience, truthfulness or representativeness, inspiration and/or engagement by management" especially when they get to the "shop floor" level.

They summarize the discussion of the reasons for this ineffectiveness by offering two general conclusions about how a mission statement can become an empty set of platitudes.

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<sup>3</sup> As quoted by Fairhurst et al., "The Mission Statement of the U.S. Air Force is 'To defend the United States through control and exploitation of air and space.' Its core values are 'Integrity, excellence in all we do, and service before self.' Finally, its vision is, 'Air Force people building the world's most respected air and space force...global power and reach for America.'"

The first is that mission statements generally suffer from under-communication. They are often not incorporated into the daily, even hourly, activities of the organization. The statement thus begins to be viewed as “little more than window-dressing, not a set of useful, identity shaping ideas that members can use to weather chaos and turbulence in the environment.” Lacking frequent communication of the organizational identity with both its members and external audiences, these authors conclude, there is little opportunity to foster discussion about who and how it wants to be, and “the countervailing forces of the environment are more likely to prevail.”

Here I can not help thinking about James T. Burtchaell’s thesis in his *The Dying of the Light*, a study of the mostly sobering history of several selected faith-based colleges in America. He makes the point that the countervailing forces of the surrounding culture have indeed diluted and negatively impacted the distinctiveness and effectiveness of many educational institutions originally founded in the name of Christ, many times because the stated mission was not understood, debated, or appropriated fully by boards, administrations, faculties, students, staffs, and /or the larger supporting communities. Burtchaell is interested in the health of our common vision, I believe, and he is in that sense a prophet well worth reading.

A second conclusion Fairhurst et al. come to is that mission statements can be effective when leaders work to weave them into even the most routine aspects of the organization’s work, thereby making them personally meaningful to others. This “managing the meaning of the mission statement” is the activity by which they distinguish “leaders” from “managers” who pay most attention to how things get done. The authors then go on to an interesting discussion of the results of their own research into factors that influence some persons to actively manage the meaning of their organization’s mission statement and so become effective leaders. They end by elaborating some implications of their findings. Their most important, it seems to me, is that organizations should encourage debate among all relevant stakeholders about aspects of the mission statement and its possible future practical outworkings because this can lead to better effectiveness in the present situation. Of course, there is a risk of change in the mission, the vision, the core values, or the implementation of these within the organization. But not keeping the document and the sense of calling alive in this way often means that it gets shelved in the press of the internal and external demands of the day.

## **ROLE OF MISSION STATEMENTS IN ASSESSMENT AND ACCREDITATION**

Much of the foregoing serves as excellent rationale for all of us to enthusiastically embrace the advice of Dr. David Holger, an Associate Dean of the College of Engineering at Iowa State University and a member of its Department of Aeronautical Engineering & Engineering Mechanics. He served as a participant in a pilot visit to Georgia Tech in the fall of 1997. At the 1998 ASEE meeting in Seattle, Holger spoke about the team’s conclusions in light of ABET’s Engineering Criteria 2000 requirements. He emphasized that under EC 2000, ABET is really asking us to explain what approach we take to defining the mission, the objectives, and the outcomes of our programs. We are being asked about who is involved in this, how we execute that mission, and how we assess the outcomes and make changes to improve. He emphasized that we need to involve all of our stakeholders in significant parts of the “Two Loops” process (see Figure 1), including the formulation and/or revision of our department mission statements and the determination of curricular goals, as well as the

establishment of measurable outcomes. Institutions will need to document these interactions and the action items that result. Failure to do so will certainly be cited by ABET as a program weakness to be corrected. I think this fits with the foregoing conclusions of the management and communication theorists. He concluded by emphasizing that ABET intends to be more open to unique approaches so that institutions may have opportunity to pursue the goals important to them, but it wants proof that all appropriate constituencies have been meaningfully involved in the discussion.

So welcome (and record) the debate! Get your existing mission statements and your program's curricular objectives into the hands of as many interested parties as soon as you can, and make it easy for them to provide comment or questions as feedback. Consider the statements of your college and of other departments as context for your department's statement, and be willing to engage them in discussion of your program's objectives. The engineering education community has never been so open to letting us define our unique missions as Christ-centered engineering programs, but it insists that we don't do this in isolation from our larger context. In short, we are being encouraged now to document our efforts in sharing and developing the vision in consultation with our supporters and with those we serve most directly.

## **THE MISSION STATEMENTS OF DORDT COLLEGE AND THE ENGINEERING DEPARTMENT**

Recognizing now that we will be looking at a statement that must be constantly subject to reformation so that our department's work is effective and obedient in its calling within the kingdom of Christ, here is our mission statement:

The Dordt College Engineering Program seeks to provide serviceable insight in the field of engineering from a distinctively Christian perspective; in a manner that demonstrates the unity of creation and rejects the classic polarizations between technical and humanities, vocational and liberal arts, or natural and spiritual; while demonstrating the highest possible quality of undergraduate teaching, which we understand to be, most fundamentally, the enabling for Christian discipleship.

(Underlining for emphasis is mine, to point out our three "answers" to Cox's earlier questions.)

As we note the key components in the above statement, it will be useful to examine its context and origins within the whole college. Dordt College was founded in 1953 as the Midwest Christian Junior College with the primary purpose of addressing the critical shortage of qualified teachers for the Christian schools in the area. In 1956, the institution adopted its present name, and it offered a 2-year program until in 1965, the first 4-year BA students graduated. Rapid growth in the 60's and 70's, followed by some slight enrollment declines through the eighties and new growth in the 90's, brought many additional programs and a larger staff and student body to the campus. The college now has approximately 1450 students, about 75 faculty members and a variety of programs such as agriculture, social work, engineering, and business administration, as well as many of the usual liberal arts and science majors.

Our engineering department has about 115 majors and 4 faculty members (with some help from our two colleagues in Physics). We offer a mechanical and an electrical emphasis within a general engineering major accredited under ABET's criteria for "non-traditional"

programs. The basis and motivation for the Dordt College Engineering Program is our awareness of the calling we have as God’s covenant people, standing in the tradition of the Reformation, to bring every area of life under the lordship of Christ. As it is expressed in the college’s present statement of purpose titled *The Educational Task of Dordt College*, we are to

train Kingdom citizens [to be] aware of the demands of the cultural mandate, equipped to take their place and carry out their tasks within the community of believers, able to discern the spiritual direction of our civilization, and prepared to advance, in loving service, the claims of Christ over all areas of life.

The potential breadth of scope for the curriculum is apparently quite unlimited:

One goal of the College is to identify those occupational areas where serviceable insight is increasingly needed. In principle, no legitimate profession, occupation, vocation, or station in life can be precluded from Dordt’s educational concern. Wherever insight is required, there Dordt College is called to supply it.

### **CONTEXT OF THE COLLEGE’S STATEMENT**

A word about process and the involvement of the “stakeholders”: The college’s present statement of purpose was completed and finally adopted in 1996. *The Educational Task of Dordt College* supersedes and extends the previous *Scripturally Oriented Higher Education*, a 1968 document with a more philosophical-sounding title. Our current “mission statement” is not short, though we like to think that it still inspires! A “Purposes Committee,” composed of members of the board, the faculty, and the administration, worked together to draft the chapters of the document and to receive feedback from the college community. It includes a discussion of the biblical basis and Reformed religious commitment of the college. It explains the structure of the college as a community of office-bearers with differing responsibilities, and it outlines the nature of authority within this institution. It offers general criteria for implementing curricula and adopting new programs based on the need for “serviceable insight”, and it sets forth the college’s commitment to academic freedom within the bounds of the Word of God and obedience to Christ. (It apparently did not have as its goal a “succinct, inspiring, and memorable” leading sentence!)

The previous references to “a reformational Christian perspective” and to “standing in the tradition of the Reformation” means that every element of the Dordt College Engineering Program is (or is intended to be) rooted in a particular Christian worldview and nourished by an identifiable Christian philosophical tradition. That tradition believes the Bible to be the Word of God, and finds the writings of historic, sixteenth century Calvinism to be helpful in effectively using the “glasses” of Scripture to view God’s creation. Following a reformational “revival” during the nineteenth century in the Netherlands, that Calvinist tradition was further articulated by Christians such as Guillaume Groen van Prinsterer and Abraham Kuyper. Kuyper, a pastor who also served as the Prime Minister of the Netherlands for some time, founded the Free University in Amsterdam. Two professors there, Vollenhoven and Dooyeweerd, expressed and taught this Reformed tradition in terms of a Christian philosophical system. Working from that system, Hendrik van Riessen and Egbert Schuurman have laid the groundwork for a Christian philosophy of engineering and technology. Schuurman’s book, *Technology and the Future*, and the 1986 publication by the Calvin Center for Christian Studies, *Responsible Technology*, have been the most helpful

statements of that philosophy to date. Part of the mission of the Dordt Engineering Department is to contribute to that philosophical tradition.

Technology, and, in particular, the profession of engineering, refers to an area of life where the redemptive healing of the gospel is sorely needed. The problem of energy consumption and stewardship, cited in a number of places in *The Educational Task of Dordt College*, exemplifies the need for biblically directed serviceable insight in an area where failure of the various denominations of naturalism, humanism, and economism has already been tangibly experienced. The ubiquitous but directionless proliferation of computer technology represents another area crying out for meaning and direction. We see our task as that of training Christian engineers who can address tomorrow's technological problems and bring the healing and the claims of the Kingdom to a misdirected and suffering world.

#### **ELABORATION OF THE MISSION IN OUR CURRICULUM:**

A more specialized document, adopted by the college in 1993, *The Educational Framework of Dordt College* provides further elaboration of how we desire to organize and implement curricula in our academic programs, as well as in our co-curricular activities and campus life. In a manner consistent with a reformational Christian perspective, it offers four coordinates around which to build a coherent curriculum and to assess student outcomes. These coordinates are labeled “*religious orientation, creational structure, creational development (unfolding), and contemporary response*.” This “framework document” is an important part of how the college presently “manages the meaning of its mission.” The college has developed and used a detailed Course Goals Inventory based on these coordinates to study how its various courses and programs fit into the total mission. Table 1 shows how the department's present curricular goals ‘plot’ onto this ‘coordinate’ system. (I suspect this nomenclature may have something to do with the fact the chair of the General Education Committee is a mathematician.) These categorizations of our goals give a clearer idea of what the coordinate labels mean. The intent is that these coordinates are not separable, but all apply concurrently to our programs and courses. Courses may emphasize one or several of the coordinates more than others, and every course should be designed with this coordinate frame in mind.

Finally, the department has also developed and debated a longer list of specific curricular goals which begin to lead us to some measurable student outcomes based on the overall mission of the department and the college. (See Table 2.) In our recently adopted proposal for a curriculum revision, we suggested 18 specific changes to our existing program based on these newly reformulated general and specific goals. We had the benefit of considerable feedback from several years of graduating classes. We engaged in some intense discussions, even disagreement at times, with colleagues in other departments and with our administration, before the proposal was accepted. In the future, we do need to more actively engage employers and our graduates in similar discussions about our mission and about the details of our program, and we need to document this process more explicitly.

#### **CONCLUSION**

I believe that Dordt's mission statement is well-rooted in scripture and in a biblically based philosophical tradition, which is still vibrant in its supporting community, though subject to and tested by an influential postmodern and hedonistic culture. The mission statement is “alive” in our organization, and the challenge will be to continuously incorporate its meaning not only as we plan the broad contours of our programs, but also and especially

as we do the detailed teaching in each one of our courses. Dordt's curricular framework is one tool with which the institution seeks to "manage the meaning" of its mission statement.

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## APPENDIX

### MISSION STATEMENT

The basis and motivation for the Dordt College Engineering Program is our awareness of the calling we have as God's covenant people, standing in the tradition of the Reformation, to bring every area of life under the lordship of Christ. In particular, and as expressed in The Educational Task of Dordt College, we are to "train Kingdom citizens [to be] aware of the demands of the cultural mandate, equipped to take their place and carry out their tasks within our civilization, and prepared to advance, in loving service, the claims of Christ over all areas of life." "One goal of the College is to identify those occupational areas where serviceable insight is increasingly needed. In principle, no legitimate profession, occupation, vocation, or station in life can be precluded from Dordt's educational concern. Wherever insight is required, there Dordt College is called to supply it."

Technology, and, in particular, the profession of engineering, refers to an area of life where the redemptive healing of the gospel is sorely needed. The problem of energy consumption and stewardship, cited in a number of places in The Educational Task of Dordt College, exemplifies the need for biblically directed serviceable insight in an area where failure of the various denominations of naturalism, humanism, and economism has already been tangibly experienced. The ubiquitous but directionless proliferation of computer technology represents another area crying out for meaning and direction. We see our task as that of training Christian engineers who can address tomorrow's technological problems and bring the healing and the claims of the Kingdom to a suffering world.

"Standing in the tradition of the Reformation" means that every element of the Dordt College Engineering Program is rooted in a particular Christian worldview and nourished by an identifiable Christian philosophical tradition. That tradition believes the Bible to be the Word of God, and finds the writings of historic, sixteenth century Calvinism to be helpful in effectively using the "glasses" of Scripture to view God's creation. Following a reformational *réveil* during the nineteenth century in the Netherlands, that Calvinist tradition was further articulated by Christians such as Guillaume Groen van Prinsterer and Abraham Kuyper. Kuyper founded the Free University in Amsterdam, where two professors, Vollenhoven and Dooyeweerd further articulated the tradition in terms of a Christian philosophical system. Working from that system, Hendrik van Riessen and Egbert Schuurman have laid the groundwork for a Christian philosophy of engineering and technology. Schuurman's book, *Technology and the Future*, and the 1986 publication by the Calvin Center for Christian Studies, *Responsible Technology*, have been the most helpful statements of that philosophy to date. Part of the mission of the Dordt Engineering Department is to contribute to that philosophical tradition.

Thus the Dordt College Engineering Program seeks to provide serviceable insight in the field of engineering from a distinctively Christian perspective; in a manner that demonstrates the unity of creation and rejects the classic polarizations between technical and humanities, vocational and liberal arts, or natural and spiritual; while demonstrating the highest possible quality of undergraduate teaching, which we understand to be, most fundamentally, the enabling for Christian discipleship.

## TABLE 1. GENERAL PROGRAM GOALS

In harmony with and guided by *The Educational Task of Dordt College*, *The Educational Framework of Dordt College*, and the report, *Renewing Our Vision: A Strategic Plan for the 1990=s*, the Dordt College Engineering Program seeks to enable appropriately talented Christians to acquire the following:

### 1. Religious Orientation

a. Worldview. A sufficiently developed Christian worldview whereby students internalize the conviction that their occupation is an important element of their religion; i.e., their calling and opportunity to serve the Creator, fellow humans, and the non-human creation, empowered by the Spirit of Christ.

### 2. Creational Structure

a. Preparation for Industry. A capacity for technological problem-solving and design so that the student, upon graduation, may immediately begin work as an engineer, either in a large industrial enterprise where specialized on-the-job training is provided for new employees; or in the smallest of companies, where responsibility for design decisions is immediately given.

b. Preparation for Graduate School. A general engineering education with sufficient technical (mathematics, natural science, engineering design) understanding so that the student may continue his or her education at the graduate level.

c. Passion. Enthusiasm and intellectual excitement when contemplating the creation structure, the prospect of new technological discoveries, and the opportunities for meaningful design.

### 3. Creational Development

a. History and Philosophy. An understanding of the historical and philosophical roots and problems associated with Western science and technology.

### 4. Contemporary Response

a. Perseverance. The enthusiasm, and perseverance required to complete the full, bachelor degree, engineering program, in the face of weak high school preparation and/or cultural forces that tend to cause typical freshman engineering students to quit engineering.

b. Holism. A general, broad, and holistic education that actively thwarts the traditional technical-humanities dichotomy, meaningfully unifies all aspects of the curriculum, and starts the student on a path of life-long, self-initiated learning, whether in engineering design, the humanities, the natural sciences, or the social sciences.

c. Gospel. A sensitivity to the need for redeeming technology, i.e., bringing the redemptive healing and direction of the Gospel to this increasingly important area of modern life.

d. Distortions. A sensitivity to current problems associated with technology such as the already mentioned technical-humanities dichotomy, the enslavement of technology to economics, the dehumanization of many work environments by inappropriate technology, technophilia: the faith that technological development is always good and will solve humanity's problems, and technophobia: the fear that technology is an autonomous and evil force that will destroy humanity.

e. Normativity. A dedication to the concept of "appropriate" or "responsible" technology supported by an awareness of current environmental/ecological problems and founded on the biblical principles of Christian stewardship.

f. Justice and Mercy. An awareness of the need and possibilities for using appropriate technology to “act justly and love mercy” by helping to solve the problems of developing nations and the poor in all parts of the world.

g. Community. A vision for a community of Kingdom-committed engineers, scientists, industrialists, etc., who become a light in the world by developing normative technological models and living normative lives.

## TABLE 2. SPECIFIC CURRICULAR GOALS

The specific curricular goals enumerated below serve to facilitate the achievement of the general goals described in Table 1 above.

1. All curricular experiences ought, to at least some extent, enable the engineering student to develop his or her Christian worldview. Some specific courses ought to *focus* on worldview, particularly because of the ubiquitous belief, even among Christians, that one’s religion has little to do with one’s technical vocation or with technology in general.
2. The curriculum ought to enable the student to overview his or her academic experience, understand the relationship of its parts to the whole, and its relationship to the student’s life as a whole. To this end, experiences that provide thorough grounding in neo-Calvinist philosophy as well as critical understanding of modern philosophical trends ought to be woven throughout the curriculum.
3. The curriculum must have a strong, foundational component that enables the student to appreciate the numerical and spatial aspects of the creation and to develop the mathematical abilities needed for modern engineering design. This will include the following components:
  - a. A thorough facility with algebraic, geometric, and trigonometric manipulation.
  - b. An understanding and competence in differential and integral calculus.
  - c. The ability to solve differential equations.
  - d. A basic understanding of vector calculus.
  - e. A problem-solving facility with elementary linear algebra.
  - f. An acquaintance with probability and statistics so that the student may approach engineering design and analysis from either a deterministic or stochastic viewpoint.
  - g. The ability to use the computer as a professional tool.
  - h. Knowledge of other elements of advanced calculus (e.g., Laplace transforms, complex variables) to the extent that they are useful in particular engineering design situations that are studied (e.g., control systems, mechanism analysis).
4. The curriculum must have a strong, foundational component that enables the student to appreciate the physical aspect of the creation and to develop the natural scientific insights needed for modern engineering design. This will include a thorough, calculus based grounding in elementary physics and chemistry that includes both theoretical (classroom) and empirical (laboratory) components.
5. The curriculum ought to enable the student with the opportunity to learn about the biotic and sensitive aspects of the creation and must enable the student to appreciate the interwovenness of those aspects with others in the context of engineering design.
6. The student’s capacity for critical thinking ought to be strengthened by all the elements of the curriculum. Although logical analysis is foundational to courses in mathematics,

- natural and engineering science, and engineering design, the student ought to be provided with the opportunity to study logic in a formal sense as well.
7. The curriculum ought to enable students to develop appreciation for the aesthetic dimension of creation. Aesthetics ought to be understood as integral to the engineering design process, the student ought to develop the ability to appreciate aesthetically qualified cultural artifacts, and the student ought to have opportunity to exercise and exhibit aesthetic creativity.
  8. Enabling the student's communication abilities must be a significant part of all curricular experience. These abilities must include public speaking, listening, reading, writing, and graphical forms of communication.
  9. The student's appreciation of the social and economic aspects of creation ought to be developed. This requires that the student have opportunity to study those aspects in dedicated courses, but also that the social and economic dimensions of engineering design be stressed in appropriate engineering courses. In addition, the social dimension of the engineering profession ought to be experienced by the student. This requires that opportunities to be active in professional societies and to engage in departmental and college-wide social activities be provided. The student ought to learn to appreciate the broad, stewardship meaning of economics, and, as mentioned above in A4d, become sensitive to the distortions of economism.
  10. The curriculum ought to enable students to develop understanding of the juridical, ethical, and fiduciary aspects of the creation, in abstraction, in general, and with reference to these aspects of engineering design. In addition, students should develop a commitment to the communal task of building models of normative technology with respect to these aspect of the creation.
  11. The curriculum ought to enable students to understand the history of Western thought, and in particular, the history of science and technology. That knowledge should help students to know their places and tasks in the dynamic unfolding of creation in time, what has been called *the cultural mandate*.
  12. All engineering students ought to gain a basic understanding of engineering science. Engineering science includes the foundations of such topics as mechanics, analog and digital electronics, thermodynamics, materials engineering, linear systems, and automatic controls.
  13. All students ought to develop their talents in engineering design. This must include both classroom work and a senior design project experience. The classroom work ought to cover general engineering design principles as well as design in at least one specialized area.
  14. Students choosing the electrical engineering emphasis ought to learn sufficient electromagnetic field theory, analog and digital electronics, and power systems analysis so that they may do entry level design or graduate work in engineering. In addition they ought to have the opportunity to study one of those areas, or others, such as communications systems, at a more specialized level.
  15. Students choosing the mechanical engineering emphasis ought to develop their understanding of mechanical systems, thermal-fluid systems, and materials so that they may do entry level design or graduate work in those areas. In addition they ought to have the opportunity to study in one of those areas at a more specialized level.
  16. All students ought to have the opportunity to experience the industrial workplace firsthand during their undergraduate years. Thus a formal internship component ought to be part of the curriculum.

# CHRISTIAN PERSPECTIVES ON TECHNOLOGY THROUGH SCIENCE FICTION

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## ABSTRACT

It is important for engineering students to consider the effect technology has on society. In order to fully address such questions, engineering students need more than just technical skills. They must understand concepts relating to the fields of sociology, psychology, philosophy, and economics to name just a few. They must also be able to make appropriate value judgements, which Christian engineering students can be distinctively equipped to do. While standard engineering courses sometimes ask broader questions concerning how technology affects society, students often do not get an adequate understanding of the “big picture.” Standard courses are often purely technical in nature and do not grapple enough with difficult issues: questions of resource use, side effects, ultimate goals, and purpose.

Science fiction considers the most important questions about technology. A course based on science fiction readings and films can direct the students towards a considered approach to engineering design and development of technology. Such a course provides multiple advantages. First, it can give the students leverage on their own culture. An effective way to understand one’s own culture is to first look at a very different culture. Science fiction places the student in another world to examine important human conflicts, issues, questions, and desires. Second, science fiction provides a mental playground in which students can perform thought experiments with new technology. Third, science fiction provides a fresh look at important issues such as stewardship of creation, the cultural mandate, the relationship of capitalism and Christianity, the nature of humanity, the effects of sin, and the appropriate use of technology. Fourth, a science fiction course can allow engineering students to interact with students in less technical disciplines. This cross-fertilization is often very helpful in working through issues of technology and its interaction with the human society it is embedded in.

## INTRODUCTION

Archibald Putt has said “technology is dominated by two types of people: those who understand what they do not manage and those who manage what they do not understand.” We generally suppose engineers, as the designers of technology, understand what they create, but is this truly the case? Even when engineering students learn the technical aspects of design, it is not the whole story. Design of technology is not a simple, straightforward application of scientific principles. The engineer seeks a solution to a problem through a complex process of optimizations and trade-offs. The engineer, as the technology physician, must properly diagnose the problem and select the appropriate treatment that will cure the problem without killing the patient. An engineer that understands technology only as a narrow application of a few scientific principles will be unlikely to comprehend the broad impact technology can have on its environment. As T.S. Eliot has said in *The Rock*,

Where is the life we have lost in living?  
Where is the wisdom we have lost in knowledge?  
Where is the knowledge we have lost in information?

The responsible design and appropriate use of technology requires the designer and user of technology to understand the broad ramifications of any technology in the physical, cultural, legal, economic, historical, and spiritual domains, among others. Thus, engineering education must include not only solid technical instruction, but also broader training in these other realms. The technological solution must be understood in its broader frame of reference, i.e., it must be contextualized.

Christian engineering educators in particular recognize the need to ground their students in a broader plane of understanding. Christ's rule extends over all creation and thus demands that Christian engineers take a broad view of their vocation and of their product. While such liberal education is a laudable goal, it is often difficult to effectively convey the importance of a broad understanding of technology. Such perspectival issues can easily get short shrift by the students and even by the instructors in the press to cover all the technical material in a semester course. In this paper we will examine a number of possible curricular approaches to technology, broadly construed, and then focus on the use of science fiction to study technology issues from a Christian perspective.

### **CURRICULAR APPROACHES TO TECHNOLOGY PERSPECTIVES**

Technology perspectives can be introduced into the curriculum as part of a technical course or in separate courses. These two are not mutually exclusive – one could strategically plan exploration of technology perspectives across the curriculum within technical and non-technical courses.

Perspectival issues can be interwoven throughout a technical course, discussing the issues as they come up. This “just-in-time” curricular approach emphasizes the integrated, holistic nature of reality – one cannot neatly separate the broader issues from the detailed technical aspects. Unfortunately, this approach often shortchanges the larger issues since they are only touched on in passing. Some instructors take a slightly different route, going into more depth on technology perspectives using a more intentional, explicit treatment, often at the beginning or end of the course, or during devotions done at the beginning of class. Added depth is gained at the expense of direct integration with the technical material, and students often discount the importance of the philosophical issues as “padding” to the technical material in the course. In addition, whether the perspectives content is interwoven throughout or packed into explicit segments, only students majoring in technical areas will benefit. Developing an appropriate perspective on technology is important for non-technical majors as well, since they are users and sometimes managers of technology. Non-technical majors can also add a vital component to discussions of technology, but their input is missed when technology perspectives are discussed in purely technical courses.

There are several ways of exploring perspectives on technology within a separate course. For example, Calvin College, as part of its recent core curriculum revision, will include a Research and Information Technology course as part of its new core. This course will teach basic information technology skills, such as word processing, email, and Internet use, while at the same time helping the students develop some deeper insights into the technology that they are using. This approach is promising, but such a course runs the danger of becoming a purely skills-development course. One could also work on

perspectives on technology in integrative capstone courses, such as an engineering senior design projects course. However, capstones can be narrowly focused since they are usually intended for a specific major. A third possibility is technology from the viewpoint of a particular discipline, such as history of technology, philosophy of technology, or ethics of technology. Even here, the courses are often comprised mainly of students in one particular major.

### **A SCIENCE FICTION AND TECHNOLOGY COURSE**

A course that combines perspectives on technology with a focused study of science fiction literature offers an interesting solution to the problem of introducing students to broader issues of technology. Many students have a personal interest in science fiction and are attracted to such a course. In addition, science fiction can be studied in a variety of media (feature film, short story, novel, etc.) that makes for an exciting course.

Science fiction asks the most important questions about technology: questions that are of particular importance for a Christian. What are the benefits of a technology (real or imagined), and for whom? Is the benefit perceived or actual? What are the harms of a technology? Some very good science fiction often revolves around the unintended consequences of technology that were not foreseen by the technology creators or users – from the man who is replaced by his own machine, to the explorer who accidentally destroys an intelligent life form through carelessness. Through exploration of unintended consequences, science fiction teaches us that human problems are never purely technical and never have purely technical solutions. Engineering solutions must always take a holistic approach that incorporates all pertinent aspects of reality: economic, aesthetic, and so forth. Science fiction explores the fundamental nature of technology and its relationship to humanity – to art, culture, literature, music, economics, language, religion, science, history, and more. In works like “The Ship Who Sang” by Anne McCaffrey, films such as *Blade Runner*, and in the episode “Best of Both Worlds” from *Star Trek: The Next Generation*, science fiction asks what it means to be human. The first explores a woman whose physically frail and deformed body is augmented with technology to the point where she effectively becomes the machine she controls: a starship. The second examines a human-like robot that doesn’t know it is a machine and suffers an emotional breakdown upon learning the truth. The third looks at a man who is assimilated into a collective machine-like community of aliens, almost losing his humanity in the process.

The questions considered above are certainly among the important questions to ask concerning technology. However, does science fiction literature allow exploration of *all* the important arenas concerning technology? Isaac Asimov believes so, telling us “science fiction is that branch of literature which is concerned with the impact of scientific advance upon human beings.” Neil Postman<sup>4</sup> has proposed six essential questions that must be asked concerning technology:

- What problem does the technology represent a solution to?
- Whose problem is it?
- What problems will this technology create even as it solves a problem?
- What people or institutions will be hurt by the new technology?

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<sup>4</sup> Neil Postman, “Questioning the Media,” speech at *The January Series of Calvin College, 1998*, January 12, 1998.

- What people or institutions will profit from the new media or technology?
- What changes in language semantics will be affected by the technology?

Our earlier questions concerning harms and benefits essentially cover the first five of Postman's questions. His last question concerning language is the forté of science fiction, which treats us with strange new terms for incredible technology inventions from the author's imagination.

Science Fiction develops a considered approach to engineering design and the development of technology, exploring design from a broad perspective. It demonstrates the folly of allowing technology to develop for its own sake, in the name of "progress." Indeed, it questions whether technology actually represents progress. In works such as *Diamond Age* by Neal Stephenson, "'Repent Harlequin!' said the Ticktockman" by Harlan Ellison or in the film *THX-1138*, we see individuals subverting a culture that has succumbed to technology. Their acts of subversion put technology back in its place as a tool of humanity. Science fiction highlights the fundamental nature of humanity (created good but fallen into sin) and the reflection of that nature on the technology created by fallen man. We can see this interplay of humanity and technology influencing each other in Laura Anne Gilman's "Clean Up Your Room!" as well as in Larry Niven's "Cloak of Anarchy" where human depravity is no longer kept in check when technology fails. Lest we think that one can easily and simply discern between good and evil in technology, consider the film *Blade Runner*, where the main character, Deckard, first believes life is rather clear-cut: "replicants are like any other machine—they're either a benefit or a hazard. If they're a benefit, it's not my problem." However, as the film progresses, Deckard finds that replicants (human-like robots) cannot be neatly categorized as good or evil, human or machine. He learns that some good may be found in technology gone wrong, and that even "good" technology can have defects. Science fiction asks the engineer to count the cost of technology – its terrible demands for efficiency and profit. It asks the engineer to build a *complete* design matrix that considers *all* design alternatives and *all* the consequences of a considered solution – beyond design characteristics such as low cost or high strength, the complete design for a Christian engineer includes characteristics such as justice, stewardship, and mercy.

Investigating perspectives on technology through science fiction literature provides four distinct advantages. First, as a fish does not objectively discern the water, it can be difficult to discern characteristics of one's own culture. Thus, it is helpful to provide some "leverage" on one's culture by stepping outside it in some way. Historical or global studies can provide this service, but science fiction is particularly helpful in providing this step "outside" when thinking about technology. Science fiction transports the reader to another world, or their own future world, and there the reader can examine her own preconceptions and cultural conditioning in contrast to the perspectives of the characters in the story. Second, science fiction, in fashioning this other world, also provides a mental playground, or workshop, in which we can construct thought experiments about current or future technologies and what their effects might be. It frees the mind to conceive of possible side-effects that we might not recognize otherwise. Third, many issues that might be too sensitive to allow for unbiased consideration in their immediate social context receive a fresh look when placed in a science fiction context. Fourth, science fiction courses are multi-disciplinary in nature. Students from a wide spectrum of majors are drawn to them: from

English to Economics majors, from biologists to philosophers. Such a rich mix of interests and backgrounds provides a wonderful milieu in which to discuss technology.

## **PEDAGOGY**

Before discussing the specific pedagogical methods for the course, it is important to note that I have taught the course as part of Calvin College's January Interim term. This is a one-month intensive period during which the students take a single course for several hours each day. The interim is used for experimentation and innovative exploration of topics often outside of the student's major. This unusual feature of Calvin's academic calendar provides a perfect home for a science fiction and technology course.

Science fiction is found in a variety of media, and I have taken advantage of this variety in my course. I typically assign four science fiction novels, along with quite a few short stories from a collection. In the most recent incarnation of the course, we used Huxley's *Brave New World*, Miller's *Canticle for Leibowitz*, Lewis' *Out of the Silent Planet*, and Stephenson's *Diamond Age*. Our short story collection was a compilation with excellent commentary by Applewhite Minyard, *Decades of Science Fiction*. I also use feature-length films (such as *THX-1138*, *Contact*, and *Blade Runner*), as well as television episodes (such as from the various *Star Trek* series).

One of the most effective pedagogical tools for the course has been the jigsaw discussion method, which consists of a research phase and a learning phase. After the students have read a particular work, they are assigned to "expert" groups to work through a set of instructor-prepared questions. This is the research phase. It is preferred to have the same number of groups as there are students in each group (such as five groups of five) but this is not necessary. Each expert group works through a different set of questions. The questions can be divided among the groups by chronological section from the readings, by theme, by story element, or any other logical taxonomy. Although a few "easy" questions might be included to stoke the fire, most of the questions should be open-ended. While the expert groups research and answer the questions, the instructor moves from group to group, insuring that they give each question appropriate consideration by prodding and probing where necessary. After the groups have finished the research phase, the students are rearranged into learning groups. Each new group has one expert for each topic (one from each of the previous groups). During the learning phase, the groups allow each "expert" to teach the others what they learned about a particular topic. Students can ask questions during the learning phase, or make brief comments, although they must work more quickly since all the questions from all groups must be covered. The jigsaw method involves every student, giving each one responsibility for learning and teaching material.

Three major projects were assigned during the class. The first was a short-story writing assignment. Each student selected a common technology and then wrote an alternate-history treatment of a society in which the technology was introduced earlier than it was actually discovered, such as the gasoline-powered automobile in the early 19<sup>th</sup> century rather than the 20<sup>th</sup>. These stories were shared in small groups and the students were allowed to vote on the best stories. The second project split the class into two groups to debate the proposition: "Resolved that the federal government shall restrict the advancement of technology in the United States." The students were allowed to use any of the literature from the course as evidence during the debate. The third project split the class into several groups, each of which was assigned the task of developing a plan to preserve human culture in the

face of a worldwide disaster. Each group was asked to fill in the details of the imaginary catastrophe as well as their prescription for survival of human culture. Using a variety of pedagogical styles keeps the students interested and focused.

## **CONCLUSION**

A course combining science fiction and technology can be very effective in helping students explore the broader issues related to technology and its development. Science fiction is an exciting basis from which to launch meaningful discussions about the nature of technology, its relationship to human culture, and its appropriate use based on a Christian worldview. It provides the four advantages of cultural leverage, a mental playground for thought experiments about technology, a fresh look at tough issues, and a multidisciplinary approach. Science fiction contextualizes technology, helping students see the big picture.

# ABET 2000 – CAN ENGINEERING FACULTY TEACH ETHICS?

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## ABSTRACT

The so-called “soft 6” of the ABET 2000 Outcomes includes “an understanding of professional and ethical responsibility.” Most engineering educators are unsure how to include this element in their curriculum, and even if they do have some idea, are almost certain to not know how to assess whether or not this outcome has been achieved. Much of this uncertainty is a result of the “relative” ethics that permeates U.S. society – “We cannot know what is right and wrong.” This situation provides an opportunity for faculty in secular universities who can develop a plan for concisely presenting the elements of ethical engineering decision making to have a natural opportunity to share their Christian faith and how a Christian worldview of absolute truths can aid this decision making process. This paper provides a summary of available resources and some thoughts on what student abilities are needed to meet this outcome, available education strategies to meet the outcome, and measurement of the outcome.

## STUDENT ABILITIES TO MEET THE OUTCOME

ABET 2000 criterion 3(f) (ABET, 1998) states that “Engineering programs must demonstrate that their graduates have an understanding of professional and ethical responsibility.” It should be noted that this criterion requires only an “understanding of” as contrasted with most of the criterion that require an “ability to.” While this difference makes the criterion relatively easier to accomplish, it should still be the goal of engineering programs to seek to go beyond graduates who merely hear about engineering ethics to graduates who can function ethically. In fact, one can interpret criterion 3(h) and 4 as strongly encouraging engineering schools to provide students with structured opportunities to make ethically wise decisions.

Criterion 3(h) states – “Engineering programs must demonstrate that their graduates have the broad education necessary to understand the impact of engineering solutions in a global and *societal context*.” This criterion highlights the importance not only of right choices made by individuals in engineering practice (“microethics”), but also the importance of right choices made by societies as a whole with respect to engineering and technical projects (“macroethics”). A final reference to ethics in the ABET 2000 criteria is in criterion 4 – “... a major design *experience*... that includes most of the following considerations: economic, environmental, sustainability, manufacturability, *ethical*, health and safety, *social*, and political.” This criterion indicates the need to provide students with design experiences in which they are required to make ethical decisions that have consequences.

What exactly is the challenge that ABET has provided engineering schools in relation to the teaching of ethics? Simply stated, it is to teach students arguments and theories about what actions are right (or wrong), and which states of affairs are good (or bad) related to the professional practice of engineering. Additionally, students need to be provided with

structured opportunities to make ethical decisions related to engineering practice. A sample list of what students need to be able to do to satisfy this outcome is as follows:

- 1) ability to offer and defend a definition of engineering ethics,
- 2) ability to recall the essential elements of a professional engineering society code of conduct,
- 3) ability to list and explain multiple reasons for being ethical in the practice of engineering,
- 4) ability to identify and critically analyze common ethical dilemmas in the practice of engineering, including possible consequences,
- 5) ability to analyze ethical arguments to discover which argument one has the best reasons to believe and act upon,
- 6) ability to speak and write in a way that is logical, complete, consistent, and clear, and that can recognize potential objections to one's position,
- 7) ability to recognize the historical importance to our society of previous ethical decisions made in relation to engineering and technology,
- 8) ability to recognize actions that expose oneself to legal liability,
- 9) ability to use basic risk assessment techniques in the engineering decision-making process,
- 10) ability to recognize the regional and global consequences of engineering decisions.

This list is based on the belief that there is significant overlap in criteria 3(f), 3(h), and 4, and thus, they should be considered together.

#### **EDUCATIONAL STRATEGIES TO MEET THE OUTCOME: CURRENT STATUS OF ENGINEERING ETHICS TEACHING**

A recent survey indicates that 80% of engineering graduates attend schools that have no ethics-related course requirements (Stephan, 1998). While 16% of institutions and 7% of graduates do have one or more required courses with ethics-related content, these courses are usually not courses in engineering ethics, but rather courses in philosophy or religion that have no specific engineering ethics component.

Why do so few schools have an engineering-ethics requirement? Significant barriers include faculty indifference, student indifference, and the belief that engineering faculty are not competent to teach ethics (Herkert, 1999). Engineering faculty are most comfortable with quantitative concepts, and often do not believe they are qualified to lead class discussions on ethics. Many engineering faculty do not think that they have the time in an already overcrowded syllabus to introduce discussions on professional ethics, or the time in their own schedules to prepare the necessary material. Koehn's (1997) findings from courses at Lamar University suggest that while undergraduate students may lack motivation to study ethics, they do have an interest in the social aspects of engineering that could be used to leverage an interest in ethics.

While these are significant barriers to overcome, there are a number of factors, in addition to the ABET 2000 criteria, working in favor of the expanded teaching of ethics in an engineering context. One factor is the increasing emphasis in government and industry on environmentally sustainable development and related ethical decisions on regional and global resource allocation. As a result of significant advances in biotechnology over the past twenty years, ethical decision making related to genetic engineering has become important. A third factor is the rapid rate of change in information technology and ethical issues related to

intellectual property and the ease of transmission of undesirable content to large populations. Additionally, the high level of media attention given to cases such as the Challenger disaster, the Kansas City Hyatt-Regency Hotel walkways collapse, and the Exxon-Valdez oil spill has increased interest in engineering ethics.

These factors have led to increased government and industrial funding of engineering ethics course materials. This growth has resulted recently (1995) in the publication of the first scholarly journal in the area – Science and Engineering Ethics (Opragen Publications). Numerous engineering ethics case studies are now available as indicated in the list at the end of this article. Case studies are valuable and popular because they are widely available, pre-packaged, easily inserted into courses, and engaging for students and faculty (Pfatteicher, 1999). However, they can have the disadvantages of being hard to generalize, unusual rather than typical, and deceptively well-defined.

### **CURRICULUM MODELS TO MEET THE OUTCOME**

How can engineering ethics be incorporated into an already tight engineering curriculum? There are five basic approaches that one may take – (1) required course in engineering ethics (e.g., Texas A&M University), (2) required course that integrates engineering ethics (microethics) with the social context of engineering (macroethics) (Herkert, 1999; Soudek, 1999), (3) integration of engineering ethics across the curriculum (e.g., University of Michigan; Steneck, 1999), (4) integrated humanities and social science program that addresses all non-technical ABET 2000 outcomes (e.g., Illinois Institute of Technology) or (5) integrated engineering related community service project and lecture series (e.g., Purdue University; EPICS, 1999). Which of these approaches or combination of approaches is best for a given engineering school will depend on the unique attributes of that school. Generally, however, approaches that require coordination and cooperation between faculty within a department or between faculty from different departments will require more effort to successfully implement than an individual course. Any successful strategy needs to consider minimization of the cost in terms of faculty time and curriculum hours, instruction in a number of courses so as to prevent students from gaining the impression that ethics is a side issue that is not really important, and mentoring (role-modeling) by faculty.

Given the earlier stated higher initial interest level for societal aspects of engineering (macroethics) compared to ethical aspects (microethics) by students, the teaching of a required course for engineers that covers both areas is an important strategy to consider. Course topics should include basic concepts and methods in ethics, typical professional engineering society code of conduct, history of engineering and technology, organizational loyalty versus professional rights, engineers and the environment, risk and the engineering decision-making process, whistleblowing, and social responsibility versus legal liability.

Engineering related community service projects offer a number of advantages that make them worthy of serious consideration as a strategy to use. The Purdue University EPICS Program uses a vertical integration approach with interdisciplinary teams of students mixed with sophomores, juniors, and seniors. Advantages of the community service approach include opportunities to apply engineering ethics, improved relations between university and its local community, student experience working on an interdisciplinary team, real start-to-finish design experience, and customer awareness.

## MEASURING THE OUTCOME

Assessment of the engineering ethics criterion should be carried out using appropriately designed and tested student surveys, faculty surveys, employer surveys, and course exams (Huband, 1998). However, probably the most effective way to demonstrate most of the desired outcomes is through student portfolios that contain samples of student essays analyzing ethical issues with which a practicing engineer may be faced. These types of essays provide opportunities to demonstrate how a student applies knowledge of different ethical theories to make a decision on what the right thing to do is in a given engineering decision dilemma. Essays on ethical issues faced during internships and community service projects will also be valuable assessment instruments to include in student portfolios.

## CONCLUSIONS

The ABET 2000 criteria offer new opportunities for presenting engineering in terms of a Christian worldview on the secular campus. As more engineering schools implement curricula that address engineering ethics, it is expected that in the majority of cases the most effective model will be one in which students are required to take a course that integrates engineering ethics with the social context of engineering. A strategy that is growing in popularity and has a number of benefits is engineering community service projects.

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# **A NEW BSE UNDER THE NEW ABET CRITERIA AT GEORGE FOX UNIVERSITY**

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## **ABSTRACT**

For more than a decade George Fox University has offered a dual degree, 3/2 engineering program. The Math, Computer Science, and Engineering Department is currently in the proposal process for a full engineering major to be in-house with electrical and mechanical concentrations, culminating in a BS in Engineering (BSE) degree from George Fox. The purpose of this paper is to present the objectives and curriculum of the new BSE designed to meet the ABET Criteria 2000 in light of the necessary balance of the liberal arts, Christian faith, and technical experiences of the engineering student at a Christian university. We have the advantage in meeting the new Criteria of a starting-from-scratch approach, but are equally disadvantaged in that no precedents have yet been set. Comparative studies of the 21 BSE programs and of the engineering programs of Christian schools currently accredited by ABET are included. The goal of this paper will be to stimulate discussion among those interested in these topics.

## **INTRODUCTION**

In May of 1998 the Math, Computer Science, and Engineering Department began the formal process of proposing that an engineering major be offered by George Fox University (GFU). The program would build on the dual degree program currently in place for more than a decade. The four-year degree offered by GFU would be a Bachelor of Science in Engineering (BSE), with two concentrations: electrical and mechanical engineering. With the desire to offer a top-notch program, the department indicated it would seek national accreditation by the Accreditation Board of Engineering and Technology (ABET). As of this writing, the proposal process is almost complete, awaiting final approval by the Board of the University.

This paper is a presentation of the engineering program developed for GFU. The primary focus is on the curriculum, especially in light of the fact that the program will be examined for accreditation under the new ABET criteria, namely Engineering Criteria 2000 (EC2000). The general, ABET accredited BSE degree is currently offered by 21 other US schools in the United States, seven of which are members of the Council of Christian Colleges and Universities (CCCU). In developing the BSE, a comparative study was done between a selected number of these schools, and the data are presented herein.

First a brief overview of the current dual degree program is discussed, since it is acting as the backbone of the new major. Then the features and curriculum of the proposed BSE are presented, including comparisons between other engineering programs. Finally the EC2000 criteria pertinent to the complete curriculum are discussed.

## **BUILDING ON THE 3/2**

Students pursuing a dual degree in engineering spend three years at George Fox, completing their core engineering courses and most of their general education requirements,

and then spend two more years at the cooperating university, taking mostly the upper division engineering courses in their particular area of interest. Thus the “3/2” program brings them two degrees, a BS in Applied Science (BSAS) from GFU, and a BSx $E$  degree from the other school, where  $x$  would be  $E$  for Electrical,  $M$  for Mechanical, etc. Credit hours are transferred between the two schools to achieve the two degrees, as shown in Fig. 1 below.

One of the motivating factors in pursuing the full engineering major for GFU is that many students regret leaving after only three years. In that time, students generally love GFU and do not really want to get on to another school—they have established friendships, community, athletic commitments, etc. From a recruiting point of view, the Admissions office finds the BSE very attractive, in that it is a much “cleaner” program to explain to prospective students, as evidenced by Fig. 1.

Along with numerous other rationale for the new major, one of the challenges was to discover how it would fit into the broader mission of the University. The BSAS of the 3/2 program is not nearly as extensive and rigorous as an engineering major would be, and it could not be assumed that the presence of the former justified the inclusion of the latter, especially since GFU is primarily seen as a liberal arts school. However, one does not have to look far to see the inclusiveness of Christian higher education. The GFU Mission Statement is as follows:

To demonstrate the meaning of Jesus Christ by offering a caring educational community in which each individual may achieve the highest intellectual and personal growth, and by *participating responsibly in our world’s concerns*.

Given the predominance of technology in today’s world and the many problems its advantages bring us (need I say—Y2K?), the emphasized phrase in the above statement reveals that the possibility exists for including the proposed engineering major at GFU, as evidenced by its recent approval by the faculty. The issue was stated this way in Rationale #5 of the proposal:

Although the highly technical field of engineering is often perceived as being value/issue neutral, it is far from it, given the impact technology has on our daily lives—socially, politically, economically, culturally, and spiritually. The BSE would provide GFU the opportunity to apply its integration of faith and learning to the fields of electrical and mechanical engineering, thereby *participating responsibly in our world’s concerns* through these disciplines.

And may it be done with God’s guidance!

### **THE NEW BSE**

The diagram of Fig. 2 is indicative of the many loops that are part of designing an engineering program—certainly more than the Two Loops of EC2000. Under the influence of the University mission, the primary curriculum requirements to be balanced were the engineering science and design, the liberal arts or humanities, and the math and natural sciences. Numerous other issues exist, of course, and a few are included in the diagram. In general, once the math and natural science requirements were established, the primary balancing act was between the engineering and liberal arts courses along with the total degree hours, which went beyond the 126 semester hours required by GFU for all other undergraduate degrees. Detailed results are presented in what follows.

First, the basic features of the proposed BSE at GFU are as follows:

- A general engineering major, with electrical and mechanical concentrations.
- Mostly a traditional engineering curriculum, with some novel courses offered using a top-down approach.
- Collaboration between the engineering students and other departments, such as computer science, biology, chemistry, and business, on the course related engineering design projects.
- Senior design sequence to have close ties with industry.
- Potential for mission/serve engineering projects (e.g. the Burkina Faso Solar Project at Messiah College for which engineering students designed and installed solar electric power and water pumping systems for a medical clinic in the isolated rural village of Mahadaga, Burkina Faso in West Africa.)
- The dual degree program to stay intact.

A few comments on these features: An example of a course that could be taught with a top-down approach is Microwaves and RF—start with the big picture of a device, say a cellular phone, and introduce the concepts needed for analysis and design as the semester goes on, i.e. with a just-in-time methodology. This helps the students to break out of the otherwise linear, chronological methodologies of engineering coursework. What I personally get most excited about from this list is the opportunity for mission/serve engineering projects—to see engineering students finding practical solutions to those in need, giving them an excellent experience outside of academe in step with the mission of the University.

The additions and changes to the curriculum of the current program are indicated in Table 1 below. Four current engineering courses are modified and twenty-one new engineering courses are added to fill out the junior and senior year. Two new full-time engineering faculty will be hired—one mechanical, one electrical—and one new full-time physics faculty. Three additional faculty offices and three additional lab spaces will be required, as well as the necessary equipment. The proposed four-year phase-in is shown in the chart below.

The curriculum was designed with ABET’s minimum requirements in mind: one year of math and natural science, one and a half years of engineering science. However, the “old” criteria were also considered since the three hundred some ABET accredited programs will not suddenly change come the year 2000; see Table 2 for the curriculum listed by these subject areas.

The flexibility of the new criteria is certainly attractive to Christian institutions that typically require a larger general education component given the addition of bible and religion courses. The general education requirements of the BSAS were modified slightly and increased by four hours for the proposed BSE (refer to Table 3). The total hours are 54, compared to 57 hours typically required for other degrees at GFU. To give a somewhat objective perspective, a comparison of general education credit hours (excluding the math and natural science) with other engineering programs within the CCCU is given in Table 4. Some liberty was taken in calculating the hours for each category given the wide variety of definitions across the board. The credit hours required by GFU are similar to the other schools, with the exception of Messiah College, and the percentage of the total curriculum would be higher than most given a lower total hour requirement.

1st	❖ Two current engineering courses are modified to offer the freshman sequence Egr Principles I & II.
2nd	❖ One new course is added, two current courses are modified to offer both freshman and sophomore courses. ❖ Begin offering all core engineering courses on yearly basis. ❖ Begin purchase of electronics lab equipment.
3rd	❖ Two new engineering faculty are on board. ❖ Ten new courses are added to complete the junior year. ❖ Purchase remainder of electronics equipment. Begin purchase of mechanics lab equipment.
4th	❖ One new physics faculty is on board to take over all general physics courses. ❖ The remaining ten new courses are added to fill out the senior year.

The engineering major is listed in Table 5. All students take the core courses in the first two years, with the exception of Robotics Control Systems, taken the end of the junior year. Then the electrical and mechanical concentrations begin the junior year. Staying with our current tradition in the 3/2 program, one or two course related design projects will be assigned per semester starting the freshman year, in addition to the senior design sequence. For ongoing curriculum development, an Industrial Advisory Committee will be established for direct input from the marketplace.

Table 6 provides another comparison with other programs; the engineering, math, and natural science requirements of the BSE are compared to those of the other seven CCCU schools that offer a BSE. Two schools require significantly more math and natural science courses, and one requires significantly more engineering courses. Otherwise GFU and the other schools show very similar numbers; the differences are mostly due to GFU having the smallest number of total degree hours required out of the eight schools.

The total hours for the proposed BSE come to 129, compared to the 126 hours required by GFU for other bachelor's degrees. This, in addition to the discrepancy in the general education requirements, is due to the large number of required engineering (61 hours) and math and natural science (32 hours) courses. The math and natural science alone almost constitute another major (in fact, students in our current program can obtain a math minor for the 19 hours of math courses they're required to take). This led to the collection of data shown in Table 7. As expected, most engineering degrees require significantly more credit hours to complete than degrees for other majors. However, some schools have already been moving in the direction of downsizing their curriculum well below 130 hours while staying within the ABET guidelines. This is not as simple for a Christian, liberal arts school, which, while maintaining at least the same humanities requirements of the state schools, also requires eight to ten hours of bible and religion, central to our ethos. Thus, our program could be compared to, say, that of Washington University which requires 120 degree hours of its students. At this time, we are satisfied with the 129 hours (though there has been discussion of adding another two-hour course to the requirements, History and Philosophy of Science).

## THE NEW ABET CRITERIA

We have had the advantage in designing this program virtually from scratch, with no major curricular modifications or changes in mindset with regard to the ABET criteria. Coincidentally we are equally disadvantaged in that no precedents have yet been set for a new program to come completely under EC2000 for its initial accreditation. Be that as it may, we proceed with trust in God for what He has guided us to pursue.

The primary change that has been emphasized in EC2000 is the requirement of a more rigorous *assessment* process of the program outcomes—the second of the Two Loops of EC2000. We are not yet on that loop, but I include the Criterion #3 here to indicate that the proposed BSE certainly covers the requirements, albeit in theory:

### *Program Outcomes and Assessment*

Engineering programs must demonstrate that their graduates have:

- a) an ability to apply knowledge of mathematics, science, and engineering
- b) an ability to design and conduct experiments, as well as to analyze and interpret data
- c) an ability to design a system, component, or process to meet desired needs
- d) an ability to function on multi-disciplinary teams
- e) an ability to identify, formulate, and solve engineering problems
- f) an understanding of professional and ethical responsibility
- g) an ability to communicate effectively
- h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
- i) a recognition of the need for, and an ability to engage in life-long learning
- j) a knowledge of contemporary issues
- k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

These criteria are not necessarily all new to ABET, since the conventional criteria contain most of these components implicitly if not also explicitly. What I find uniquely interesting in this list are items *d, f-j*, the so-called Soft Six, that they comprise more than half the list. These components are not only inherent in curricula of liberal arts institutions, but Christian schools as well have much to contribute, especially in offering a Christian worldview on items *f, h*, and *j*.

As with any design, this process of curriculum development is certainly open-ended. Before we begin the program a year from now, much tweaking will likely occur. But by building on the 3/2 program and with the expertise of our two engineering faculty, we feel we have a solid, professional engineering program which will meet the new ABET criteria. And we look forward to servicing students and teaching them to participate responsibly in our world's concerns. May God receive the glory of our efforts.

## Engineering Science & Design

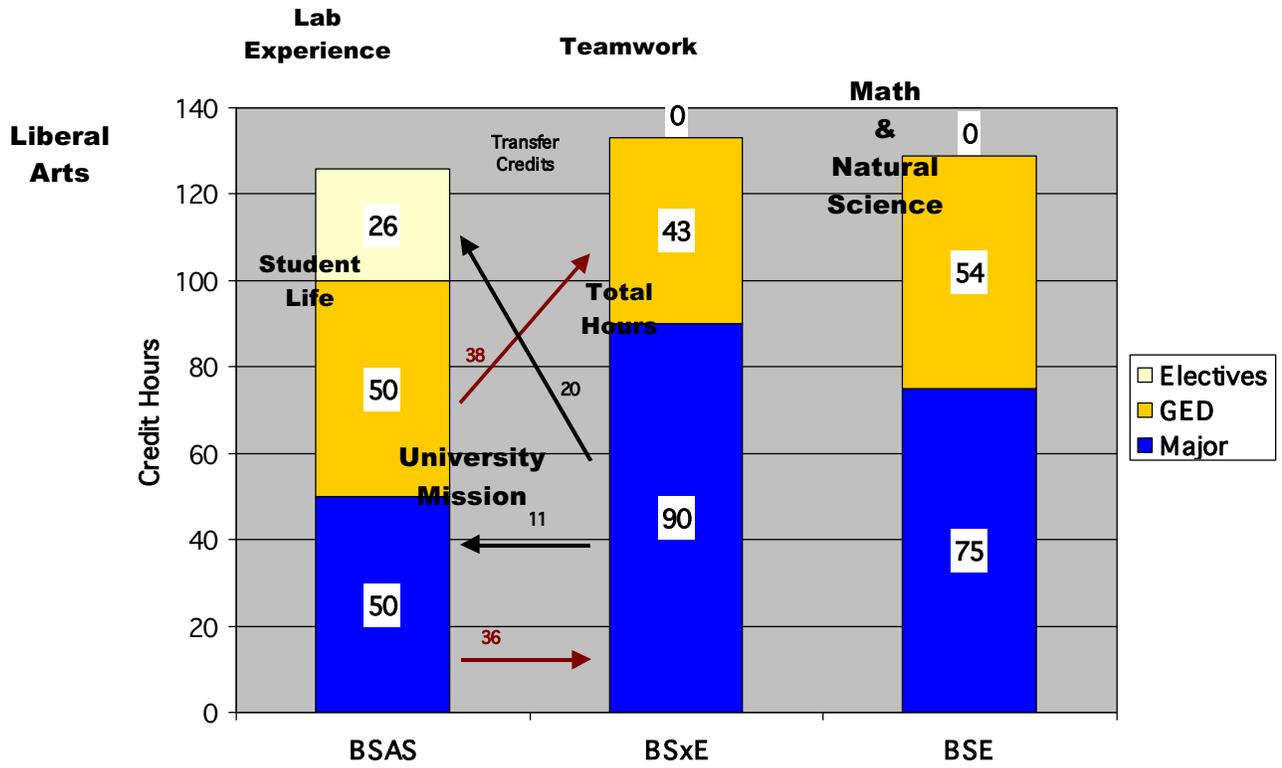


Fig. 1. Credit hour comparison of the dual degree program and the proposed BSE.

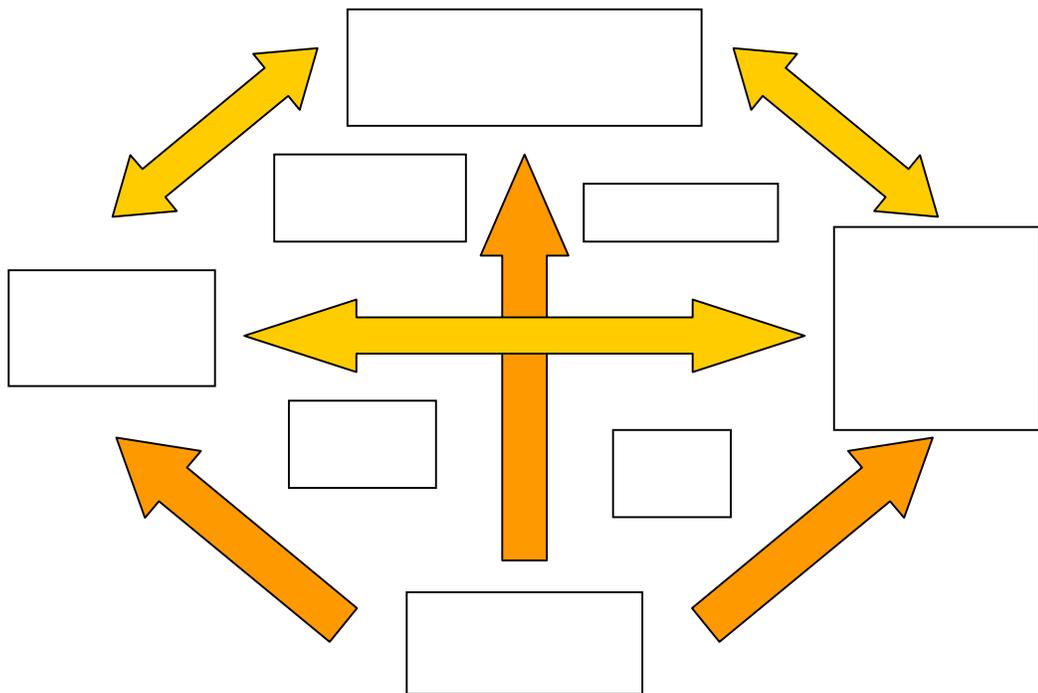


Fig. 2. The  $N$  loops of Engineering program design.

**Table 1. Credit hour comparison of the BS in Applied Science and the proposed BS in Engineering.**

	<b>BS Applied Science</b>	<b>BS Engineering</b>
<b>GENERAL ED</b>		
Bible & Religion	6	8
Communication	6	6
HHP	2	2
Humanities	11	11
Sciences	22	24
Globalization	3	3
	<b>50</b>	<b>54</b>
<b>MAJOR</b>		
Math	9	6
Physics	8	8
Engineering Core	15	27
EE/ME Concentrations	7	34
Transfer (engineering)	11	0
	<b>50</b>	<b>75</b>
<b>ELECTIVES</b>		
Free	6	0
Transfer (engineering)	20	0
	<b>26</b>	<b>0</b>
<b>Totals:</b>	<b>126</b>	<b>129</b>

**Table 2. The proposed BSE listed by “old” ABET subject areas.**

<b>Engineering Science –</b>	<b>55</b>
Core	21
EE/ME Concentration	34
<b>Math &amp; Natural Science –</b>	<b>32</b>
<b>Humanities &amp; Social Science –</b>	<b>28</b>
<b>English Proficiency –</b>	<b>6</b>
<b>Computer Based Experience –</b>	<b>4</b>
<b>Other Requirements –</b>	<b>4</b>
<b>Total:</b>	<b>129</b>

**Table 3. Comparison of the general education requirements for the BS in Applied Science and the proposed BS in Engineering.**

	BS Applied Science	BS Engineering
<b>GENERAL ED</b>		
Bible & Religion	6	8
Fr Composition	3	3
Intro to Communication	3	3
HHP	2	2
Fine Arts	2	2
History	3	3
Literature	3	3
Ethics	3	3
Calculus I, II, & III	11	11
Gen Chemistry	8	4
Nat Sci Elective	0	3
Psych or Sociology	3	3
Economics	0	3
Globalization	3	3
<b>Totals:</b>	<b>50</b>	<b>54</b>

**Table 4. Comparison of non-math/natural science GED requirements for selected CCCU schools with engineering programs.**

	GFU (BSE)	Calvin (BSE)	Dordt (BSE)	LeTourneau (BSE)	Messiah (BSE)	SPU (BSEE)
Bible/Religion/Philosophy	11	12	12	12	12	10
Communications	6	6	6	6	6	2
Health	2	3	3	4	3	2
Arts	2	3	3	3	3	6
Literature	3	6	3	3	3	7
Social Science/History	9	6	9	6	6	10
Globalization	3	0	0	0	6	0
Language	0	0	3	0	6	0
<b>Totals:</b>	<b>36</b>	<b>36</b>	<b>39</b>	<b>34</b>	<b>45</b>	<b>37</b>
<b>Total degree hrs:</b>	<b>129</b>	<b>136</b>	<b>140</b>	<b>139</b>	<b>134</b>	<b>136</b>

**Table 5. The Engineering Major.**

<b>Math &amp; Physics –</b>		<b>14</b>
Differential Eq	3	
Math Elective	3	
Physics I & II (Calc)	8	
<b>Engineering –</b>		<b>61</b>
Core:		
Egr Principles I & II	6	
Statics & Dynamics	4	
Digital Logic Design	4	
Materials Science	3	
Thermodynamics I	3	
Circuits I	4	
Robotics Control Systems	3	
	27	
EE Concentration:		
Circuits II	3	
Electronics I & II	7	
Electromagnetics	3	
Signals & Systems	3	
Microprocessors	4	
Senior Design I & II	5	
<i>3 of the following 4:</i>		
Integrated Circuit Design (3)		
Microwaves & RF (3)		
Communications (3)		
Power Systems (3)	9	
	34	
ME Concentration:		
Strength of Materials	3	
Thermodynamics II	3	
Fluids	3	
K & D of Mechanisms	3	
Machine Design	4	
Heat Transfer	4	
Senior Design I & II	5	
<i>3 of the following 4:</i>		
Fuels & Combustion (3)		
Acoustics/Noise Control (3)		
Materials Proc. & Man. (3)		
Vibrations of Machinery (3)	9	
	34	
<b>Total:</b>		<b>75</b>

**Table 6. Comparison of Engineering, Math, and Natural Science requirements for CCCU schools with BSE programs.**

	ABET*	GFU	Calvin	Dordt	Geneva	John Brown	LeTourneau	Messiah	Oral Roberts
<b>Engineering</b>	<b>48</b>	<b>61</b>	<b>63</b>	<b>65</b>	<b>60</b>	<b>71</b>	<b>67</b>	<b>59</b>	<b>63</b>
<i>Core**</i>		27	25	29	23	47	44	32	19
<i>Concentration***</i>		34	38	36	37	24	23	27	44
<b>Math &amp; Nat. Sci.</b>	<b>32</b>	<b>32</b>	<b>34</b>	<b>33</b>	<b>38</b>	<b>30</b>	<b>38</b>	<b>30</b>	<b>30</b>
<i>Math</i>		17	19	17	19	18	20	18	18
<i>Natural Science</i>		15	15	16	19	12	18	12	12
<b>Totals:</b>	<b>80</b>	<b>93</b>	<b>97</b>	<b>98</b>	<b>98</b>	<b>101</b>	<b>105</b>	<b>89</b>	<b>93</b>
<b>Total degree hrs:</b>	X	<b>129</b>	<b>136</b>	<b>140</b>	<b>137</b>	<b>136</b>	<b>139</b>	<b>134</b>	<b>136</b>

\*For 16 hr semesters

\*\*Includes computer programming

\*\*\*Includes Senior Design

**Table 7. Total credit hour comparison of BS degrees in engineering and degrees of other majors for selected schools.**

	Engineering Majors	Other Majors
<b>BSE Schools</b>		
Baylor Univ.	141	124
Calvin College*	136	124
Dordt College*	140	122
Geneva College*	137	136
Grand Valley State Univ.	138	124
John Brown Univ.*	136	124
LeTourneau Univ.*	139	126
Messiah College*	134	126
Oral Roberts Univ.*	137	128
<b>BSxE Schools</b>		
Cedarville College*	146	130
Colorado State Univ.	129	128
Michigan Tech	131	124
Oregon State Univ.	128	120
Portland State Univ.	132	120
Seattle Pacific Univ.*	136	120
U. of Michigan	128	128
U. of Portland	136	120
U. of Washington	120	120
Wash. Univ., St. Louis	120	120

\*CCCU member

# STRATEGIES AND RESOURCES FOR TEACHING THE HISTORY OF TECHNOLOGY AND ITS SOCIAL IMPACT<sup>5</sup>

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## ABSTRACT

Courses dealing with the history of technology and its social impact are offered at many colleges and universities in various forms and, often, by engineering departments. Developing and teaching these courses can be enhanced by wise use of video and print resources. This paper explores many of these materials, emphasizing those that are useful to the professor in the classroom, and suggests a general strategy for teaching that emphasizes technological innovations and their social consequences.

## INTRODUCTION

This paper updates an earlier work presented at the 1997 IEEE-ASEE Frontiers in Education conference in Pittsburgh [1]. The opportunity for this new presentation made it possible to expand the previous paper by mentioning some video resources that have been introduced in the intervening years and by including an increased coverage of print resources. The materials described in this paper should be useful in classroom instruction. Moreover, the discussion below of these video and print resources follows the general outline of each course and shows the emphasis of both courses to be the study of technological innovation and its social consequences.

Excellent video materials and print resources are available to serve almost any aspect of courses on the history of technology and its social impact. These courses support personal and professional enrichment and help lead us toward pursuit of human conduct that respects the environment and promotes the dignity of human beings. Education in the history of technology and its social impact helps students to understand things from a broader perspective and serves as a gateway to the reality of life and work that students and faculty face. At North Dakota State University we have two such courses: Impact of Technology on Society I and II [1]-[2]. Students call the first "Impact I" and the second "Impact II."

Impact I deals with the history of technology going back to the age of primitive agriculture and the Neolithic Revolution, but focuses primarily on the last 250 years of technological change in Europe and North America [3]-[5]. Impact II considers problems that have been created as the human race has become more technologically dependent [4],[6]-[7]. The videos used in these courses put flesh on what otherwise might be

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considered by some to be very dry subjects. Several helpful print resources are mentioned later in the paper.

## TEACHING THE HISTORY OF TECHNOLOGY

Impact I starts at about the time of the American Revolution but brings in relevant material from other epochs and events, such as the Neolithic Revolution, the Industrial Revolution, the French Revolution, and the often ignored revolution in the cultures of the Native American. A good starting point is in the series *Alastair Cooke's America*. It offers several episodes useful to the study of the history of technology and its impact on society since this is one of Cooke's principal concerns. *Inventing a Nation* sets the stage for the early development of the United States, and, as it does this, it shines some light on the impact of technology in the early years of the nation as we view the achievements of Benjamin Franklin, Thomas Jefferson, and, what Cooke refers to as, "the rude men of the back country." These latter individuals established a European agricultural pattern and industrial base in the United States. *Alastair Cooke's America* and other video resources discussed in this paper are available in many public libraries. Sources for other materials presented in this paper are suggested in the body of the paper or in the references [8]-[24]. The European impact on Native Americans is the frequent topic of many parts of Ken Burns' *The West*, Time Warner's *500 Nations*, and KTCA's *Dakota Exile* (PBS affiliate in St. Paul, MN). A short National Park Service video produced in North Dakota called *Maxidiwiac* dramatizes a nineteenth century oral history from the Three Affiliated Tribes (Mandan, Hidatsa, and Arikara) in North Dakota.

From here the course explores early human history with some documentaries on the transition from hunter-gatherer to domestic agriculture and the consequences of this change. The first two episodes in the *Ascent of Man* (AOM) series by Jacob Bronowski could be very useful to some especially since they are widely available in public libraries. A newer work is available as the first episode in the *Race to Save the Planet* (RTSTP) series. Its title, *The Environmental Revolution*, suggests only one aspect of its content. Similar material is available in early episodes of *The Birth of Europe*. Even students from rural areas often have little understanding of human dependence on crop agriculture. In the early United States, Native Americans and American immigrants were confronted with the changes being imposed by technological farming and the Industrial Revolution. Bronowski's *Drive for Power* (DP) gives the European background to the Industrial Revolution. Cooke's *Domesticating a Wilderness* shows how technological farming and the Industrial Revolution began to change America. Bronowski describes the impact of the clock, the steam engine, the railroad, mining, iron products for the home, and iron bridges. Cooke tells the story of immigrants in the United States, the building of the transcontinental railroad, and the development of agriculture in the U.S. He also shares with us the tragedy of Wounded Knee and the decline of Native American independence. Starting a few centuries earlier is the history of the clock told from a different perspective in *The Secret Life of Machines* (TSLM) episode called *The Quartz Watch*. The clock is a source of social revolution as it divides up a life span into a series of ticks, serves as a model for the development of automation, and takes up the position of a life director. This is nicely portrayed by Bronowski in DP and by Tim Hunkin in the TSLM episode. TSLM episodes can be used with college or university students if they are interspersed with more formal films. They are entertaining while being informative and present significant historical and social impact material.

Moving toward the twentieth century, we view Cooke's *Money on the Land*. This tells the story of the age of the great individual inventors and business tycoons that dominated the changes experienced in the U.S. as the turn of the century approached. Thomas Edison's revolving cylinder phonograph is demonstrated. The exploits of the great industrial entrepreneurs such as Rockefeller, Carnegie, and Vanderbilt are brought to life. But as the nineteenth century drew to a close, most Americans were not stakeholders, in the modern sense, in the new technologies, but had become dependent on factories, transportation, and commerce for livelihood or survival.

At this point in Impact I, we follow Edison's life and career using *Edison's Miracle of Light*, a film in *The American Experience* series. Edison's invention of sound recording was one of the greatest inventions in the history of the world. He also made major contributions to the entire electric power industry. We get a glimpse of the early history of the General Electric Company and of Westinghouse and learn that the great inventor even had a personal life. Some films on related inventions such as the sewing machine, the refrigerator, the telephone, and, later, the photocopier are available in TSLM. More formal presentations are available in various *American Experience* and *Ken Burns' America* videos.

One limitation of commonly available video materials about the history of technology is the absence of studies of women's contributions. Cooke in *Domesticating the Wilderness* does suggest that women were the reservoir of the nation's education, art, and culture in most of the U.S. in the nineteenth century, and Bronowski admits that iron products for the home that can be credited to the Industrial Revolution made a significant contribution to women's health. Spiro Kostof's *America by Design* video series has one of its five episodes devoted to *The House*. The point of view adopted here is that people like Catherine Beecher as well as the architects and engineers of the day helped liberate women by making their lives easier through improved design of living space and through laborsaving inventions. Bill Moyers in *America on the Road*, one of the studies in his *A Walk Through the Twentieth Century* (WTTC) series, claims that the popularization of the automobile increased a woman's freedom, laying the groundwork for the day when she would be out of the home as much as a man. A strong statement on the distinctive contributions of women in science was made by Dr. Karen Lebacqz in a presentation to the 1993 Summer Theology Conference at Concordia College, Moorhead, Minnesota that is available on videotape (*Science, Gender & Technology*). Lebacqz's work can be supplemented by the well-known study on women in science that appeared in the April 16, 1993 issue of *Science*. Video resources can be supplemented with a growing body of women's literature such as Golden and Friedman's *Remarkable Women of the Twentieth Century* [8].

The first decade of this twentieth century brings us to the "Age of Teddy Roosevelt." Taylorism and the assembly line are becoming significant. Spiro Kostof provides *The Workplace* to show the changes in work as a human cultural activity from colonial times all the way to the influence of Taylorism in today's office. Moreover, Kostof looks at how the slave economy had an impact on architecture, how the company-town concept failed, and how women, immigrants, and children were fitted into the assembly line.

"Teddy Roosevelt" can serve the student to see that: (1) technology now was the driving force behind the American military (witness his Great White Navy), (2) there is a beginning of an awakened consciousness of the importance of wildlife and natural resources (TR's dramatic expansion of protected public lands and the safeguarding of the Grand

Canyon), and (3) social revolution is becoming a major component in American politics (Roosevelt's Square Deal). All this we can see in episodes 3 and 4 of the Teddy Roosevelt series (*TR, The Story of Theodore Roosevelt*) in *The American Experience*. Episode 3 is devoted to TR's presidency and serves Impact I nicely. Episode 4 serves Impact II, especially as we view TR's "big game" interests as out of place for the generation entering the twenty-first century. The A&E film on the *Panama Canal* in the *Modern Marvels* series is appropriate for Impact II as an example of a project that was a great achievement early in the twentieth century, but which, due to its environmental impact, would be nearly impossible today. Kostof's film *The Shape of the Land* and Edmund Bacon's *The American Urban Experience* are appropriate at this point in Impact I since they show the different ways Americans have viewed land and the concept of space from colonial times to the present. Roosevelt's commitment to preservation of national antiquities is a significant point shared by Kostof.

In 1849 Commodore Perry forced an American presence on Japan and planted the seeds of a technological revolution in that country. By TR's time, through the Meiji Revolution, Japan was becoming a world power and a competitor of the U.S. To understand this and the eventual atomic bombing of Japan in 1945, it is essential to study this period in Japanese history. *The Meiji Revolution* in *The Pacific Century* (TPC) series (TR named the twentieth century the Pacific Century) is an efficient way of giving students this understanding. In the Pacific Century, war will be intensely technological. During the Meiji period, due to increased contacts with the rest of the world, the seeds of democracy and social justice are sown in Japan. However, the new leaders of Japan appropriate for themselves the imperialist ambitions of the Western powers.

As the Meiji Revolution occurs in Japan, inventors, engineers, and scientists in the West are busy putting their products in the marketplace. A wealth of video material is available in this area. A&E's *Subway* demonstrates the importance of the development of public transportation in human life. Also from A&E, *Wilbur & Orville* shows the Wright brothers' achievements in powered flight along with their impact on pre-World War I aviation. Questar's *The Story of Charles A. Lindbergh* gives the moving story through original newsreels of this well-known advocate of flying. We explore the myth of Lindbergh, his admiration of Goddard and Neil Armstrong's admiration for Lindbergh, and understand Lindbergh as an icon of American aviation. This is an opportunity to include a great woman in American aviation and cultural history: Anne Murrow Lindbergh. A review of her literary contributions is an appropriate lecture topic [9]. The story of the Lindberghs and his subsequent involvement with the American First movement, his initial call for neutrality in World War II, his eventual Allied military service in the Pacific, and his leadership in the aviation industry in the United States in general was important to the American public during the twentieth century. Lindbergh continues to be a subject of current study as writers attempt to understand his life and views [10]. Cooke tells part of this story in *The Arsenal* in the *America* series.

Film itself is developed in this era and is used for political and social purposes. Charlie Chaplin's *Modern Times* is available at many video rental stores. However, his concern about the horrors of work on the assembly line and the plight of the working poor doesn't seem to communicate well to today's students. Nevertheless, in films like this we experience a technology criticizing technology. We also see film and radio used to speculate

about technology. The *War of the Worlds* audiotape is available at many public libraries. It is of interest principally to the scholar.

Many inventions for the human marketplace also lead to the development of weapons of war. *The Arsenal* summarizes the development of American military technology from colonial times to the present, including the war with Japan and the Cold War nuclear stalemate. This is appropriate near the end of Impact I and serves as an introduction to the more extensive treatment in Impact II. Parallel to this is the development of the American space program covered briefly by Cooke but more extensively in Holiday's *The Apollo Moon Landings*. Supplemented by early newsreel footage shown often on *A&E Classroom* about Goddard's rocket research, *Moon Landings* brings us to the last decade of the twentieth century.

At the end of Impact I, one or two of the episodes from the *Machine That Changed the World* series such as *Giant Brains* and *Inventing the Future* are appropriate, though difficult to obtain. These films are exciting accounts of stories such as Babbage's analytical engine, the world's first computer programmer (Ada, Countess of Lovelace), the great thrust towards the first electronic computer as for artillery fire control (and the ENIAC), and, finally, the modern personal computer. Two new series on the history of the computer are now available from PBS: *Triumph of the Nerds: How the Personal Computer Changed the World* and *Nerds 2.0.1: A Brief History of the Internet*. Some historical material from these series could be used in Impact I and the remainder in Impact II.

The new millennium is the occasion for the production of many video series dealing with twentieth-century history and social problems. Some episodes of *People's Century* (PBS) deal specifically with war, poverty, racism, the media, etc. Released in 1999, this series is a rich resource for Impact I and Impact II. A companion volume [11] should be helpful to the instructor. Peter Jennings's video series *The Century* [12] and Tom Brokaw's promised video series based on *The Greatest Generation* could also be useful [13].

### TEACHING TECHNOLOGY'S SOCIAL IMPACT

Through lecture and discussion Impact II looks at views of nature and the world as dependent on human value systems. We view the IMAX film entitled *Blue Planet* (BP). It surveys the earth from space, using mainly space shuttle photos, showing the beauties and the problems of "our only home," our blue planet. BP has a philosophical view that is the subject of class discussion and analysis. Graphic pictures of problems like the clearing of the Amazon rain forest for farming are shared. A common theme of the course is Ian Barbour's concept of distributive justice [6]. Both Barbour and BP suggest that the world's people should share the earth's burdens and benefits. *Sweet Fresh Water* by David Attenborough in the *Living Planet* (LP) series follows as we survey water in the world and water as habitat, focusing mainly on the Amazon. Water is more than a resource, a means of public transportation, or a source of energy. It is someone's habitat, and the world's people need to learn how to share this habitat with other living things. Beyond this, there is an inspiring magnificence or beauty in the water of the world that leads us to be its good stewards.

Print and electronic media are the most important tools in the political life of this country. As we consider the impact of technology on the planet, we must understand the history and impact of the media since it shapes public opinion on these crucial topics. The short film *The Radio Set* in TSLM does a nice job in showing the history and impact of

wireless communication on human life and can be supplemented by material found in the textbooks used in Impact I and II [4]-[6]. A film trilogy by Bill Moyers in WTTC (*The Image Makers*, *World War II--the Propaganda Battle*, and *The 30-Second President*) threads together the interactions among media, business, psychological warfare, human values, and political persuasion, from Rockefeller's Bloody Ludlow to the Nixon-Kennedy debates. These three films are essential for anyone wishing to understand the impact of the media in the twentieth century. They also serve as background to Moyers' WTTC episode *The Arming of the Earth* where we are led by Philip J. Noel-Baker, pacifist, later British wartime cabinet member, and winner of the Nobel Prize for Peace, to understand the impact of the submarine, the machine gun, and the airplane in creating the concept of total technological war, which culminated in the twentieth-century wars with Germany and Japan. A "remake" of *The 30-Second President* called *The 30-Second Candidate* was useful when it was released in 1998, but had little enduring value.

*Crusade in the Pacific* (CP) communicates the mood of the war years and the magnitude of the Pacific War, showing clearly that it was, in its essence, a great technological war. About 30 minutes of *Bloody Iwo* (from CP) along with excerpts from the Okinawa episode set the stage for the History Channel's *Enola Gay* (EG). EG carries us from the Einstein-Szilard letter to President Roosevelt to the pilots' choices and problems in dropping Little Boy and Fat Man on the now famous targets in Japan. The historical details of the Manhattan Project, Oppenheimer's leadership, and Allied strategic decisions leading to the only two uses of atomic weapons in combat in the history of the world are adequately presented in a reasonable time for successful use in the college classroom. The recently released PBS film *Race for the Superbomb* carries us through the invention of the hydrogen bomb.

To study the consequences to the world today of Japan's unconditional surrender to the Allies and the subsequent rebuilding of Japan, TPC offers *Reinventing Japan*. In this moving film about Japanese suffering and General Douglas MacArthur's attempt to create a new Japan, the student can see the elements of future Japanese technological achievements. Under the direction of the Supreme Commander for the Allied Powers (SCAP), a new constitution for Japan is written. Business and government leaders with strong ties to the "Old Japan" are fired, new Japanese entrepreneurs are encouraged, labor unrest is manipulated, and a conservative alliance of government, labor, and business emerges. Japan develops into a permanent base for American political and military influence in Asia and the Pacific.

*Inside Japan, Inc.*, also from TPC, brings us to the decade of the 1990's, showing the success and current challenges of a technological Japan firmly committed to a worldwide market that achieves success through its influential Ministry of International Trade and Industry (MITI), which promotes continuous development of a Japanese industry that is able to lead worldwide consumers to become faithful customers. Serious social conflict still exists in a conservative society which has labor and women's movements with deeply committed core leadership and membership. National survival tied to industrial success in a government controlled by regional, and, thus, usually, rural interests make the Japanese a very political people. The instructor must provide an update on current problems in Japan.

Asia and other concerns of the course offer many opportunities for dealing with current events in the classroom. The course World Wide Web (WWW) site is available to the

student and instructor for this purpose [14] and, by the nature of the course, this site is always being improved.

The final sections of Impact II focus on interaction among government, culture, the economy, and the environment. We enter a part of the course that involves less study of history and more emphasis on current issues. A study of the great impact of one woman on the use of pesticides is available through the film (or book) *Silent Spring*. It should be essential viewing in a course like this and can be used together with the recent *Frontline* video *Fooling with Nature*. Another study that deals with the complex interaction among scientists, government, and the public concerning nuclear issues of great importance to humankind, especially in relation to energy and the environment, is a recent film *Atoms for Peace*. Although the title reflects a dominant theme of the Eisenhower era, the material is current and shows the stalemate that exists in current nuclear energy development in the United States while Japan appears to be headed toward a leadership role in the peaceful uses of atomic energy in the twenty-first century, which suggests that it will also be a “Pacific” century. The problems in the development of nuclear energy are considered in greater detail in the new PBS film *Meltdown at Three Mile Island*. *Half Lives* presents the nuclear waste dilemma [15].

Energy and the environment are treated in an entertaining way in episodes on heating and on the internal combustion engine in TSLM. Historical backgrounds are reasonably thorough although current topics and problems are presented in a general way, requiring the instructor to supplement the films with appropriate current information. This is true also of some of the films in the ten-episode series *Race to Save the Planet* (RTSTP). The first episode, already mentioned above, contains a summary of late twentieth-century environmental, agricultural, and energy concerns. Some films in this series are inappropriate since they tend to be overly repetitive or are a little out of date. The episodes *More for Less* and *It Needs Political Decisions* survey several countries in the world that are dealing creatively with environmental issues. The approach in these two episodes is to consider general principles of wise use of resources, prudent avoidance of unnecessary environmental risks, local determination of methods of solution, and economic development focused on sustainable industries. Population management through birth education rather than abortion is dealt with in some of these country studies. Serving the global perspectives component of a university’s general education mission, these films guide us through significant programs for energy and the environment in Brazil, Zimbabwe, Thailand, Sweden, India, and Denmark. Such programs can serve as model human projects for future agricultural, environmental, and energy solutions. *Only One Atmosphere* is an elementary though useful summary of theories of global warming and the greenhouse effect.

A 1999 PBS series called *Journey to Planet Earth* covers some of the material found in RTSTP. There are three episodes: *Rivers of Destiny*, *The Urban Explosion*, and *Land of Plenty, Land of Want*. Portions of each of these can be used in Impact II and some of *The Urban Explosion* seems appropriate for Impact I. However, *Journey to Planet Earth* is presented at the high school level and the instructor will need to supplement it with current facts and figures appropriate to a university audience. Nevertheless, these episodes are a welcome addition to the set of resources available for these courses.

*The Battle for the Great Plains*, hosted by Jane Fonda, brings agricultural, ecological, Native American, and economic issues home to students in the Upper Midwest and the West

in general. Confronted by external critics, resident owners offer their claim that the land is better through their intervention or stewardship. Fonda showcases organic methods while raising questions about the sustainability of a system that is dependent on agricultural and environmental management methods that make intensive use of herbicides, pesticides, fertilizers, or irrigation. The highlighting of positive efforts by local residents is good news in a discipline in which hope is often a stranger.

What the human species has done with the entire planet is summarized by David Attenborough in the great film *New Worlds* in the LP series. We see the scars left by past generations, we hear stories of species extinct centuries or millennia ago, but we sense that, even in the midst of ambitious human projects, hope for the future is justified if provision is made to sustain all living things in the path of human progress. Attenborough advocates a three-part proposal in regard to the exploitation of the natural world that summarizes some of the environmental concerns discussed in Impact II: (1) “we must not exploit natural stocks of animals and plants so intensively that they are unable to renew themselves, and ultimately disappear”; (2) “we must not so grossly change the face of the earth that we interfere with the basic processes that sustain life, and that could happen if we continue destroying the earth’s green cover of forests and if we continue using the oceans as a dumping ground for our poisons”; and (3) “we must do our utmost to maintain the diversity of the earth’s animals and plants” [16].

### **GENERAL ETHICAL CONCERNS**

General ethical concerns appropriate to Impact I and II, especially the human risks of industrial development and technological warfare, can be found in the films *Knowledge Or Certainty* from AOM and *Heroic Materialism* from Kenneth Clark’s *Civilisation*. The PBS/WNET program *Religion & Ethics Newsweekly* is a good source of current material (see WWW site and viewer’s guide [17]). A religious perspective on some of the issues involved in Impact I and II can be found in the books by Monsma [18] and Sider [19]. Especially helpful are Sider’s “Seven Short Principles for a Political Philosophy” [19]. With all the resources available, six semester hours (three per course) barely allows time for even half of what’s described in this paper since every film is an occasion for instructor critique, class discussion, presentation of additional details or related issues, and presentation of current data. Some sources of additional information particularly relevant to environmental ethics include V. Harms’ *Almanac of the Environment* [20], J. Seager’s very useful book *The Earth Atlas* [21], which surveys world environmental problems, and some very fine material on environmental legislation from an engineering perspective in *Engineering Ethics*, by Harris, Pritchard and Rabins [22]. Further information is available through links provided at the Impact II World Wide Web site [14].

### **CONCLUSIONS**

Courses on the history of technology and its social impact serve as gateways to the realities of life and work. Video and print resources are available to serve almost any aspect of these courses [23]-[24]. Informed use of these materials should enhance the effectiveness of the educational experience. Through these courses students can learn to understand the potential that technology has for changing society in unforeseen ways.

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- 24) Films for the Humanities & Sciences (P.O. Box 2053, Princeton, NJ 08543-2053) has a large collection of videos available for purchase or rental. The WWW site is at: <http://www.films.com> .