Proceedings

of the

4th

CHRISTIAN ENGINEERING EDUCATION CONFERENCE

JUNE 19-21, 2002
AT
THE PRESBYTERIAN COLLEGE
MONTREAL, CANADA

Relating Christian Faith and Engineering

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Foreword

The 2002 Christian Engineering Education Conference was a wonderful time for sharing ideas, encouraging one another, and for fellowship in Christ. We had faculty, staff, and administrators from a variety of schools in attendance, with a correspondingly diverse set of papers for our formal sessions. It is my prayer that you find the papers in these proceedings to be a blessing as you read them and that they provide some helpful insights into the variety of ways in which our Christian faith and our engineering profession relate.

My thanks go to Baylor University folks for helping with the organization. Jim Farison helped with planning and organized our registration process, Ken Van Treuren led our worship time, and Linda Kerr did much of the clerical work for the conference (including work on these proceedings). Our host location, the Presbyterian College of Montreal, was right in downtown Montreal, not far from the ASEE conference site. Caroline O'Connor was very helpful as we worked out the details of the conference site, lodging requirements, and helping us find everything when we arrived.

We plan to have a dinner gathering of Christian engineers in Nashville, Tennessee during the ASEE conference (June 22-25). As details are worked out, more information on the exact date, time, and location will be posted on the CEEC website, http://engr.calvin.edu/ces/ceec. The next CEEC is tentatively planned for June 24-25, 2004 in Salt Lake City, Utah (immediately following the ASEE conference).

In Christ,

Steve VanderLeest
2002 CEEC Chair

Guiding Principles for an Office of Information Services

Charles C. Adams
Dordt College

Introduction

Just as educational institutions of even modest size have long had business offices and maintenance departments, it is a characteristic of twenty-first century educational institutions that they have departments or offices of *information services*. These offices have evolved in response to needs created by the rapid growth of information technology occurring in the last quarter of the twentieth century. But with that evolution has come a host of problems. For example, it is a rare college campus that is not forced to deal with tensions between those persons serving in offices of information services and those serving on the faculty.

It may be argued that a primary cause of the problems associated with offices of information services has been a lack of direction accompanying their creation and growth. In response to needs created by new information technology, these offices have grown up like weeds rather than like cultivated gardens. This is understandable when one considers how technology in North American culture is viewed as *neutral*, unaffected by questions of normativity, except perhaps at the point of application.

But technology is not neutral. As with every other human activity it is normed by the Word of the Lord for justice, love, faithfulness, stewardship, and so on. Thus the problems that have arisen in connection with offices of information services pose an excellent case study for Christian engineering students who are in the process of learning how their engineering design work is not neutral, but normed by the Word of God.

This paper describes a set of guiding principles for an office of information services at a college that seeks to be self-consciously Christian in every area of campus life—information services and technology included. The normative framework out of which the guiding principles arise is one that has general applicability to technological artifacts, systems, and organizations. It may thus function as an effective tool for Christian engineering educators seeking biblical distinctiveness in the teaching of technical courses.

Fundamental Principles

The fundamental principles that guide information services and technology at any Christian college ought to be those same principles that provide foundation for the overall task of the college. For the purpose of this paper these are taken as articulated in the statement of purpose of Dordt College (Sioux Center, Iowa), *The Educational Task of Dordt College* (1979, hereafter referred to as *Task*). Of particular importance for information services and technology are the following:

The creation belongs to God, is under his sovereign rule, and is an integrated totality, a cosmos in which each part is designed to function coherently and meaningfully. (*Task*, p. 5)

All things are God's creatures, whether those found in "nature," or those fabricated by humans (artifacts) in response to *the cultural mandate* (Genesis 1:28). "Each creature is accountable to the sovereign King and must obey the laws which God has established for it." (*Task*, p. 5) To exist is thus to be subject to law, to be a servant of God with a task to fulfill within the creation.

All things bear the mark of humanity's fall into sin. There is no part of creation that is uncorrupted by the fall. Technological artifacts bear the corruption of those who design and fabricate them.

"Christ redeems not only humanity, but the cosmos as well." (*Task*, p. 6) Thus those who claim his name are called to be agents of reconciliation, to labor together "in fulfilling the original mandate according to

the claims of Christ." (*Task*, p. 6) Faculty, administrators and staff involved with information technology at a Christian college are called to bring healing and redirection to that technology.

Faculty, administrators, and staff, i.e., all persons who are called to labor at a Christian college, are *servants* who occupy a particular office (calling). "It is important that a sense of office pervade all aspects of the college." "To occupy a position at the college means to be placed in a God-ordained office requiring educational service in self-effacing love and obedience to the Lord." (*Task*, p. 9)

A Christian college aims to train kingdom citizens to be aware of the demands of God's mandate to transform culture, to become equipped to take their place and carry out their tasks within the community of believers, to be able to discern the spiritual direction of our civilization, and to be prepared to advance, in loving service, the claims of Christ over all areas of life. (*Task*, p. 13) This is the *central task* of the college and the ought to be the motivating force behind all persons or artifacts involved with the college.

The above principles may be summarized for information services and technology as follows:

Every information artifact—whether computer, web page, user guide, library categorization scheme, telephone, overhead projector, etc.—is a creature, the purpose of which is to serve God. That service is rendered by enabling human servants in the task of developing and transmitting serviceable insight. Likewise every person associated or involved with information services and technology is a servant called to serve the central task of the college.

Guiding Principles

A more specific set of guiding principles, normative for and peculiar to those persons and artifacts involved in information services, are adapted below from the book *Responsible Technology* (Monsma, 1986). These, in turn, are based on the Christian philosopher Herman Dooyeweerd's theory of cosmic modalities (Dooyewerd, 1969), accessible summaries of which are found in Kalsbeek (1975) and Clouser (1991).

Cultural appropriateness. Information services and technology must be culturally appropriate to the college community at any given point in its history. This is achieved by paying careful attention to and making appropriate decisions regarding the following five sets of opposites:

Continuity and discontinuity. Whenever a change is made in a campus-wide information system or service, that change may be characterized as "continuous" or "discontinuous." An example of discontinuous change is the shift from using a card catalog to an online database for library research. Another example is the choice between upgrading the official campus word processor (a continuous change) vs. moving to a different word processor (a discontinuous change). Which of the two alternatives is more culturally appropriate can only be ascertained after a careful examination of the current situation in light of guiding principles 2-8 below.

Differentiation and integration. A good example of this set of opposites is found in the history of educational infrastructure. Fifty years ago a classroom was a room with a chalkboard, desks, and possibly a roll-down screen. To make use of other kinds of audio-visual technology one was required to bring into the room a 16-mm film, slide, overhead, or opaque projector borrowed from a central location. Today many classrooms are "multimedia integrated," equipped with every variation of projection equipment as well as one or more computers. The appropriate degree of integration needs to be judged in light of guiding principles 2-8 below.

Centralization and decentralization. Many small institutions have a centralized library. Larger institutions, however, may employ a system of branch libraries, dedicated to particular schools or departments within the university. Clearly size, considered in light of norms for stewardship and functionality, is one factor that determines whether centralization or decentralization is appropriate in this example, but there are other factors as well. Guiding principles 2-8 below provide the criteria by which that appropriateness is judged.

Uniformity and pluriformity. One example of this set of opposites is posed by the question of how responsibility for computer acquisition, maintenance, and use is governed on campus. In some institutions, the office of information services shoulders most of that responsibility and this centralization is accompanied by a fair amount of uniformity. It could be different. If the office of information services merely supplied the network connection and each department (or each individual) was responsible for the

hardware and software within its domain, there would likely be greater pluriformity. Another example is the types of "media" upon which information is "stored." Books, journals, etc. printed on paper are different from digital storage of the same. Photographic prints and film are different from videotape, which is different from digital images and video. All of these types exist on many campuses, exhibiting pluriformity rather than uniformity. Whether uniformity or pluriformity is more appropriate in a given situation needs to be evaluated in terms of guiding principles 2-8 below.

Large scale and small scale. The simplest example of this set of opposites is the size of the teaching environment. When the goals of a particular computer training exercise demand "hands-on" activity, a small class size is appropriate, enabling each student to interact directly with the hardware/software and the instructor. When the primary goal of a session is the transmitting of information (learning the basics of an email system, for example), time stewardship makes a large class size more appropriate. As with the above sets of opposites, guiding principles 2-8 below provide the criteria to judge whether large or small scale is appropriate.

All of this is important in 21st Century North America where, at times, there has been a bias toward decisions favoring discontinuity, integration, centralization, uniformity, and large scale. That bias arises from the belief that humankind can save itself through the application of science and technology (scientism and technicism). A good example of culturally appropriate decision-making is the decision made during the early 1980s by many small colleges to move away from mainframe computer technology toward personal computers. While involving a discontinuity, it was a choice favoring small scale and decentralization. The past two decades have shown it to be a wise choice for most schools, despite some new issues having to do with differentiation and pluriformity that have arisen. The basis for making appropriate decisions regarding the five sets of opposites is found by examining a given cultural situation and its history in light of the following seven principles.

Clarity and availability of information. This norm is central to a department of information services in its role to provide culturally appropriate information technology artifacts and to enable the campus community in using them to manage and share information.

Therefore all information technology artifacts must be accessible to those served by those artifacts. That is, information, artifacts, and services used to manage that information must be both *available* to the user when needed and *comprehensible* to that user.

Availability manifests itself, for example, in the form of a library open to the campus community, multimedia equipment available for checkout, and a web based interface that allows faculty to access academic records of advisees. Whether all information must be immediately available to the entire community can only be ascertained after a careful examination in light of guiding principles 3-8 below.

Information technology artifacts that are comprehensible to the user allow for use given the current knowledge and skills of the user. While technical language, jargon, and acronyms may be useful and appropriate for written reports or email within a department or discipline, such use is inappropriate (without appropriate interpretation) for reports or email shared with a broad audience such as faculty and staff. Replacing ponderous user manuals with one or two page, user-friendly instruction sheets for digital cameras, multimedia equipment, or telephones, enhances the comprehensibility, and thus the usefulness, of increasingly complex technology. Since the level of precision and detail of a class of information generally decreases as the information is shared with more general audiences, the appropriate balance between these can only be ascertained after careful examination in light of guiding principles 3-8 below.

However, it should be understood that clarity and availability of information implies that the user has the appropriate knowledge and skills to use the needed information artifacts. The needed knowledge and skills might be expected as prerequisite knowledge when the person enters the campus community (as student or employee), provided by instruction, or self-taught.

Communication. It is through communicating that we share information and thereby work to fulfill the central task of a Christian college in the training of kingdom citizens. This task presupposes coherence and interrelatedness and is thus communal, as opposed to individual, in nature. At the core of communication is the norm of honesty, which is characterized by justice, caring, and faithfulness.

Information services and technology provide a variety of mechanisms by which we can communicate, beyond the fundamental form, which is face-to-face speaking. This includes telephones, email, web pages, video conferencing, even radio and television. When our communication is mediated, such that not all the senses can be used, particular care must be given to reflect the characteristics of justice and

caring. This is because some factors that give us a greater comprehension of the communicator's message are missing. For example, while it is possible to admonish a colleague (in the spirit of Matthew 18:15) by email, telephone, or in person, the most appropriate method would reflect a high level of justice and caring.

Honesty in communication, building on clarity and availability of information, shuns secrecy and privacy, particularly amongst a group of Christian brothers and sisters. However, in light of our sinful nature, the degree to which particular information might legitimately have limited availability among the members of the community is properly determined by examination of guiding principles 4-8 below. A good example of appropriate communication may be the keeping of content-laden minutes by committees and the subsequent publishing of those minutes on the college intranet, where the entire campus can view them, while limiting access off-campus.

Stewardship. Information services and technology involve many resources, both material and human. All of these are "creatures accountable to the sovereign King" (*Task,* p. 5) and are to be respected and given their due. Many resources are finite and need to be carefully conserved. Among the more obvious of these are paper, energy for space heating or air conditioning, and building space itself. Humans are not resources and should not be treated as such. However, their time and the specific work that they contribute to the college are resources, and as such require stewardly respect. The nature of information services and technology is such that non-tangible resources predominate. Thus, in most situations, the critical resource to be considered will be time. Changes in information services and technology need to be accomplished in ways that prove stewardly to short range as well as long range time constrained projects (e.g., time saved or spent in learning the change and time saved or spent as a result of the change).

Delightful harmony. Information services and technology have an aesthetic dimension that is normed by delightful harmony. Any information artifact, whether service or instrument, ought to be *effective* in accomplishing its purpose, *satisfying* to those being served by it or using it, and should originate in the direct request of persons to fulfill specific, justifiable needs. Such services and technology promote right relations between the human and non-human creation (e.g., student and computer), between humans (e.g., computer service personnel and teaching faculty), and between humans and God. Achieving right relations or delightful harmony in general is difficult precisely because of the wide variations in information technology expertise that exist on a college campus.

Justice. The normative principle of justice requires that all persons, groups of persons, as well as the rest of creation be allowed to be the persons, groups, or created things that God has called them into existence to be. Information services and technology ought to *enable* students, faculty, administrators, and staff to fulfill their respective callings as students, faculty, administrators, and staff. Within each group, some may not be favored at the expense of others. One step in achieving the norm of justice is the proper recognition of authority and the exercising of that authority in a spirit of mutual responsibility and accountability and in ways that serve, facilitate, and edify. (*Task,* p. 11) Organizations such as Christian colleges experience two kinds of authority, institutional and expert. Institutional authority exists by virtue of the office to which one has been appointed. Expert authority is unofficial, and derives from one's education, experience, and background, giving one relatively greater insight in a particular area. In an institution normed by justice, institutional and expert authority will usually coincide in the same person. Information services and technology ought to be designed to thwart injustice whenever it has the potential for arising. For example:

"The call …is to design computers and computer systems so that they are culturally compatible, economical with respect to resources, pleasant to use—and so that they discourage the discriminatory use of information. Computer systems that encourage the invasion of privacy certainly discriminate against those whose lives are then open to wrongful public scrutiny. The normative principle of justice is given its due when designers of computer systems take steps such as making them easier to understand and use so that everyone can deal with them more easily." (Monsma, p. 176)

Caring. Caring goes beyond justice and asks not only if an information service or technology embodies what is due persons, but also if it reflects loving care for them. The service rendered by those involved with information artifacts needs to be exercised "in self-effacing love and obedience to the Lord." (Task, p. 9) Thus, for example, even though the norm of availability of information opposes the valuing of

individual privacy, the norms of justice and caring may require that the privacy of persons be respected. Further, the norm of caring ought to guide the communication from expert to novice and vice-versa.
Trust. The final normative principle governing information services and technology is that of trust and there are two distinct ways in which that principle functions. The first relates to artifacts (products and services) and suggests that they must be dependable. Dependability implies reliability and safety. Information products and services must accomplish what they claim to do and must do so without endangering the health or safety of those who they are designed to serve. Secondly, the norm of trust implies that information services and technology must promote faith in Almighty God rather than faith in an idol such as human autonomy, riches, or the pretended saving power of modern science and technology.
In particular, a positive response to this norm will require that persons entrusted with the responsibility for handling sensitive information be trust-worthy and that trust in such persons will be justified and encouraged. A positive response to this norm will also be evidenced by the absence of a false trust in information artifacts that leads to an over-tolerance of failure in those artifacts (e.g., computers and computer networks). Likewise a false trust in the Web, as over against print-published materials, for the location of reliable information, will be discouraged.

Conclusions

It is important to note that these norms must function *simultaneously*. They cannot be pursued in isolation from each other because they are all aspects of one single, and overall norm: *love*. Just as the overall task of a Christian college—training kingdom citizens—is an expression of love—love for God and for one's neighbor—so these norms are ways offices of information services and technology respond to that central, divine command to "love God with all one's heart and to love one's neighbor an oneself," as summarized in the italicized paragraph on page 2 of this document.

On the basis of guiding principles such as these, policies may be developed that deal with issues such as proper use of email, when to upgrade software and hardware, college-wide standards for archiving materials, etc. Without such a set of guiding principles, policies and decisions will continue to be made based on the intuition of a few, and, more often, as dictated by the surrounding culture.

Acknowledgements

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Learning Engineering Pedagogy from the Master Teacher

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Abstract

Recent engineering education literature shows the value of a real-world environment in terms of experiential learning. This paper shows that this valuable teaching method could be learned by observing the master teacher, Jesus Christ. Problem-based learning, interdisciplinary teamwork, outcome assessment, and distance education, are shown to demonstrate the effectiveness of Jesus' teaching methods in the context of engineering education. Novel opportunities for engineering education are identified including student-teacher comparison assessment, the student written textbook, the single faculty curriculum, faculty recruiting of their own students, and a focus on relationship building. An evaluation tool, in the form of a questionnaire, is given with the result of its use presented as a teaching philosophy for engineering educators. The model for learning engineering pedagogy from the master teacher is also shown as transferable to faculty-to-faculty mentor relationships.

Introduction

For eleven years, in the quest for improved manufacturing engineering education at North Dakota State University, this author has experimented with teaching methods derived from the Christian Scriptures. It appears that teaching methods used by Jesus Christ have been rediscovered, renamed, and applied in engineering education for effective results. This paper considers why and how to learn teaching from the most effective teacher of all time. Jesus Christ qualifies as the most effective teacher of all time as evidenced by the expansion and effects of the Christian church.

Teaching has a long history. Since moderns and post-moderns are typically not well educated in history, they are not well suited to learn from it [1]. Since modern research is based on modern research [2], it is easy to understand that the best teaching information might be hidden from view in historical literature. Therefore, the teaching methods of Jesus Christ are respectably considered from the Christian Scriptures written nearly 2000 years ago. Teaching, like the created laws of gravity, has laws that are obvious, when carefully considered [3]. Since Jesus Christ created the laws of gravity and the laws of teaching [4, John 1:3], He is the most respectable reference source on teaching methods.

For the present consideration, five of Jesus' teaching methods are presented to show how modern literature can affirm Jesus' teaching methods. Five teaching methods not used in the modern university are then presented as novel opportunities which could be partly or wholly implemented to improve engineering education. Considered as a whole, this presentation shows that Jesus' methods of teaching are worthy of study and modern implementation.

Effectiveness of Jesus' Teaching Methods in Engineering Education

Jesus Christ taught in a real world environment.

The Society of Manufacturing Engineers (SME) Education Foundation grants millions of dollars to bring real-world experiences to engineering students during undergraduate education. This funding represents the manufacturing industry's voice calling for new hire engineers trained through experiential learning. The SME industry perspectives report [5] showed that present class and lab methods of educating manufacturing engineers are inadequate through the identification of competency gaps among newly hired engineering graduates. The need and call for experiential learning in engineering education, especially in manufacturing engineering education, is coming from many sources. The following quote is typical evidence, from The Boeing Company.

"*Ever since the proliferation of research-oriented universities began in the early 1960s, a widening gulf has been developing between our colleges of engineering and the industries they support* [6]*."*

In the context of "real world environment," this author compared his teaching of manufacturing processes by lecture, video, laboratory demonstration, laboratory experiment, and manufacturing factory to Jesus' teaching on faith by walking on water (Matthew 14:22-31). Of the several methods used to teach manufacturing processes, the manufacturing factory was the closest to the real world environment. It is interesting to notice that Jesus used a difficult environment for the students to learn in (i.e., in a boat, on the sea, in a storm, late at night, and out in creation). This is consistent with other Scripture (James 1:2-4) and crowned with the fact that even Jesus "learned … by things suffered" (Hebrews 5:8). The traditional classroom is a comfortable, well-lighted, well-heated, stable, and uncreated (unnatural) environment. This environmental contrast can also be observed between the "real world" manufacturing factory environment and the classroom where manufacturing engineering students are most often taught.

By partially applying Jesus' teaching method of "real world environment" to an Introduction to Industrial and Manufacturing Engineering course at NDSU, student learning and the corresponding ratings of instruction were improved [7]. This would be expected for proper implementation of a teaching method used by the master teacher.

Looking further at the "real world environment" aspect of Jesus' teaching, one notices that Jesus always taught in the relevant real world environment for the respective principle being taught. For example, the woman at the well (John 4:6-30) did not apply for acceptance, pay tuition, buy the book, and then attend Jesus' class, rather the master teacher taught in the context of her environment.

Problem Based Learning

In modern terms, problem based learning (PBL) is where the learning results from working toward the understanding of, or resolution of a problem. The problem is encountered first in the learning process rather than after learning the subject fundamentals. When PBL is practiced in the institutional setting, it is student-centered, it uses small groups, has the teacher as guide, poses problems as the organizing focus and stimulus for learning, and uses a problem as the vehicle for the development of the problem-solving skills. As one illustration of how Jesus Christ used PBL, consider the Great Commission of Matthew 28:18-20.

And Jesus came and spake unto them, saying, All power is given unto me in heaven and in earth. Go ye therefore, and teach all nations, baptizing them in the name of the Father, and of the Son, and of the Holy Ghost: Teaching them to observe all things whatsoever I have commanded you: and, lo, I am with you alway, even unto the end of the world. Amen.

Table 1 aligns the core features of PBL with the practice of PBL as observed in the Great Commission. As with modern PBL implementation, the initial presentation of the problem can be overwhelming, the student (disciple) becomes an active doer versus passive listener, small groups encourage progress, the master teacher provides guidance when needed, and the students (disciples) become the "gifted" subject experts, who teach one another toward the common goal.

Table 1. PBL aspects of the Great Commission

PBL Core Features	Great Commission Practice of PBL
Problem posed first.	Go..teach..baptize.."all nations..all things."
Student centered.	Disciple as student and center.
Uses small groups.	Disciple groups of two or few.
Teacher as guide.	Holy Spirit as guide (John 14:26) .
Problem as organizing focus and stimulus for learning.	Five-fold ministry given for perfecting saints for the ministry work of edifying till "all nations...all things..." (Ephesians 4:11-13).
Problem as vehicle for the development of problem-solving skills.	Spiritual gifts given..to edify (1 Corinthians 12).

Interdisciplinary Teamwork

Most engineered products are both interdisciplinary in nature and require a team to develop. For accreditation, engineering programs must demonstrate that students graduate with "the ability to function on multidisciplinary teams" [8, criteria 3d]. In the engineering education context, the "ability to function" is typically measured in terms of contribution to the project, as a member of the team and or by team efficiency [9]. The general thought is that interdisciplinary teamwork should be included in the curriculum to link and apply the previously and separately learned subjects to real world experiences.

What is less commonly understood is that the university curriculum is like the K-12 government school curriculum in its unnatural separation of subjects. The need for interdisciplinary teamwork is actually a correction for the educational practice of separating subjects. The ideal curriculum might include interdisciplinary teamwork throughout.

The consanguineal family and church are the primary teams in Scripture. They both function to build up the Body of Christ and are naturally interdisciplinary and require teamwork. Looking, therefore, to the family and church educational practices encouraged in Scripture, educators can notice the value of interdisciplinary learning and teamwork at all ages and experience levels and demonstrate the value of interdisciplinary teamwork based on Scripture.

Outcome Assessment

There is political and public pressure on colleges and universities to explain what they are trying to do and to demonstrate how well they are doing it. Faculty must demonstrate that they are effectively teaching and that students are learning along the lines of the course objectives. Assessment is, at best, a system of providing feedback, ultimately to the teacher, toward continually improving the learning of students.

The value of outcome assessment can be seen in how the Scriptures also encourage outcome assessment, as indicated in the following verses:

Even so every good tree bringeth forth good fruit; but a corrupt tree bringeth forth evil fruit. A good tree cannot bring forth evil fruit, neither can a corrupt tree bring forth good fruit. (Matthew 7:17)

But the fruit of the Spirit is love, joy, peace, longsuffering, gentleness, goodness, faith, meekness, temperance: against such there is no law. (Galatians 5:22)

If any man offend not in word, the same is a perfect man, and able also to bridle the whole body. (James 3:2b)

In this the children of God are manifest, and the children of the devil: whosoever doeth not righteousness is not of God, neither he that loveth not his brother. (1 John 3:10)

The metrics used for spiritual life in the Scriptures include spiritual fruit, as evidenced through a person's words and actions. The data is taken daily and feedback also to be provided daily, which has also been effective in engineering education.

But exhort one another daily, while it is called Today; lest any of you he hardened through the deceitfulness of sin. (Hebrews 3:13)

Distance Education

We are now in the midst of an educational revolution based on technology enabled distance learning. The lecture is understood as among the least effective teaching method and more attention is paid to learning styles. The effectiveness of distance learning using the world wide web can be shown through observing the effectiveness of the Holy Spirit. When Jesus ascended to the Father, he sent the Holy Spirit to maintain communication to and between all believers.

Nevertheless I tell you the truth; It is expedient for you that I go away; for if I go not away, the Comforter will not come unto you; but if I depart, I will send him unto you. (John 16:7)

Howbeit when he, the Spirit of truth, is come, he will guide you into all truth: for he shall not speak of himself; but whatsoever he shall hear, that shall he speak: and he will shew you things to come. He shall glorify me: for he shall receive of mine, and shall shew it unto you. (John 16:13-16)

Web-based education benefits the student by allowing them to learn at their peak learning time of day, learn at their own speed, learn faster, interact more with the teacher, and have more discussion about the subject than traditional lectures. Additional benefits would include not being away from family and not being among bad company (1 Corinthians 15:33). As John Thompson [10] points out, "If the primary purpose of college is educational, then something is amiss in the classroom. Simply put, research has shown that, for most subjects, tutorial instruction and guided independent study give superior results over classroom teaching... The non-classroom approach is also more flexible, allowing the student to use books, audio, video, and computer networks to study at his own pace (intensively, if he chooses), in his own home, according to his preferred schedule, even while traveling... Yes, such a course of study demands greater self-discipline and personal scheduling; but, in our judgment, it better prepares the student to be a self-starter, leader and entrepreneur in later life."

God communicates his will through Jesus Christ, by the Holy Spirit to believers in harmony with his written Word. This might be seen as the ideal distance education model, where God the Father and Jesus Christ (teacher), communicate through the Holy Spirit (web) to believers (students) in harmony with his written word (textbook written by teachers). The effectiveness of this teaching method has been demonstrated throughout the Christian church and through modern engineering education [11, 12].

Novel Opportunities for Engineering Education through Jesus Teaching Method's

The paragraphs above attempted to demonstrate that modern effective methods of teaching validate the teaching methods of Jesus Christ, the Master Teacher. This section identifies new opportunities for improving engineering education by observing aspects of Jesus' teaching methods that are not currently used. The opportunities presented below may not fit neatly into traditional institutional programs, which may in itself point to better pedagogy outside the institutions.

Student-teacher comparison assessment

Jesus stated that: *"The disciple is not above his master: but every one that is perfect shall be as his master."* (Luke 6:40) Consider the sophomore engineering statics student who demonstrates his statics

ability by proving that he can do statics as well as his teacher. This is a higher assessment standard than currently used, but not far from reasonable for practical implementation. The engineering student desiring to become an experienced professional engineer will need to spend significant time with his teacher, accomplishing real-world engineering projects, before being "as his master." This points to the reasonableness of Professional Engineer licensure, with its respective experience requirements. However, Jesus didn't limit the teacher influence to academics. Indeed, the teacher's skills and life philosophy are transmitted to the student. Perhaps this points to the need for students to spend more time with the professor of spirit and skills to which they aspire, rather than a composite of professors of spirit and skills to which they do not aspire. This would seem to point to the need for the engineering student to learn on the job or during entrepreneurial activities, since professors are not what most students want to be!

Student written textbook

College engineering professors do not typically ask the students to write the textbook for their course. However, Jesus Christ did ask his disciples to write the Scriptures, by the Holy Spirit. They wrote about what they saw, heard, and did. The importance of writing is immense in terms of impact upon the world, in both the Biblical context and engineering context. Therefore, for students to have the most impact on the world, they should be encouraged to write. Where a Christian philosophy of education can be implemented in whole or in part, the students could be encouraged to write toward glorifying God while communicating technical detail [13].

This author does ask students to "write the textbook" in the Aircraft Design for Manufacturing (DFM) course at NDSU. The students accomplish company and research projects, write papers, and create PowerPoint presentations with audio narration about DFM concepts, DFM company implementations, and DFM research proposals. The student writing completed prior to the end of the course becomes the required text for study. The students thereby learn from what they see, hear, and do during the company or research project activity, then they "write the textbook" for each other to study. The newly developed materials become online references for the next offering of the course.

One teacher for all subjects

Jesus Christ taught his disciples how to live and how to learn all subjects. In practice, the professional engineer regularly uses knowledge from many engineering subjects plus general education subjects such as English, Physics, Math, Sociology, and Psychology. Therefore, the practicing professional engineer could disciple (mentor or apprentice) an interested engineering student through all the subjects required to become a professional engineer. The professional engineer would also become a better engineer as a result of this teaching process.

This apprenticeship teaching method has been lost to modern engineering education, though it is still used for teaching electricians and plumbers. Since Jesus Christ taught using the discipleship method, one can hypothesize that engineering education could be improved through replacement of the traditional curriculum with apprenticeships. These apprenticeships would provide the "one teacher for all subjects" and "real world environment" aspects of the Master Teachers' pedagogy.

For manufacturing engineers, manufacturing plant apprenticeships would lead to the synergistic use of other Master Teacher methods, with corresponding results. This would include: (a) careful selection of students by the teacher, (b) careful selection of the teacher by the students, (c) keeping the teacher filled with fresh relevant knowledge, (d) allowing student graduation when he was like his teacher, (e) encouragement of entrepreneurial activity, and (f) improved student retention.

Faculty recruiting of their own students

Jesus Christ chose his own disciples as God directed (Luke 5:27, John 5:19, John 17:6). Christians might likewise choose their students (apprentices), as God would direct them. In an institutional setting, the faculty could recruit specific students to apprentice in faculty directed research and service, plus dialog with a Christian philosophy of education. Imagine if Jesus tried to "educate" the unregenerate Pharisees with the same methods that he used with his disciples. He would have wasted his time and been as

ineffective as Christian educators are in the secular institutions toward the true purpose of education, which is "to make Christian men, men transformed by the renewing of their minds after the image of Him who created them" [14, 15].

Focus on relationship building

The Scriptures command and demonstrate the value of relationship building in terms of the "one anothering" activities of the believers (loving, John 13: 34,35; saluting, Acts 21:6; receiving, Romans 15:17; forbearing, Ephesians 4:2, 32; submitting, Ephesians 5:21; waiting, 1 Corinthians 11:33; caring, 1 Corinthians 12:25; fellowshipping, 1 John 1:7; being hospitable, 1 Peter 4:9; honoring, Philippians 2:3; serving, John 13:14). Having the focus of education on relationship building would revolutionize education in itself. For the Christian educator desiring to focus education on relationship building, the relationships of paramount importance are (for both educator and student): one's personal relationship to Jesus Christ and His word, one's relationship with other believers, one's relationship to unbelievers, then the relationship of each subject or work product to Jesus Christ, His Word, and His Works (natural creation).

Relating all aspects of education and work to Jesus Christ and the Scriptures requires the sacrifice of time to study, meditate, and communicate the discoveries of truth. Since most books do not link the subject matter with Christian thinking, ample opportunities exist for Christians to uniquely glorify God in the subject matter, not to mention the blessing upon the diligent student (Hebrews 11:6). In project meetings, with Christian minds, the technical detail might purposely give glory to God, through scheduling time to communicate the relationships between project tasks and God's word, God's works, and people relationships and attitudes.

The relationships built through such experiences would be expected to extend beyond the semester into the remainder of life with both personal and business benefits. Of course this focus on relationship building could and perhaps should be practiced by any Christian desiring to be transformed through the "renewing of the mind," (Romans 12:2), not limited to the engineering education context.

Evaluation Tool towards Christ-likeness in Teaching

Christians have a desire to be conformed to the image of Christ in all areas of life. Therefore, it is also appropriate to consider moving toward Christ-likeness in teaching methodology. The ten questions in Table 2 are posed to encourage personal reflection on Jesus Christ's teaching methods toward developing Christ-likeness, with the acknowledgement of God (Proverbs 3:6) in modern engineering educational practice. Brief responses are provided as example responses from this author's reflection. Interested faculty could answer the questions from their own understanding toward identifying and implementing a Christian philosophy of education. The value of answering these questions comes from receiving new faith to consider acting upon, which is expected when meditating upon God's word (Romans 10:17).

Table 2. Questions to Motivate and Evaluate Christ-likeness in Teaching Methods

Questions	Brief Author Personal Responses
1. What methods have you already adapted from Jesus?	Real-world emphasis, problem based learning, interdisciplinary teamwork, distance education.
2. Would it be of value to ask oneself "How would Jesus teach?"	Yes, the neglect of this question would promote secularization [15].
3. Since post-modern culture thinks of old literature and old people as less valuable, could post-modern educational research thinking have pushed Scriptures out of vogue for modern teaching consideration?	Yes. Valuing Scripture as the Master Teacher's timeless and infallible communication to man about Truth would help modern educators transcend modern research and learn teaching truths also by revelation.
4. Where engineering educators are not	Yes, or at least similar to living on "bread alone"

learning teaching from Scripture, is this like the blind leading the blind?	without the Word of God (Matthew 4:4), as important toward the implementation of the Christian Philosophy of education for renewing the mind.
5. Can a modern secular university adopt more of Jesus' teaching methods?	Yes, the modern secular university can implement pieces of Jesus' teaching methods and thereby improve student learning. However, not acknowledging God in all one's ways misses the mark (Proverbs 3:5-6), is therefore sin, and contributes more toward secularization of society, than the edifying of the Body of Christ [15].
6. What would it take to adapt more of Jesus' teaching methods?	An awareness of the applicability of Scripture to modern education. Valuing Scripture above modern literature. Budgeting time to meditate on Jesus' teaching methods. A willingness to change how one teaches to align with the Christian philosophy of education.
7. What is your Department and College doing to improve teaching? Would this be what Jesus would do? How could Jesus get the glory?	My Department and College embrace every popular trend toward improving teaching and learning. This is not what Jesus would do. Improving learning, without acknowledging Christ, blind's the student's perception to the glory of God reflected in the unique mirror of mathematics, science, and engineering [13].
8. Which of Jesus' teaching methods might be opposed by the modern university?	Regarding the five novel opportunities for engineering education mentioned above, none would be opposed where implemented to a small degree without acknowledging God. However, all the teaching methods would be opposed, if full implementation is the goal with the acknowledgement of God.
9. Could the seemingly unlimited aspects to the teaching methods of Jesus prove His deity?	The impact of Jesus Christ teaching methods upon civilization points to the value of learning his teaching methods. Study of his teaching methods, by the Christian, reveals an exponentially increasing depth that points toward his omniscience, which proves His deity.
10. Could the seemingly unlimited aspects to the teaching methods of Jesus mean that one's best chance to master teaching is to know the Master Teacher?	Without knowing Jesus Christ personally, educators won't perceive the depth of His educational riches (Romans 11:33). Therefore and of course, knowing the Master Teacher personally as his apprentice, is the best arrangement for learning how to educate others.

A Christian Teaching Philosophy for Engineering Educators

The result of this author's use of the above questionnaire became a Christian teaching philosophy for use in engineering education. The author also home educates four children and applies the same Christian philosophy of education in the home towards family growth in the Christian worldview. A written teaching philosophy can help focus and direct a teacher the way a mission statement can help focus and direct an organization. Based on study and experimentation with the teaching methods of Jesus Christ,

the following teaching philosophy was written and presented to engineering students by a homepage web link.

Dr. Bartlett's Teaching Philosophy

Secular education trains students (and teachers) to not acknowledge God in any subject. Christians that are unaware of the history and influence of cultural philosophies also inadvertently promote these philosophies in all modes of education. For example, what is known as "common sense," is a philosophical line of reasoning that gained importance in America following the Scottish Enlightenment in the 18th century. Where the common sense philosophy is valued above Scripture, the Christian may unknowingly deny the Scriptures in practice, if not in word also.

A Christian philosophy of education differs from educational philosophies of the world. The Christian philosophy of education is faithful to God's purposes for the Christian student and Christian educator as demonstrated through God's Word, God's Works, and God's Spirit. Such a philosophy acknowledges the omnipotence, omnipresence, and omniscience of God in all its ways. Both the educator and student of a Christian philosophy of education become filled with the knowledge, wisdom, and understanding of God. God's Word, God's Works, and God's Spirit become integrated and applied to all of life.

Since God is the creator of all knowledge and the beginning of knowledge is the fear of the Lord, there is no curriculum, course, topic, or simple complete thought where the discovery of God's thoughts would be unexpected. Therefore, the educator and student with a Christian philosophy of education apply diligence to think God's thoughts after him, which brings both glory to God and heaven to earth through the life of the educator and student.

The Compromise

A partial implementation of the Christian philosophy of education in the secular university appears to be a compromise. This compromise is rationale for the Christian educator to gradually move toward the full implementation of the Christian philosophy of education, even if that means leaving the secular institution.

Faculty to Faculty Mentor Relationships

The model for university educators to learn pedagogy from the Master Teacher also applies to new faculty learning from a "master faculty" or even the inexperienced student learning from a "master student." Learning occurs more efficiently when the inexperienced learn from a master, as compared with two inexperienced persons learning from each other. The ten teaching methods of Jesus presented above could, for example be applied to the new faculty / master faculty mentor relationship. They could work together on industry problems as the real world environment combined with problem based learning, they could involve faculty from other disciplines to benefit from interdisciplinary teamwork, the outcome assessment could be by new faculty to master faculty comparison, the web and email could serve as the communication medium as distance education, the new faculty could write "the textbook" during the experience of being mentored, the master faculty could team teach all subjects with the new faculty, the new faculty and master faculty could co-recruit their own students, and keep the focus on relationship building.

Conclusions

Since Christian teachers possess the Spirit of Jesus Christ and endeavor to lead a life in His footsteps, it seems only reasonable that the Christian should consciously use and promote Jesus' teaching methods for the best results. Since every Christian teaches (Matthew 5:14-16), the study of Jesus' methods would benefit every Christian. Beyond the obvious faculty applications explained in this paper, this use of Jesus' teaching methods extends to college staff, fathers, mothers, church leaders, and students in equal

significance. We can thereby learn from how Jesus taught, in addition to what Jesus taught, to learn more of what Jesus taught and created (e.g., teaching principles). Taking Jesus' example of teaching in the real-world environment to its natural limit would point to the best engineering learning to occur through entrepreneurship [16].

To be a Biblical Theist in thought [17] requires that the educator look first to the Scriptures for the discovery of innovative teaching methods, with the aim of being consistent with the Christian philosophy of education. This paper demonstrated the value of Jesus' teaching methods by comparing five of them with modern teaching methods known to be effective, as a secular humanist would prove Scripture with experience and science. Secondly this paper suggested novel teaching methods for implementation, based on valuing Jesus' teaching methods above modern teaching methods and science, as a Biblical theist would. From either view, learning teaching from the Master Teacher, is valuable for modern engineering education

The evaluation of Christ-likeness in teaching with the Christian teaching philosophy for engineering educators was provided as a starting point for focusing and directing the educators' attention toward Christ-likeness in teaching methodology. Though helpful to improve student learning, the use of the Christian philosophy of education without acknowledging Christ could further blind the student to the glory of God in the subject matter.

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Experiences with Identifying Senior Level Engineering Design Projects to Meet Developing Country Needs

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Abstract

One method used to ensure that engineering students have learned the engineering design process and are able to put the process into practice is to require them to complete a senior level engineering design project. There are many different ways that the projects are identified. They can be generated to meet the needs of local industry, to meet the needs of some other influencing body or to meet the perceived needs of the students and faculty. The success or failure of the project may depend upon the project itself, how and why it was identified and the practical aspects of completing it under the given constraints. During the past several years the students, faculty, and the administration at Grove City College wanted to investigate if there were reasonable design projects that the students could complete that would meet the needs of developing countries and still also meet the requirements placed on the students of completing a senior level engineering design project. Recently, several faculty members from the mechanical and electrical engineering departments at Grove City College traveled to East Africa on two separate trips to investigate potential projects for the senior design programs of the College. Because both of the engineering programs are ABET accredited, a requirement for the projects was that they would meet the definition of design from the ABET perspective. Another requirement was that the students should be able to complete the projects even though Grove City College is approximately 8,000 miles from East Africa. This paper describes the methods used to identify appropriate projects, suggestions as to how the constraints could be overcome and the knowledge gained from our experiences.

Introduction

Grove City College is a small (2400 students), private, primarily liberal arts college in Western Pennsylvania. Of the 2400 students, approximately 400 of them are students in the College's ABET accredited electrical and mechanical engineering programs. Although the College is not directly related to any church or denomination, it offers an education from a Christian perspective. A significant percentage of the student body are children of full time Christian workers and a few have grown up on the mission field.

The College offers a capstone design project program during the senior year for which the students receive six credits. The students in both the electrical and mechanical engineering programs choose their design projects at the end of their junior year and work on them throughout their senior year. The projects are usually student initiated and generally there are three to four design projects in each program. The college funds the projects for between $500-$1500 per project. The three projects for the electrical students this year were entitled 1) Hawkeye Scoreboard; the objective was to modify a college football scoreboard so that it displayed the real time on the playing field. 2) Physical Therapy Monitoring System; the objective was to let the physical therapist prescribe a regiment of physical therapy activities and then monitor for a week or more the patients performance and 3) Stereo Video Camera; the objective was to develop a dual digital camera and a dual video display system so that the user would be able to capture two digital images at the same time, one offset from the other, and view them in three dimensions. Each project was commercial/consumer oriented and had a significant engineering design component. Past projects have also been sponsored by local industry. Mechanical engineering projects have been

similarly motivated, supported and developed. However, two years ago, a team of mechanical engineering students modified the design of a "RAM Pump" and had castings made. A RAM Pump is a pump that essentially uses a water head to develop pumping action. The net effect is that a limited water drop can produce a pumping action that lifts the water a much greater distance. A student who was the son of a missionary and had grown up on the mission field led the team. He had previously known about RAM pumps and was aware of potential applications for them in Central America. The student initiated senior project in mechanical engineering that year produced a cheap, easily used RAM Pump

Grove City College students over the years have always participated in short term missionary work. Many of the engineering students have worked in technical areas assisting missionaries in the field. They have worked at radio stations, helped in construction and have developed computer programs. However, the students have not received any engineering credits for their work. Students in the health sciences and education have been very active in doing work to aid mankind. There are courses in place at the College so that the students in those fields are able to receive credit for their work. It was within this background that the students, faculty, and the administration at Grove City College decided to investigate if there were reasonable design projects that the students could complete that would meet the needs of developing countries and still also meet the requirements placed on the students of completing a senior level engineering design project.

About two years ago one of the electrical engineering faculty members had the opportunity to do engineering work to benefit the church in Africa. He traveled to Uganda, East Africa and worked to provide wireless e-mail and also to provide solar power for the Bunyoro Kitara Diocese of the Church of Uganda. This Diocese is the poorest in Uganda, which makes it one of the poorest, if not the poorest in Africa. While in Uganda, he began to see that there are many opportunities for engineering students from the United States to work hand in hand with people from Africa in order to assist in the development of that continent. About that same time, the administration of Grove City College decided to fund engineering faculty members for the purpose of investigating potential senior level design projects for the electrical and mechanical engineering majors. One of the faculty members in the biology department had led several teams of students in the life sciences to Africa and Asia over the last five years. The success of his program had led the college administration to ask if similar trips could be provided for the engineering students. A team of two faculty, an electrical and mechanical engineer went to Kenya and the one faculty member who had previously been to Uganda went alone on his second trip to Uganda. This report discusses what was learned from these trips. Several projects that were identified will be discussed. It is important to note that the projects are still in their conceptual stages and much work needs to be done in order to see them through to completion.

Identification of Potential Projects

Two areas that seem to be especially promising as potential electrical engineering projects in Uganda and probably in other developing countries are in communications and energy. Communication technology is developing rapidly in Uganda. The old landline telephone system is very unreliable and usually has a maximum modem connect speed of 9600 baud. Cell phone technology has leap-frogged over landline communications. However, the technology is still very expensive and will probably remain so in the future. It is possible today to send e-mail by cell phone in Uganda if you have a $400 cell phone and a $400 interface box. The cost of the phone connect is about equal for cell or landline. There are two potential electrical engineering projects that appear to be feasible in the area of communications. The first project is to further develop cheap wireless e-mail. The second project would be to develop a proprietary cell system for short distance (20 miles or less) for communications using Microsoft Outlook.

There is a need for engineering students to work with "technical" missionaries from organizations such as Missionary Aviation Fellowship (MAF) to assist them in the development of systems that they are working on to provide Microsoft Outlook based wireless e-mail and other similar systems. One need for such a system arose when a group of individuals from the Pittsburgh area started a nonprofit organization to develop coffee plantations in Uganda. They leased land from the Church of Uganda and have developed it with the necessary infrastructure for irrigation, planting and maintenance and harvesting. The plan is that when the coffee plants mature and start producing, the beans will be sold and the profits

will be used to fund the church work in Uganda. The wireless e-mail is needed for the communications that has to take place between the managers of the field sites, those located about 20 miles away in the church offices, and those in the world market place. The system consists of two radio/antenna systems and laptop computers with associated interface circuitry so that the computers communicate to the radios and then the radios communicate with each other. Although the system operates, there are several things that could be done as electrical design projects. The system now uses a proprietary interface box developed for marine radio service to communicate between the computer and the radios. A potential project would be to design a wireless e-mail system that does not depend on proprietary interface components. Also, in the MAF system, HF radios are used as the transmitters/receivers of the sound information. Another project could be to utilize a part of the commercial cell system to provide the communications link between computers. One idea is to rent cell space on the towers and the other is to develop a unique cell system for church work.

Solar power is the most reliable, renewable, non-polluting form of energy in Africa. Solar panels are routinely installed in homes, offices and public buildings such as churches. However, to get the most out of such systems, it is necessary to maintain them and to also implement energy management schemes. Several projects have been investigated that would further the use of solar power in Africa. One need is for a monitoring system that would provide the user with the information necessary for optimum energy management. The user of a solar panel system does not know when to use the stored up solar energy and when to use the power grid energy if and when available. A cheap, user-friendly system that would monitor the reserve in a solar battery and pace the user as to when to use solar power and when to use grid power would assist the owner of a solar panel tremendously. The second need is for the design of system components that are easily maintained and sustainable. The solar energy is normally stored in deep cycle batteries. When one cell of a battery fails, the battery is usually rendered useless and is discarded or left lying around. There is a need for a replaceable cell battery in developing countries. If a cell goes bad, the user would simply replace it. There were such batteries at the turn of the century in the United States. But they are no longer produced because they are no longer needed in our through away society. There is one company producing such a battery for today's marine market at a price of $1,300. There is also a need for solar panels to be designed with uniformity for quick swapping of panel parts. The systems are too costly to discard when one panel or part goes bad. But the only way to keep a system operating is to scavenge a part from one system and try and mate it to the other system; a common practice in Uganda.

Several engineering projects have been identified as a result of discussions with missionaries working on the field. The team of engineering faculty from Grove City met the missionaries at their work sites during the investigative trips and were able to discuss first hand the needs and potential solutions. A medical doctor working with the African Inland Mission in Kenya has a great interest in the wireless e-mail since short distance communication using the proposed system would be very advantages for all the same reasons that we associate with e-mail. Another project that he proposed was to have our engineering students assist in providing wind power for a proposed hospital complex that he was responsible for developing. The hospital would be located in the area of Kenya called the Rift Valley. This valley is a natural corridor for wind. He had researched potential suppliers of smaller wind power generators and had found that there is one company that is building and marketing systems for developing countries. Their systems are designed to not only produce electricity but they also have developed custom integrated systems to pump water and provide lighting. The company, along with its distributor in Kenya, is willing to discuss potential projects for our electrical and mechanical students.

A second project where he needs technical assistance is on the development of a local area network that would expedite the gathering of information related to the spread of AIDS. Although this project is not suitable for a senior level design project, it may be suitable for a group of students in a network programming class (required in our computer engineering option) to collaborate with the appropriate people at the site to develop the required computer network.

In addition, one of the investigative team members had the opportunity to visit Makeere University in Kampala, Uganda and also Uganda Christian University (UCU) in Mukono, Uganda. The chancellor of UCU is from Western Pennsylvania and recently took a position as chancellor of a former seminary (Bishop Tucker Seminary) of the Church of Uganda. The seminary was recently renamed Uganda Christian University. UCU wants to develop a technology program and have asked a consortium of Australian engineering educators and the Grove City College faculty member for advice. There is also

the need for developing computer literacy and the necessary computer labs. Also, while in Kampala, one of the investigators visited the chairman of the electrical engineering department and several of his colleagues at Makeere, the largest university in East Africa with 30,000 students. They expressed great interest in pursuing collaborative projects in electrical engineering.

Obstacles That Need to be Overcome

From our investigations and evaluation of the potential projects, it appears that there are many appropriate senior level design projects. The projects would not only have significant design components but would also help meet the needs of developing countries. Three of the major obstacles to a successful implementation of the projects are 1) faculty and student commitment 2) funding and 3) mechanics of carrying out projects where the participants are separated across continents.

The faculty has been reluctant to approve projects in the past, primarily because they do not feel that the projects have the necessary design challenges that the classical projects have had. As a result of the investigative trips, a segment of the faculty has begun to recognize that the projects could contain significant design components and meet the design requirements of ABET. The students show interest; but many are not convinced that the payback would be as great as from other commercially viable projects.

It is recognized that these projects could be very expensive to complete. The investigative trips have cost approximately $1500-$2500 each so approximately $10,000 has been invested so far. Two of the trips have been personally funded and Grove City College has funded the other three trips. The college has been willing to fund the work until now. However, there are some alternatives that should be investigated. One method to fund the projects is to make use of a grant distribution mechanism that the College has recently put into place. Money can be put into a special account and distributed as any funded grant. A non-taxable NGO could be set up for the purpose of funding engineering projects to aid developing countries. Just such a fund was set up by a group of businessmen in Pittsburgh to fund the coffee plantation that was mentioned previously. In fact, their resources funded the money needed to develop the wireless e-mail.

There are mechanisms for telecommunication today that were not available two years ago. There is definitely a need for global communications for the projects that have been proposed. Two products that are available today and lend themselves for the communications requirements are WebCT and BLACKBOARD.

Knowledge Gained

First, we have learned that investigative trips are not only profitable but also perhaps necessary. So far, a total of five man trips have been made to East Africa. The trips have given the faculty the opportunity to see the problems first hand and to formulate meaningful engineering projects. They have also given credibility to our work and have been a source for additional contacts and future work. They have served to make the faculty more aware of what is being done in missions today and also to see how developing countries are attempting to solve their problems. Recently, one of the Grove City College faculty members had the opportunity to discuss first hand with two African professors their work at their American universities to meet developing country needs. One colleague grew up on the grounds of Bishop Tucker Seminary and is leading a senior level design project in Agricultural Engineering in cooperation with Makeere University. Indirectly, one of the Grove City faculty members had the opportunity to have dinner with the president's wife of Uganda, Janet Musevini, who is a Christian and has dedicated herself to furthering the education of the Ugandan children.

A second thing that we have learned is that it is necessary to carefully choose and limit the area for work. From our experiences, it appears that East Africa and particular Uganda and Kenya are the areas that should be targeted for Grove City College. Both have English as their native language having come from British rule. Both have relatively stable supportive governments and both are relatively safe in today's environment of AIDS and terrorism.

A third thing that we have learned is that with the availability of software products such as WEBCT and BLACKBOARD, the obstacle of distance can be overcome. As engineering faculty develop more expertise in the use of such products in distance learning, it will be much easier to provide the communications necessary for the proposed projects.

Conclusions

In conclusion, it is anticipated that Grove City College students will participate in senior level design projects not only to meet developing country needs (specifically East Africa) but also to meet ABET design requirements in the near future. The projects can be done on an individual school basis or possibly in collaboration with other like-minded schools represented here or developing country universities. The problems associated with the projects seem daunting, especially for a school with limited resources. However, if a model similar to the one developed by the group of business people to develop the church land for the coffee plantation is followed, the engineering design projects can be completed successfully.

A Normative Approach to Ethical Engineering Design

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Abstract

One of our tasks as Christian engineering educators is to motivate students to behave ethically as professional engineers. The Christian engineer is called to serve others through technology and guide the application of technology toward God's purposes. Unethical behavior undermines an engineer's ability to serve and is contrary to God's directives. This task is not an easy one. Students may not recognize the ethical dilemmas inherent in engineering work or understand their own responsibility in making appropriate choices. They often focus on the technical aspects of engineering while ignoring ethical considerations because the issues are broader and more subjective.

This paper presents an innovative method of teaching ethics as part of the design process. Design norms are moral guidelines based on Biblical principles. Normative engineering design attempts to balance design trade-offs not only among technical constraints but also among ethical constraints. Designing to such norms forces the engineer to consider the broader impact of the design on the society in which it will be embedded. Biblical design norms include concepts such as cultural appropriateness, transparency, stewardship, integrity, justice, and caring. These criteria can be incorporated into an expanded decision matrix, allowing the engineer to evaluate how well a proposed solution meets both ethical and technical constraints in an explicit trade-off. Because of this organized, quantitative approach, students are more likely to apply these ethical standards. By making the ethical judgments less abstract, both students and instructors will be motivated to integrate design norms into all levels of engineering evaluation.

Introduction: Motivations for Ethical Behavior

People have many different reasons for making appropriate ethical choices. Those motivations are often directly or indirectly related to their own self-interests. They might choose to follow ethical rules because if they do not there will be unpleasant consequences. Breaking the law may result in fines or jail-time. Violating one of the specifications of a professional code of ethics may result in being barred from practicing that profession. Discovery of dishonest behavior may result in shame and loss of credibility in the eyes of family and society. More positively, people often desire the respect and admiration of others and might therefore be motivated to behave in ways that would benefit others. Some might even imagine a celestial being keeping a tally of the good and evil they have done. They mighty therefore make sacrificial choices in the short term to gain a long-term reward or escape eventual punishment. Some people also behave morally out of a sense of altruism. They exhibit a desire to help others, although this can also be a thinly veiled form of self-interest. The presumption is that if an individual behaves ethically, the world will be a better place, and all individuals will be better off.

Christians may share some of these same motivations, but ultimately Christians are motivated to behave ethically out of gratitude to God for his love and salvation. Those who are saved are called to serve God and others. This is accomplished by obeying God's laws, or in a less negative sense, trying to achieve God's ideals. Christians try to become the type of persons God wishes them to be and to act in the way

God has directed them to act. These ideals are spelled out in the Bible. This type of ethical model, attempting to live up to a set of ideals or norms, is referred to as a normative ethical model.
In this paper I would like to describe a particular normative method for teaching ethical decision making skills to engineering students. First, the relationship between Christianity and ethics will be explored, focusing particularly on teaching ethics in engineering. Next, a set of Biblical norms, which can be used as engineering design and decision-making principles, will be presented. Then the use of an expended design decision matrix to evaluate various alternatives against those norms will be described. Finally, some examples are included of how this method can be implemented in a first year engineering design course.

Christianity, Ethics and Engineering Education

Christians emphasize a connection between belief and behavior. A life of integrity involves not just knowing what is right, but faithfully doing what is right amidst the constraints of life. Unethical behavior undermines a Christian's ability to serve and is contrary to God's directives. But, teaching morality at the college level is difficult based on the nature of higher education today. As Garber points out in his book, *The Fabric of Faithfulness*,[1] modern colleges and universities see themselves as purveyors of technical knowledge. Morality is seen as a personal matter that must be developed somewhere outside of the classroom. Our culture has embraced a separation of facts from values. Knowledge (facts) must be objective (verifiable by scientific method). Since ethics (values) are subjective, they are not considered knowledge. Conventional wisdom holds that if values are only related to emotions or preferences (all relative) then they have no place in a modern education, particularly a technical one. Thus professors are disinclined to attempt the teaching of morals. When complicated ethical problems are presented, students (under the influence of the cultural bias toward relativism in all moral discussion) believe that any response is good as long as it can be rationally justified. The prevailing attitude is that ethics is just a game that depends on your perspective. Interestingly enough, various professional societies, in response to recent scandals, have become more concerned with instilling ethical attitudes and behavior into students. Unfortunately, teaching the codes has very little to offer as motivation for ethical behavior beyond an interest in maintaining professional standards.

Christian universities, as well as Christian engineering educators in secular universities, have an explicit commitment to ensuring that their graduates make ethical decisions. This includes motivating students to behave ethically as well as providing them with appropriate tools for ethical evaluation. Sometimes Christian engineering programs can be guilty of not giving these issues enough attention because we take for granted that they are dealt with elsewhere. We assume that students have already formulated an adequate ethical structure or that the core curriculum or college co-curriculum will provide that insight. Even if these assumptions hold true, the danger is that students will still adopt the notion that ethical issues are separate from the technical aspects of their training. The Christian engineer is called to serve others through technology and guide the application of technology toward God's purposes. This requires a holistic approach to engineering and ethics.

Michael Davis, in his book *Thinking Like an Engineer* defines Engineering Ethics as "a kind of applied, or practical, philosophy. It is concerned with understanding – and helping to resolve – certain moral problems arising in the practice of engineering."[2] This definition may reveal why many engineering students resist studying in this area: they may have chosen engineering because they are interested in computation and construction and may not see the relevance of anything that involves philosophical or religious discussion. Students may not recognize the ethical dilemmas inherent in engineering work or understand their own responsibility in making appropriate choices. Although they may assume that their employers or government policy makers will make the difficult ethical choices while they focus on only technical issues, the implied autonomy of the engineering professional virtually guarantees that they will have to make decisions with broader implications than the merely technical.

Faculty members also face their own barriers to integrating these issues into a particular engineering class. The content of most engineering courses is computational in nature. It is not always easy to see the

connection between technical fundamentals or mathematical skills and the broader ethical issues. Presenting ethical issues in this context can seem contrived. Complex mathematical concepts may require a different teaching style than broader societal issues. It is also the case that our technical courses are already packed and it is difficult to add a focus on ethics without losing something else. Finally, professors may have less confidence in dealing with ethical issues in the classroom since they perceive them to be outside of their technical area of expertise.

The technique described in the following sections is aimed at making the inclusion of ethical considerations a central part of the design process. Some of the barriers described above can be overcome by relating ethical norms directly to the evaluation of technical design alternatives, which occurs in many engineering courses. Engineering course material needs to reflect the importance of a holistic view of technology. The integration of ethics is especially important in engineering design, since in the design phase critical decisions are made that will determine the technology's ethical implications.

An educational strategy for considering ethical issues must achieve two goals in order to be successful. The curriculum must promote motivation for students to follow the ethical rules that are taught. Presumably this will be more effective if the ethical models taught tie in with the students' existing belief systems or worldviews. Also, the method must allow for evaluation of different alternatives with sufficient precision to arrive at a conclusion as to which alternative is preferable. It is rare to find a situation where one rule solves the dilemma. Some method for weighting the desirability of an action with respect to a set of norms is required, which implies a higher level of moral reasoning beyond just following simple rules.

Normativity and Design

God calls us to serve him in our technological designs as he does in all of life. The Bible provides us with principles to guide us as we seek his will. These principles can be described as design norms. They relate to how designs "ought" to be, to "right" design. Design norms are moral guidelines that can be used to determine ethical behavior. As Christians, we do have directions for our responses outside of what an individual or society thinks. Those directions are found in the Scriptures. However, we don't want to apply isolated verses alone (with the potential for being taken out of context) to contemporary engineering decision-making, since it is rare that one principle alone might be the only consideration in a complex situation. Rather, we want to use a set of principles (norms) that are based on Scripture, and which speak directly to technology. Normative design attempts to balance design trade-offs not only among technical constraints but also among ethical constraints. Designing to such norms forces the engineer to consider the broader impact of the design on the society in which it will be embedded. The principles presented here, based on work in Monsma[3], should resonate with students who are Christians and allow them to connect their faith to their engineering work.

Cultural Appropriateness. The design ought to fit the culture into which it will be introduced. It should respect cultural differences. Designs should be appropriate for the intended culture with respect to size, scale, specialization, centralization, and so forth. Finding a suitable solution requires understanding the worldview of each involved party. Divergent thinking is necessary to see the design from various perspectives, in order to gauge its fittingness to the task. For example, in our first year course we give students a design problem in which they must solve an electric power shortage. One of their options is construction of a hydroelectric dam. The norm of cultural appropriateness helps them to recognize the complex societal impact of such a solution, for example the positive social impact of a renewable, non-polluting power source as well as the negative social impact of the drastic environmental and geographical changes caused by a dammed river. Issues of appropriateness are especially highlighted in situations where technology is being designed for applications in developing countries. Needs for relief from burdensome labor must be met without disrupting other wholesome aspects of the existing way of life.

Transparency. The design ought to be understandable to the user. Transparency means that users are not misled or confused by the design, particularly with regard to safety and potential environmental hazards. The design process and the design itself should openly communicate the intended purposes and associated risks. Transparent designs are consistent, reliable, and predictable. The design should promote honesty and communication between users and should be communicated in language that non-engineers can understand, avoiding attempts at deception of any sort. An example of violating this norm might be a chemical company locating a chemical plant in an impoverished area where people might be accepting of possible hazards due to lack of education. Using interdisciplinary design teams that include representatives from many constituencies is one way of achieving this norm.

Stewardship. The design ought to carefully use earth's resources, frugally and thoughtfully. Stewardship is the idea that we are responsible to God for taking care of the earth. Consider the difficulty in recycling a computer or a refrigerator, two common products that combine a variety of materials in ways that make reuse almost impossible. Stewardship addresses not only economics issues, but also environmental effects such as pollution and environmental degradation, and sustainability. Stewardship also applies to human resources: designs should appropriately utilize the contributions and capabilities of those who make and use them.

Harmony. The design ought to demonstrate completeness, a harmony of form and function. The product must do the job that it was created to do, do it in a way that makes it pleasing to use, and should promote human values and relationships. For example, both a car interior and a computer graphical user interface can be designed to be intuitive and pleasant to use, in which the pieces all work together well. On the other hand, electronics devices like VCRs sometimes are built with so many complicated functions arranged in ways that are difficult to learn, that users become frustrated and fail to use the capabilities of the machines.

Justice. The design ought to respect the rights of all persons. The engineer must consider not only the user, but also others who are directly or indirectly affected by the design. Certainly a just design will comply with any applicable laws and codes. The decision as to where to locate a manufacturing plant and what safety standards should be followed at that plant should be heavily influenced by social and economic justice.

Caring. The design ought to show due care for persons. It should take into account the effect of the technology on individuals – physically, socially, and psychologically. For example, the graphical user interface of many modern operating systems can be difficult or impossible to navigate for the blind. Web page navigation can be done via an audio web browser if the pages are designed using standard HTML, but can be made unintelligible when non-standard components are included. Technological solutions should address a real need, one that has been appropriately defined while keeping the individual in mind. This should include an attitude on the part of engineers that recognizes that technology does not exist for its own sake, but to better the lives of others. One way caring design can be compromised is by abstracting technical models that do not apply to the individual situation. For example, time and motion studies might be appropriate ways of setting up workstations on an assembly line, but this approach would cause difficulties for particular individuals if their capabilities were significantly different from the established averages.

Trust. Designs and designers should be trustworthy. Designs should be dependable and live up to the expectations of those who use them. Designs should be robust (insensitive to unanticipated changes in manufacture and use) in order to assure reliable functioning. The norm of trust implies that engineers should be loyal to their employers and the broader community. They should avoid conflicts of interest that might lead them to make decisions that compromise their duties to others. Engineers should also be competent to do the required design work in order to avoid violating the public trust. Roger Boisjoly and other engineers who pointed out the O-ring deficiencies before the launch of the space shuttle Challenger exemplify the norm of trust.

The Enhanced Design Decision Matrix

A common design tool introduced to engineering students early in their academic careers is the use of a decision matrix (sometimes called a "design matrix"). The matrix allows the designer to quantify and objectify a decision between multiple alternative solutions to a specified problem. The columns of the matrix represent the various potential solutions. The rows of the matrix are the criteria by which the alternatives will be judged. The criteria often include "low cost", "low maintenance", "high safety", "short design time", "manufacturability", and so forth. Usually these criteria are weighted to indicate priorities. This makes the trade-offs explicit. The decision matrix approach is similar to standard cost/benefit analysis. First, options are identified. Then costs and benefits of each are determined, and finally a decision is made based on the sums of costs and benefits. But, with the use of norms in the matrix, costs and benefits are identified and interpreted much more broadly.

Usually, the decision matrix is limited to purely technical issues, but the same benefits that accrue from using the matrix to make explicit technical tradeoffs can be applied to less technical issues as well. The design norms described in the previous section can be included as part of the design criteria. In fact, the technical criteria are always subordinate to the ethical criteria. The technical details are always aimed at satisfying a set of requirements that are derived from values expressed by organizations and individuals. The process of weighting the criteria and assigning numerical scores to design alternatives within each of the norms makes the ethical as well as the technical trade-offs explicit. The ranking process, if it is to be done thoroughly, requires that engineers put themselves into the positions of others who will interact with their products and conscientiously seek out information that will reflect their interests. At a minimum, the inclusion of norms in the decision matrix makes designers aware of possible ethical ramifications of their design choices.

Example #1: Electricity Generation. Three examples are given here to illustrate the application of the normed decision matrix technique within an introduction to engineering class for first year students. The first design project in the course involves groups of students evaluating and selecting a method for generating needed electrical power. Students are provided with the following possibilities: hydroelectric dam, wind farm, solar power, natural gas turbines, nuclear plant, and coal-fired turbines. Dollar amounts for initial construction of the plant and yearly operating costs are provided for calculation of the financial requirements for building and maintaining each plant using engineering economics principles. The students are required to do some library research to determine the nature of the power generating technology and its potential effects on the environment and society. Table 1 shows a decision matrix from one of these projects.

Having the ethical norms in front of them at the beginning of this process encourages students to fill in the gaps in their knowledge with their research in order to completely assess the effects of the various alternatives. Some higher order thinking (analysis, synthesis, and evaluation in Bloom's taxonomy) is required in order to rank each of the alternatives accurately with respect to the norms. One of the dangers of this quantification might be redundancy in categories that could give inappropriate weight to a particular issue, although this can occur with purely technical criteria as well. Care must be taken in establishing the weightings for the various norms and technical criteria so that tradeoffs are accurately reflected. Having team members work together to define the weightings can help to avoid a substantial bias. Also, the final ranking numbers should be used only in an advisory sense. The numerical values are not, by themselves, the solution to the problem. Rather, the process of weighting and ranking clarifies the issues. Note that the norms serve as categories that may be divided into a number of sub-criteria, as shown in the table for the Stewardship norm.

Table 1: Electric Power Decision Matrix

	Alternatives

		Hydroelectric		Wind		Solar		Natural Gas		etc. …	
Criteria	Weights	Score	Weighted Score	S	WS	S	W S	S	WS		
Cultural Appropriateness	7	7	49	6	42	7	49	5	35		
Site Availability	4	2	8	3	12	3	12	8	32		
Transportation	2	1	2	0	0	0	0	5	10		
Transparency	7	5	35	5	35	6	35	8	56		
Stewardship											
Renewability	5	9	45	10	50	10	50	2	10		
Pollution	6	9	56	10	60	10	60	3	18		
Ecosystem	4	4	16	7	28	9	36	5	20		
Decommissioning	2	2	4	3	6	4	8	5	10		
Cost	10	10	100	4	40	2	20	8	80		
Resource Reliability	4	9	36	4	16	3	12	10	40		
Harmony	2	5	10	3	6	4	8	3	6		
Justice	5	7	35	8	40	8	40	7	35		
Risk	5	9	45	9	45	10	50	5	25		
Caring	6	4	24	5	30	7	42	4	24		
Trust	7	9	63	6	42	5	35	6	42		
	Total		528		452		457		443		

Example #2: Backwards Math Case Study. A second example of this method involves a typical engineering ethics case study. The following case study[4] from the Murdough Center for Engineering Professionalism at Texas Tech University has been used in class as a tool in teaching engineering ethics.

> *"Pat's boss is an acknowledged expert in the field of catalysis. Pat is the leader of a group that has been charged with developing a new catalyst system, and the search has narrowed to two possibilities, Catalyst 'A' and Catalyst 'B'. The boss is certain that the best choice is 'A', but directs that tests be run on both, 'just for the record.' Owing to inexperienced help, the tests take longer than expected and the results show that 'B' is the preferred material. The engineers question the validity of the tests, but because of the project's timetable, there is no time to repeat the series. The boss, therefore, directs Pat to work the math backwards and come up with phony data to substantiate the choice of Catalyst 'A', a choice that all of the engineers in the group, including Pat, agree with. What should Pat do?"*

Some of the alternative responses identified in this situation might be: 1) alter the data as your boss requests, 2) alter the data, but write a memo to keep in your file that expresses your disagreement with this request, 3) refuse your boss's request, 4) refuse your boss's request and go to your boss's superior to report his unethical behavior. The simple form of a decision matrix (without weights) that might aid in analysis of this case is shown in Table 2. In ranking each alternative with respect to cultural appropriateness one might consider the corporate culture of the employing company. The scores in the table might reflect that in this company data are not always taken that seriously and loyalty to an immediate superior is highly valued. Transparency might include the idea of honesty and the idea of whether or not the decision would stand up under scrutiny by peers. Caring might involve which option responds best to the felt needs of the people involved. Justice would involve who wins or loses by the different decisions, and which of them are legal. Under harmony one would place a higher value on actions that are in harmony with one's personality and job function. Under trust one would consider which option might undermine your loyalty to those involved or violate another's trust.

Table 2: Ethics Case Decision Matrix

Criteria	Alternatives: Alter	Alter with Cover	Do Not Alter	Do Not Alter and Report
Culturally Appropriate	9	7	5	3
Transparency	2	5	8	7
Harmony	1	2	8	9
Justice	3	3	7	4
Caring	6	2	6	5
Trust	4	3	6	3
Total	25	22	40	31

Example #3: Service Learning as Ethics Education. The final example of the application of the normed decision matrix is a service-learning design project. This is a team project in the first year engineering course used to teach the design process, in which groups of students work with a person of some level of disability (usually in conjunction with a business or institution) to design an object or process that will help the disabled person to more easily perform his or her job. As they work toward solving the problem, students are required to generate several alternative designs and to carefully evaluate them before proceeding to develop the final detail design and prototype. Students are taught how to use the decision matrix tool at this point and are required to develop the matrix to evaluate their alternative designs. Including the Biblical norms as part of the design or task specifications for the device or system reminds them of the true goal of the project: to help a particular individual. Engineering culture often reflects what Postman refers to as a "technopoly,"[5] which focuses on technology as an end in itself and feeds the forces of consumerism and materialism. The ethical norms push the students beyond an object-centered approach to technology toward a value- or people-centered[8] approach. Although there may not be significant differences in how their design alternatives align with some of the norms, it is useful for them to reflect on the broader implications of choosing one alternative solution over the other. Forcing them to decide which norms to include and how to weight them can also help them focus on what's important.

These norms can also be applied in a broader context to guide engineering students and practicing engineers into ethically appropriate careers and help them to choose meaningful projects to pursue. Those who identify with these Biblical norms might be more likely to do volunteer service projects, to work in disadvantaged neighborhoods, and to find specific needs to address that are not met by market forces in order to serve society. This makes explicit the calling of the engineer to serve society by creating technologies that improve human lives.

Conclusion

According to Martin and Schinzinger[6], there are three components to ethical analysis: normative/evaluative, conceptual, and descriptive. The expanded decision matrix that includes Biblical design norms helps students to recognize all of these levels of thought. It requires them to reflect on and assimilate a set of norms for evaluative purposes. It requires them to conceptualize about the ramifications of a given design as they rank items in the decision matrix, and it requires an appropriate and complete set of descriptive facts about the design alternatives involved. Students should be motivated to participate in these levels of thinking since these norms arise from their own worldviews

Above all, students need to realize that the technology they will design will be embedded with the values that are operative during the design process. Charlie Adams[7] suggests three ways the engineering curriculum might be changed to reflect this value-ladenness: 1) the curriculum must contain courses in

the humanities which are seen as an integral part of students' training, 2) each individual course must be taught so as to reduce the tendency to abstractionism, and 3) engineering educators should be sensitive to the values we are teaching. The ethical modeling tool described here can help in satisfying goals 2 and 3 when used in engineering courses. Focusing on ethical and societal implications of a design can avoid abstracting a problem into a purely computational exercise. The expanded design decision matrix can be used in any course involving choice between alternatives, therefore bringing ethical considerations to bear in an integrated way. And, the design norms provide instructors with a concise way to express their Christian convictions about engineering work and how it fits into their overall vocation. In this way, students can be inspired to engage in the task of reforming the engineering enterprise to serve God and to serve society.

This paper includes material from a presentation at the ASEE Annual Conference, June 2002 entitled "Using Design Norms to Teach Engineering Ethics" by G. Ermer and S. VanderLeest.

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[2] Davis, M. *Thinking Like an Engineer*. Oxford, New York, 1998, p. 173.

[3] Monsma, S. V. (ed), *Responsible Technology*, William B Eerdmans Publishing Company, Grand Rapids, MI, 1986.

[4] Found at http://www.murdough.ttu.edu/EthicsModule/Ethics1.htm. Reprinted from *Chemical Engineering Magazine* (McGraw-Hill, Inc).

[5] Postman, N. *Technopoly: The Surrender of Culture to Technology*. Vintage Books, New York, 1992.

[6] Pacey, A. *Meaning in Technology*. MIT Press: Cambridge, MA, 1999.

[7] Martin, M. W., and Schinzinger, R., *Ethics in Engineering.* McGraw-Hill, New York, 1993.

[8] Adams, C. C. "Automobiles, Computers and Assault Rifles: The Value-Ladenness of Technology and the Engineering Curriculum." *Pro Rege*, Vol. XIX, No. 3, March, 1991, p. 6.

Coming to Terms with Our Most Slack Objective

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Abstract

This paper describes a system that was put into action by the engineering faculty at John Brown University to assure and validate a personal contact between ***every*** faculty member and *every* new graduate. The contact was to be directed at describing the individual student's major strengths and most important areas for long term improvement.

The ABET 2000 Stimulus

The engineering program at John Brown University was first accredited in 1996, using what was then termed the 'old' criteria, but with a vision and allusion to ABET 2000 criteria. As we entered the new era of assessment in 1996, we began to look seriously at our objectives and assessing their potential for complete implementation. We had heard many comments at the preparation meetings that specifying too many objectives was a widespread problem with engineering programs. One EAC evaluator told me in a private conversation in 1999, that as far as he was concerned no program could support more than five objectives.

Twenty years ago we had listed more than twenty objectives, but the distinction between EDUCATIONAL and GENERAL objectives was not being made. Or even between objectives in the ABET 2000 connotation and desiderata. By 1996 we had identified the eleven learning objectives, and we began a serious testing of our objectives. We began to institute regular input from the constituencies of senior students, alumnae and advisory board. At first we used open ended queries to gather information, but in the mood of the last few years we evolved into making very pointed quantitative questions about the individual objectives. As we started to prepare our self-study and print the most recent catalog we had reduced the objectives to seven in number.

We found several items in the original objectives, that we felt were desirable and for which we could find a great deal of anecdotal evidence over a many year span. However these aspects were not characteristics or experiences that we could validate across the board with our students. Typical of these features would be 'having a life changing spiritual experience', 'participating in an overseas mission adventure', or the perhaps the toughest, 'becoming a Christian'. We tried to eliminate the impossible without diminishing our uniqueness.

The John Brown University Educational Intent

A description of the JBU engineering educational experience commences with the University's mission statement and then the Engineering Division's mission statement which is a subset . The mission statements are given as **Figures 1 & 2**. The next level of breakout is the list of Educational Objectives. The John Brown University Engineering Department has published their educational objectives as given in **Figure 3.** They appear in our University Catalog, and our Engineering Handbook, as well as on our Web Site.

In our ABET self-study the Division has provided text and shown several process diagrams to illustrate the flow of assessment and evaluation to improvement. The objectives are related to the JBU outcomes and hence the outcomes are related to the assessment tools. However as the process proceeded we found that the last objective presented a difficulty to assess. We have very small classes particularly in the last two years of the program and one on one assignments with the senior design projects, and the faculty members continuously engage the engineering students in personal conversation on a one to one basis. However, there is no **assurance** that every faculty has a personal interaction with every student. In particular, there was no way to assure that every faculty had discussed the individual strengths to be exploited and weaknesses to be attacked with every student.

Another interesting aspect of the assessment results, are the ratings given during the exit interview for graduating seniors. Some of our students felt that the 'progress' toward an individual interaction is not very good. But the questionnaire does not state 'relative to what other individual interaction experience'…State of Michigan, your Church School, your parents, your girl-friend, or etc.

The Blue Cards

In that context of quality assurance, the department faculty implemented the 'Self-Learning System' in 2000. The Self-Learning Card is shown as Figure 5, the actual cards are printed on blue card stock with dimensions of 8.5" by 4". Of course the faculty refer to the process as the "blue cards". The process starts when the office manager prepares a card for each faculty member and student. The cards are then distributed to the faculty and when they have completed the cards, they are returned. The office manager then prepares a mailing for each student with a cover letter from the Division Chair, **Figure 6**, explaining the process and intent along with the cards as prepared by the faculty. The first set of packets were mailed in the fall of 2001. Copies of the card images are kept in a file in the records room, but the comments are considered confidential.

Assessment, Evaluation and Improvement

Evaluation of the process by the faculty was done with the form given as **Figure 7**. The descriptive section of the ABET-EAC Self Study is included as **Figure 8**. That evaluation gives the numerical outcome of the assessment. We feel that the Self Learning process has allowed us to maintain our last objective and with some changes in timing and process will be used every year. Some of the most gratifying feedback has been given by the visiting 2001 graduates and via email. They seem to feel that the interaction is very special and reaches them at a time in life when they are setting their patterns for their early career.

John Brown University's basic mission is to provide Christ-centered higher education that contributes dynamically to the intellectual, spiritual and occupational effectiveness of men and women in God-honoring living and service.

FIGURE 1 University Mission Statement

The purpose of the engineering program of the Division of Engineering and Technology at John Brown University is to educate persons in the application of science and technology to the service of God and humanity. The goal is to produce graduates who can begin effective engineering practice or pursue advanced studies.

FIGURE 2 Engineering department Mission Statement

JOHN BROWN UNIVERSITY
DIVISION OF ENGINEERING AND TECHNOLOGY

Program Educational Objectives

• To develop and maintain an engineering program with electrical and mechanical concentrations that graduate students who are prepared and confident to begin an entry-level engineering position, pursue graduate studies, or contribute as a Christian technical missionary.
• To provide a quality education with emphasis given to appropriate scientific principles and engineering fundamentals.
• To extend the theoretical aspects of the curriculum to practical application through laboratory and computer experience and appropriate design activities.
• To stay exposed to technological progress within the engineering community, such as computer-aided design, and to integrate these developments into the curriculum.
• To increase student awareness of global community activities, particularly appropriate third-world country technologies so that students may involve themselves in community service.
• To provide ethical training, to promote an attitude of professionalism and social responsibility, and to encourage involvement in professional societies.
• To identify the particular abilities of students and encourage involvement in experiences that will develop and enhance those abilities, strengthen character and stimulate perseverance.

FIGURE 3 Educational Objectives

To identify the particular abilities of students and encourage involvement in experiences that will develop and enhance those abilities, strengthen character and stimulate perseverance.

FIGURE 4 Self-Learning Educational Objective

JOHN BROWN UNIVERSITY
DIVISION OF ENGINEERING AND TECHNOLOGY
SELF-LEARNING OBJECTIVE FOR GRADUATING SENIORS

To identify the particular abilities of students and encourage involvement in experiences that will develop and enhance those abilities, strengthen character, and stimulate perseverance.
[STUDENT NAME]

_____
[Professor's Name]

FIGURE 5 The Blue Card

{date} { letterhead}

Dear _____;

I am writing to you, as a recent graduate, on behalf of the Engineering Faculty. During your tenure at JBU the engineering faculty have no doubt each impacted you in many ways, through a variety of classroom and incidental encounters. This communication is to validate and give closure to those interactions. The reason for preparing this mailing is to culminate our desire to sustain your propensity for 'self-learning'.

This desire has been presented as the last learning objective as published in the Catalog and Handbook and elsewhere. The objective is given on the top of each card along with the faculty person's name. It is our hope that from these brief comments you will discover some new personal characteristics, capitalize on some of your known characteristics and seek to control characteristics that may seem disruptive to your career goals.

The enclosed cards have been prepared by each individual faculty (and staff) member for you as an individual. Please read them carefully and use them to consider your lifetime career and personal goals.

Sincerely yours in Christ's love,
Kenneth W. French
Chair Engineering Division

FIGURE 6 The Card Presentation Letter

JOHN BROWN UNIVERSITY
DIVISION OF ENGINEERING AND TECHNOLOGY

SELF-LEARNING RATING SHEET

1 = strongly agree; 2 = moderately agree; 3 = neutral; 4 = moderately disagree; 5 = strongly disagree

The cards are sent in a timely manner.	1	2	3	4	5
The cards are too personal to satisfy the objective.	1	2	3	4	5
The card format should be changed.	1	2	3	4	5
The cards have adequate space for comments.	1	2	3	4	5
The color of the card is pleasing.	1	2	3	4	5
The cards should be sent later in their career.	1	2	3	4	5
The cards should be issued their freshman year and again after graduation.	1	2	3	4	5

FIGURE 7 The Faculty Evaluation Form

3.2.12 Self-Learning

The Curriculum to Objectives Mapping (Table 2-4.1) indicates a low correlation between course work and the seventh objective. There is a consensus among the constituencies that the objective is important. However, the identification of particular abilities was not happening at a documentable point in the curriculum for any given student. Since it was apparently difficult to identify objective seven explicitly in the curriculum, the faculty instituted the Self-Learning card system. This documented interaction after graduation

becomes simultaneously *self-learning* and the initiation to *life-long* learning.

A new process was instituted in the summer of 2001, especially designed to support the last objective. The wording in that objective includes the statement, "...to identify the particular abilities of students and...develop...those abilities." Self-Learning in this context is learning about oneself. To document that objective and ensure the inclusion of every student, the Self-Learning process was developed. In the Self-Learning process a cover letter from the divisional chair, explaining the reason for the mailing, is sent to the student. Included is a card (AO800) from each faculty member, prepared for that particular student. The faculty members are independent agents in preparing their cards, but the full learning objective is printed on each card and the cards are signed. These communications are considered private and kept confidential.

The first use of this technique was on the graduating class of 2001. The cards were to be mailed together in a single envelope and were not mailed until January 2002 because of a delay in processing the cards. Faculty members completed the rating sheet (AO801) after the cards were mailed. The rating sheet is based on a 1-5 point system (1 – strongly agree and 5 – strongly disagree). The results showed (average rating of 2.2) that the cards were sent in a timely manner, were not too personal, pleasing color, and had adequate space for comments. The only two ratings in the midrange were the possible change of format (average rating of 3.8) and the prospect of issuing the cards twice—once as freshmen and again after graduation (average rating of 3.6). During the fall semester the faculty will discuss the prospect of extending to a second rating. However this is a demanding task for some faculty and a doubling must be carefully considered.

This tool relates to Outcomes 6 and 11.

FIGURE 8 The Self Study Entry with Evaluation and Improvement

Teaching Values in Engineering Ethics

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Abstract

The opportunity to teach ethics in an engineering curriculum offers an exceptional opportunity for Christian professors to introduce students to a Christian world view, providing them with a solid philosophical/theological foundation to their personal ethical system. In contrast to this, academia has addressed this concern is by teaching values. Especially in K-12 curriculum, "values clarification" has been widely practiced. However, values may be content-less ideas that do not promote virtue, character, or ethical behavior. All engineering ethics texts are "code centered" with little or no emphasis on motivational strategies to promote ethical behavior. Preliminary data show that knowledge is not the primary cause of code violations because many, if not most violations are willful. A Christian professor can bring religion into classes on ethics in an appropriate way. Such a strategy not only can increase cognitive dissonance which, in turn, will encourage ethical behavior, but can encourage students to examine the basis of their faith, making a Christian foundation a viable option.

Introduction

ABET curriculum requirements include ethics.[1] There have been a number of texts specifically written for a course on engineering ethics in recent years.[2,3,4,5,6] Papers on ethical issues regularly appear in professional journals and the National Society of Professional Engineers has a column on ethics in its monthly publication. Almost without exception, these books, articles and columns deal with knowing the codes and applying various case studies to practice making the correct decision. Similarly, most students expect a class in engineering ethics to be dry and code-centered. Consequently, the professor has two challenges; first, to "sell" the importance of the subject, and second, to set the stage for introducing religious concepts into the course. The latter challenge will always require careful thought as religion is assumed to be off limits in academia.

Convincing students of the importance of the course is rather straight forward by examples of failed careers caused by ethical violations, etc. Also, success of engineers who heroically stood by ethical decisions in spite of threats and possible damaged careers. One way to bring in the importance of a religious foundation is to present students with the need for such a foundation. For example, two samples of engineering violations indicated that most violations are willful and not due to ignorance of the codes. Figure 1 shows the percentage of violations that were willful for the country that were brought before the ASCE ethics board[7] and Figure 2 shows the violations for the state of Tennessee for all engineering professions that were brought before the Board of Registration.[8] This should plant the seed that something more is needed than merely knowing what should be done.

Of course, the various professional codes need to be taught along with the other aspects of ethics and social responsibility, but if the objective of a course is to encourage engineers to be ethical, there should be some inclusion of why ethical practices are important. In other words, there should be some motivational aspect in the curriculum which are grounded on a solid (preferably Christian) world view,

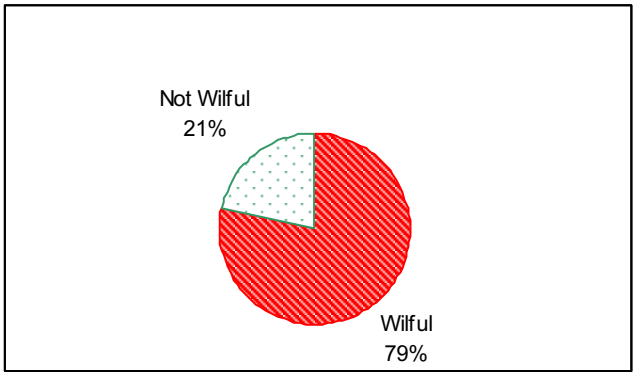

Figure 1, Engineering Misconduct in ASCE, USA, 1992

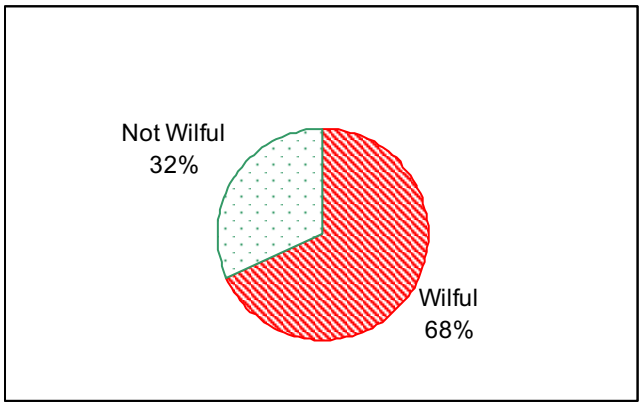

Figure 2, Engineering Misconduct in Tennessee, 1992

Introducing A Christian World View into a Course on Ethics

In his book, *The Death of Character*, James Davidson Hunter decries the "values" approach to promoting character development. In a hard-hitting paragraph, Hunter says:

> This destruction [of character] occurs simultaneously with the rise of "values." Values are truths that have been deprived of their commanding character. They are substitutes for revelation, imperatives that have dissolved into a range of possibilities. The very word "value" signifies the reduction of truth to utility, taboo to fashion, conviction to mere preference; all provisional, all exchangeable. Both values and "lifestyle" – a way of living that reflects the accumulation of one's values – bespeak a world in which nothing is sacred. Neither word carries the weight of; the conviction; the commitment to truths made sacred. Indeed, sacredness is conspicuous in its absence.[9]

Hunter defines character similarly to another definition used to define the behavior of a moral being as, "What you do when no one is looking."

Promoting moral behavior which emanates from a person of character is really the bottom line of what we would like engineers to demonstrate. One sociologist has characterized strength of character as people whose actions minimize their cognitive dissonance. In other words, people with a strong conscience who are able to eschew unethical behavior and demonstrate ethical behavior.

There are a number of reasons a person should act ethically. External reasons consist of fear of being caught and all of the ramifications that entails, such as being punished by the law, resulting social stigma, etc. Internal reasons might just consist of not wanting to feel guilty, without questioning the reason behind the guilt. There might be philosophical reasons such as put forth by Kant and the "categorical imperative," which simply says that if everyone did what you did and it would be bad for society, you should not do it. However, one of the most persuasive reason, if not THE greatest to increase cognitive dissidence is one's religious commitments.

The thesis of this paper is that we, in academia, have, in a lemming-like race, been caught up in a fear of promoting any kind of religious basis for ethical behavior. Not only is this a practical mistake, but it is philosophically flawed. One reason for this is that a major, if not the main problem in unethical behavior is not one of knowledge, but one of character. This is, the problem is not knowing what to do, but doing what we know. This is supported by the data in Figures 1 and 2.

It should be clear that there can be no rational consistent motivation to observe an ethical system without acknowledging the existence of absolutes. And, it is questionable whether or not one can claim the existence of absolutes without a theistic presupposition. Anscombe supports this by saying, "...it is not possible to have such a concept unless you believe in God as lawgiver..." This claim seems to send terror into the hearts of professors as it brings religion into the ethics class room.[10]

This can be done without violating the principle of "separation of church and state" or promoting any religion. What is important is to allow students who do have a religious aspect to their lives, to utilize this in increasing their cognitive dissonance. A similar objective is to allow students to who not have an articulated religious dimension to consider one. Of course, a Christian professors hope students would embrace the Christian faith as the foundation to their ethical system. This can be done by presenting the various ethical systems in as an objective way possible and then evaluating them.

One useful taxonomy is explained by Holmes in his book, *Ethics: Approaching Moral Decisions.*[11] What this does is give students who practice a religion, a basis for integrating their faith into their professional practice. Our education system has so ostracized religion from our curriculum that merely allowing it to be brought in as a source of promoting ethical conduct can greatly sensitize the cognitive dissonance of religious students and cause other students to consider adopting a world view that would provide the reasons why they should act ethically.

I present several specific suggestions on how a Christian professor might structure a class in Engineering Ethics. The class I teach is a one-unit required course. First, Christian professors should identify themselves as Christians on the first day of class in such a way that does not seen "preachy" but as an honest attempt to reveal their biases so students will know where they are "coming from." (a personal example may be found on my web site, http://www.leaderu.com/offices/o_helweg/kerugmatic_hints.html). We should put at least as much thought into this introduction as we do on any lesson. If you look at mine, you can see a combination of humor and challenge.

Second, at the last or next to last class,. I invite students to an after exam pizza party (Pizza is the fly paper of academia). I then write "TANSTAAFL" on the board, explaining that "There ain't no such thing as a free lunch." If they attend the party, they will have to listen to a ten-minute talk on how I became a Christian. At the end of the talk, I pass out comment cards so those who want to examine their faith later, can be contacted.

At the first lesson, I explain that the most important aspects of ethics is doing the right thing and that the philosophical basis for this will be kept for the last class, but that they should keep in mind throughout the semester the question, "Why behave ethically?" In this first class, I also introduce them to some of the main logical fallacies and critical reading/thinking. The last class is extremely important and in it I present the five ethical systems from which they must choose theirs[11]. These are:

Cultural Relativism
Moral beliefs and practices vary with and depend on the human needs and social conditions or particular cultures, so that no moral beliefs can be universally true."

Emotivist Ethics
Moral language simply expresses emotion so that nothing we say in moral terms is either true of false.

Ethical Egoism
Consider only the consequences for oneself.

Utilitarianism
Maximum benefits for the maximum number

Theistic Ethics
What God says is what we should do.

I point out the self refuting nature of "There are no Absolutes." and "Everything is relative." I point out that every ethical system is relative with the exception of Theistic Ethics. I then list the main religions and show that the ethical motivation the produce is based on keeping the "law" while Christianity is unique in that the motivation is responding to a relationship (forgiveness, etc.).

The class received some of the highest student evaluations in the college. Each semester, out of a class of 170, there are usually a dozen who request more interaction after the pizza party. It is interesting how many have never been introduces to these concepts nor thought about their faith; however, in our present culture, one should not be surprised.

Conclusion

What I have tried to show is that introducing religious beliefs into a course on engineering ethics is not only allowable, but beneficial. The instructor must, however, be non-sectarian in dealing with this area. What the instructor can do is to point out the motivations inherent in the main religions and challenge the students to internalize these, or at least to articulate them in a way that encourages them to take their faith seriously. The Christian instructor, of course, does more. In this way, the instructor enables students to lay a foundation for ethical behavior which should, in turn, increase cognitive dissidence when temptation toward unethical actions arise. Should anyone desire more information or materials, my e-mail is: Otto.Helweg@ndsu.nodak.edu.

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A Biblical Perspective on Engineering Ethics

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Introduction

It is very important for engineers to practice engineering in an ethical manner. An unethical practice of engineering can hurt many people. Engineering practice is regulated by codes of conduct that have been developed by various professional societies and the State Boards of Registration. As Christian engineers, we believe the Bible is a more important standard as to how to live and work. As Christians, we wish to be ethical in the practice of our profession. We are therefore interested in how the Bible and codes of conduct can be related to each other.
If we are to relate the Bible to codes of conduct, it is important that we understand these codes. This paper directly follows the paper we presented at the 2002 Annual Conference of the American Society for Engineering Education. Our paper at that conference was entitled: *"The use of Moral Theories to Evaluate Engineering Codes of Conduct"*[1]. In that paper we used different moral theories to evaluate the legitimacy of certain parts of the N.S.P.E. code of conduct. The theories we used were utilitarian theories, duty theories, rights theories, and virtue theories.

Our initial goal in this paper was to use the Bible to directly evaluate a typical code of conduct. However, as we did more research on the topic, it soon became apparent that we would need to do some additional preliminary work before we could directly use the Bible to evaluate a commonly used code.

Our paper has five major sections. Our first section deals with the nature of our calling by God. We then proceed to a discussion of what is the nature of work. Only after that can we begin an actual discussion of engineering. We begin this next section with an attempt to define engineering. We then have a discussion of engineering codes of conduct in the next section. In the final section we use the Bible to examine several portions of a common code.

The Nature of Our Calling

In our analysis we have been heavily influenced by Os Guinness' book *The Call*[2]. Guinness points out that all Christians have two callings. We have a calling to God (to be a disciple), and we have a calling to our work. We need to have some balance so that one of the callings does not get overwhelmed by the other one. Guinness writes:[2] *"Calling is the truth that God calls us to himself so decisively that everything we are, everything we do, and everything we have is invested with a special devotion, dynamism, and direction lived out as a response to his summons and service."*

There are two major distortions to this concept of calling. The first distortion is to elevate the spiritual above the secular. This was seen in medieval times when many people thought that to be really committed you needed to be a monk in a monastery. A common modern distortion is the view that a really committed Christian is one who is working full time in Christian service, such as being a pastor or missionary. The second type of distortion is the elevating of the secular above the spiritual. This approach says that we serve God through our daily life. While this is true, it is not the only way we can serve God. Guinness[2] makes this point by quoting two prominent Americans of the twentieth century, Henry Ford and President Calvin Coolidge. Henry Ford stated: "Work is the salvation of the human race,

morally, physically, socially." President Coolidge wrote: "The man who builds a factory builds a temple. The man who works there worships there." While work is important, many Christians would reject this conclusion.

The Nature of Work

Work was created before the fall of mankind, it is not a curse of the fall. This is made clear in Gen 1:28[3] where it is written: *God said to them, "Be fruitful and multiply, and fill the earth, and subdue it; and rule over the fish of the sea and over the birds of the sky and over every living thing that moves on the earth."* God expects us to spend time doing useful work. He even gave some specific work orders to the first human couple in Gen 2:15: *Then the Lord God took the man and put him into the garden of Eden to cultivate it and keep it.* Work is therefore important and not to be seen as just a necessary duty.

However, some aspects of work were made more difficult by the fall. As is written in Gen 3:17b-19: "*Cursed is the ground because of you; In toil you will eat of it all the days of your life… By the sweat of your face you will eat bread, till you return to the ground.*" This makes the point that work is more now more unpleasant than it was before the fall. Originally the command was to "cultivate"; now words like "toil" and "sweat" are used to describe what man was to do.

Work is therefore important to us for several reasons. God's commands to work predate the fall, so there is something important about work that transcends just the practical needs for someone to provide for his family. We do need to work to provide for our family, but there is something intrinsic to human nature that makes work important. When we work, we need to recognize that we are always really working for God. The Apostle Paul makes this point in Eph 6:7 *"With good will render service, as to the Lord and not to men."*

A Definition of Engineering

Creating a definition of engineering is not simple. There are some activities that are clearly the practice of engineering. There are some activities that are clearly not the practice of engineering. There are many activities in which it is not clear whether or not engineering is being performed. There are many written definitions of science and the scientific method, but fewer attempts have been made to define engineering. We are indebted to the careful thinking on the nature of engineering that has been done by Dr. Billy Koen of the University of Texas. His definition of the engineering methods is[4] *"the strategy for causing the best change in a poorly understood or uncertain situation within the available resources and the use of heuristics."*

Koen's definition deals with several key points involved with engineering. One key point is that engineers must use the available resources to solve problems. Another one is that the facts of a given situation may be poorly understood. However, we believe that his definition is too broad. For example his definition could, in many situations, apply to Christian ministry. Many pastors are trying to solve problems with available resources in situations that are poorly understood. We have therefore created our own definition of engineering:

> *"The application of science and human experience to solve problems faced by people. This is often done in poorly understood or uncertain situations, using the available resources."*

Our definition includes an explicit reference to science, as well as human experience. The human experience part is important, for in many situations we may know what works, but not yet understand why something works.

Introduction to Engineering Codes of Conduct

Engineering codes of conduct have been developed by the various State Boards of Registration within the United States. These codes are binding on engineers who work in each state. These codes must be treated seriously, for failure to follow these codes can result in fines and loss of your engineering license.

Engineering codes of conduct have also been developed by the different engineering professional societies. These codes typically contain more specific information than the state codes for they deal with issues unique to that given branch of engineering. Failure to follow these codes can result in your dismissal from the society. The society can also publicize your dismissal.

One problem we had in developing this paper is that there is no federally sanctioned national standard of engineering conduct. In this paper we will examine what may be the closest thing to a national standard: the code that has been developed by the National Society of Professional Engineers. This code is very similar to many state board codes. If an engineer violates this code, she has probably also violated the state code in her state.

In this paper we will assume that it is legitimate for engineers to have a written code of conduct. We recognize that not everyone agrees with this point, but an extended discussion of this subject could make an entire paper in itself. For now, we will assume that it is legitimate to have a code, and spend the rest of the paper analyzing the legitimacy of specific statements in a code of conduct.

A Biblical Perspective on Engineering Codes of Conduct

Modern engineering, with its significant scientific base, did not exist during the time of the Bible's writing. A type of engineering, empirically based on practical experience, did exist in some cultures. Examples of such engineering work include the Great Pyramids at Giza and ancient Roman aqueducts.

We therefore need to infer a Biblical approach to engineering practice from what the Bible has to say about certain other topics, such as building, work, and excellence in work.

Building things is praised in the Bible. An example of this is in the building of the ark of the covenant. It is written in Exodus 31:1-7:

> *Now the Lord spoke to Moses, saying "See, I have called by name Bezalel, the son of Uri, the son of Hur, of the tribe of Judah. I have filled him with the Spirit of God in wisdom, in understanding ,in knowledge, and in all kinds of craftsmanship, to make designs for work in gold, in silver, and in bronze, and in the cutting of stones for settings, and in the carving of wood, that he may work in all kinds of craftsmanship. And behold, I myself have appointed with him Oholiab, the son of Ahisamach, of the tribe of Dan; and in the hearts of all who are skillful I have put skill, that they may make all that I have commanded you: the tent 0f meeting, and the ark of testimony, and…*

It appears from this Exodus passage that the interest and skill in doing this work was a gift from God. Similarly, our interest in engineering, and our ability to solve engineering problems are gifts from God. This does not mean that hard work is not required for us to able to use our skills to their fullest potential. The competent practice of engineering is hard work. However, we do need to recognize that our engineering interests and abilities come from God.

While God commends building and creating, we need to recognize that what we build is not going to last forever. This is pointed out in Ecclesiastes 2:4-6, 11, where the teacher states:

> *I enlarged my works; I built houses for myself, I planted vineyards for myself; I made gardens and parks for myself and I planted in them all kinds of fruit trees; I made ponds of water for myself from which to irrigate a forest of growing trees… Thus I considered all my activities*

which my hands had done and the labor which I had exerted, and behold all was vanity and striving after wind and there was no profit under the sun.

Fortunately the above quotation is not a final statement about building. However, it makes the point, that if all we care about are the things we create, we will inevitably be disappointed. This does not mean that building great structures is bad, only that such actions can not completely satisfy your life.

While we work, we need to do what we can while we can. Paul writes in Ephesians 5:15-16:
Therefore, be careful how you walk, not as unwise men, but as wise, making the most of your time, because the days are evil.

We do not have unlimited time, so we need to be wise in how we choose to use it. We also need to strive for excellence, even if no one is watching. Paul makes this point in Col 3:23

Whatever you do, do your work heartily, as for the Lord, rather than for men.

These two passages make the point that all of our work has God for an audience. Even if no one else appears to be watching, God is. It is therefore God's opinion about our work that really matters. Guinness refers to his as working for an "audience of one."[2] Guinness writes[2]:

When asked why he was not stung by a vicious attack from a fellow Member of Parliament, Winston Churchill replied: "If I respected him, I would care about his opinion. But I don't, so I don't." Similarly we who live before the Audience of One can say to the world: "I have only one audience. Before you I have nothing to prove, nothing to gain, nothing to lose."

We need to do all of our work so that our Audience of One is pleased with what we do.

Our paper is based on the conclusion that God wants everyone to work in a productive manner. For most of us, our work will be "secular", but we should not ignore the fact that we are working to please God and not just other people. We need to recognize that the things we create will not last. This does not diminish the significance of what we create or the relationships we develop while we create.

For the sake of continuity we will examine the same portions of the code that we examined in our A.S.E.E. paper. This paper is available in the engineering ethics sections of Dr. Jordan's web page.[5] The four passages in the N.S.P.E. code were selected to represent different aspects of the practice of engineering. These same passages were examined in our A.S.E.E. paper. All of the passages from the N.S.P.E. code are from their official web page[6].

<u>Fundamental Canons of Engineering</u>

Section II.1.a

Engineers shall hold paramount the safety, health and welfare of the public.[6]

The canons appear to be very consistent with Paul's command in Galatians 6:9-10

Let us not become weary in doing good…as we have opportunity, let us do good to all people.

We have an obligation to all people, not just the immediate client who has hired us. As Christians, we are pleased that this statement is at the very beginning of the code, making it clear what our ultimate aims should be.

<u>Public Knowledge and Appreciation</u>

Section II.2.C

Engineers shall endeavor to extend public knowledge and appreciation of engineering and its achievements.[6]

Being pleased in what we do is certainly legitimate. If we are doing what God wants us to be doing, then we ought to be satisfied. The writer of Proverbs writes in 13:4

The sluggard craves and gets nothing, but the desires of the diligent are fully satisfied.

However, as mentioned previously, we can never be totally satisfied only by our work. The teacher in Ecclesiastes writes (in 5:10):

He who loves money will not be satisfied with money, nor he who loves abundance with its income.

We need to make sure that we do not get arrogant in our profession and in ourselves. In describing the reactions of the successful people in a well-to-do society the prophet Hosea warns us (Hosea 13:6):

They became satisfied, and being satisfied, their heart became proud; Therefore they forgot Me.

This part of the code may be seen as promoting a self-satisfaction and arrogance that is sinful. What is important is that our practice of engineering is ethical and competent. It is not so important that other people feel good about what we do.

Deceptive Actions

Section II.5.a

Engineers shall avoid deceptive acts. Engineers shall not falsify their qualifications or permit misrepresentations of their or their associates' qualifications.[6]

This portion of the code appears to be Biblical. We need to tell the truth at all times. It is written in Proverbs 16:14

Righteous lips are the delight of kings and he who speaks right is loved.

We need to recognize that this portion of the code does more than mandate truthfulness, it also forbids deceit. It is possible to not lie in the words we say, but still deliberately give a misleading impression. The forbidding of this deceitfulness is consistent with Biblical teaching that we need to control our thoughts and motives, as well as our action statements.

We need to speak the truth, even it does not appear to be in my immediate self interest. The Psalmist writes in Psalm 15:1-4

O LORD, who may abide in your tent?
Who may dwell in your holy hill?
He who walks with integrity, and works righteousness
And speaks truth in his heart
...who honors those who fear the LORD;
He swears to his own hurt and does not change.

There are times when it may appear that not telling the truth will help us in the immediate situation. We need to recognize that such actions are not acceptable, and not even in our best interest. An example from one of the author's career (Jordan) may be relevant. Early in his academic career Dr. Jordan was working on a sponsored research project with a more senior faculty member. Dr. Jordan's portion of the project was done, and he was faced with a summer without income. The more senior professor had not claimed all of the summer support that had been due him. He had not noticed that he had more salary due him. As a co-principal investigator, Dr. Jordan could have claimed the salary support and it is unlikely that anyone else would have ever noticed. However, Dr. Jordan knew that claiming this support was not ethical, and he notified the other professor so he could claim what was due him. While this had some short term hurt (no income that summer) it has provided Dr. Jordan with the long term benefit of knowing he has done the right thing.

Example of changes in N.S.P.E. Code

The N.S.P.E. code has been changed over the years. Sometimes this change has been voluntary, but they have been forced to make changes at other times. This section describes one of these forced changes. The following is a direct quote from the N.S.P.E. code:

"By order of the United States District Court for the District of Columbia, former Section 11(c) of the NSPE Code of Ethics prohibiting competitive bidding, and all policy statements, opinions, rulings or other guidelines interpreting its scope, have been rescinded as unlawfully interfering with the legal right of engineers, protected under the antitrust laws, to provide price information to prospective clients..."

Statement of NSPE Executive committee
In order to correct misunderstandings which have been indicated in some instances since the issuance of the Supreme Court decision and the entry of the Final Judgment, it is noted that in its decision of April 25, 1978, the Supreme Court of the United States declared: "The Sherman Act does not require competitive bidding"

1. Engineers and firms may individually refuse to bid for engineering services...

4. State societies and local chapters are free to actively and aggressively seek legislation for professional selection and negotiation procedures by public agencies.[6]

Human codes of engineering conduct do change, since they are fallible instruments. While the circumstances of how we apply the Bible may change, the Bible (and its standards of behavior) does not change. This is shown in Isaiah 40:8

The grass withers, and the flowers fall, but the word of our God stands forever.

Since the Bible does not change and the codes do change, we believe that what the Bible says is more important than what the code says.

The above N.S.P.E. quotation is interesting for another aspect. The society was forced by a federal court order to change their code and no longer call the practice of submitting competitive bids an unethical act. However, it is clear that the society has not really changed its opinion. While it cannot officially call competitive bidding for engineering services unethical, it still clearly urges engineers to not practice it. The code appears to be trying to do two things at the same time. There is a behavior that it cannot call unethical, but it still urges engineers not to do it. They completely ignore the issue of how can something be ethical (as determined by the court) but still bad to do (as determined by the society). This section clearly shows the fallibility of the codes of conduct. They do change (sometimes voluntarily and sometimes by force). As this example makes clear, even when the words do change, sometimes the basic attitudes do not change.

Conclusions

The Bible was written in a pre-technological time and cannot be directly used to make decisions on technology. However, the Bible does provide us with insight into how we should practice engineering. The engineering codes of conduct, while reasonable in many respects, contain some statements that cannot be justified by Biblical teaching. When faced with a difficult decision, a Christian engineer should consult both the code and the Bible before making a final decision.

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Christian Mission Opportunities in Engineering Education

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Introduction

A important topic for Christian Engineering Educators is how to instill Christian influence in Engineering Education. This paper is about Globalization of Christian influence in Engineering Education and covers opportunities for Christian Engineering Educators overseas. It begins with a short discussion on the biblical background for involvement internationally as Christian believers with biblical examples of an early "missionary" with a secular work situation.

Certainly of initial importance when looking at global opportunities for Christian Engineering Educators, it is important to understand that there is a biblical mandate for reaching out beyond our own geographic borders and our emotional comfort zones to minister to and share with others who are not just like us. We see this example in Jesus' commission to His own disciples instructing them as recorded in Acts 1:8 that they would: "...receive power when the Holy Spirit has come upon you; and you shall be My witnesses both in Jerusalem, and in all Judea and Samaria, and even to the remotest part of the earth." They were to begin where they were in their own city, their own nation, then a nearby but religiously different neighbor and then into all the world. We also as Jesus' disciples today should be ready to share with others where we are and then slowly outside just our own immediate circle of contacts to others geographically or culturally distant from us.

Biblical imperative

Jesus clearly indicated that His disciples were to go into all the world and preach the gospel to everyone. In Mark 16:15 it is recorded: And He said to them, "Go into all the world and preach the gospel to all creation. Again in Matthew 28:18-20 it says "And Jesus came up and spoke to them, saying, 'All authority has been given to Me in heaven and on earth. Go therefore and make disciples of all the nations, baptizing them in the name of the Father and the Son and the Holy Spirit, teaching them to observe all that I commanded you; and lo, I am with you always, even to the end of the age.'" So clearly we have a biblical commission, no, more than a commission: a Biblical imperative, as a collective (i.e. greater) body of Christ for taking the message of the gospel to all nations.

Thus we have the command to take the Gospel to other nations. How are we to do that? Can we as Christian Engineering Educators use our training as part of a mission to another country? We see in the life of Paul a Biblical example of secular work in the context of a Gospel mission.

Biblical example

The apostle Paul was probably the most tenacious of the early apostles as he traveled widely and spoke forcefully throughout the Roman world. In some of the cities where he resided he took up his profession of making tents. It seems that he did this for several reasons. One reason was to provide for his own material, physical needs and for the needs of those traveling and living with him. This is explained in Acts 20:33-35 where Paul states: "I have coveted no one's silver or gold or clothes. You yourselves know that these hands ministered to my own needs and to the men who were with me. In everything I showed you that by working hard in this manner you must help the weak and remember the

words of the Lord Jesus, that He Himself said, 'It is more blessed to give than to receive.'" Did Paul really not have enough money provided to him through other believers? It is possible. But Paul was doing more than just providing for his own needs, he was also providing a living example of what the other believers should be doing.

As we go overseas with a primary purpose of sharing the Gospel of Christ, we also can by our own example of working in a secular teaching capacity, provide a good model for national believers to follow. In many poorer countries, especially those with a majority non-Christian religion, it is common for young believers to desire to become full-time Christian workers. This is many times because they cannot find any other job. Sometimes they cannot find a job because they are Christian in a primarily non-Christian country. However, the example of every new believer becoming a full-time, paid Christian worker is not a self-sustaining model for the third world church. It is really not even a viable model for the western world! Paul saw this potential problem and exhorted the Thessalonians to have a job and to work with their hands. He wrote in 1 Thess 4:11-12 "and make it your ambition to lead a quiet life and attend to your own business and work with your hands, just as we commanded you, so that you will behave properly toward outsiders and not be in any need."

Going in this capacity in a secular teaching position you actually have at least two advantages over a preaching missionary! 1. You have an opening with a type of people who may not listen to a preacher but will listen to you as a secular person. They see an evangelist as one who is paid to do his job; but you are sharing your faith from personal conviction, not because you are being paid. And, 2. like seeds, we tend to reproduce after our own kind. If we are in full-time Christian work, we can easily produce young disciples who want to go into full-time Christian work, because that is what they see us doing. But if we are working in a regular job, those nationals that we influence for Christ will also be motivated to have a wage-earning job, and still share their faith naturally as the overflow of their lives with Jesus.

Short History of Engineering Involvement in 3rd World

In years past, western engineers, many times Christian engineers, would work in Developing Countries doing engineering projects to develop physical infrastructure and needed buildings. These projects included roads, bridges, hydro-electric projects, school buildings, hospitals, industrial development, and an unending list of engineering projects designed and usually built by western engineers.

In time nationals were slowly taken on as assistants in building projects thus learning and earning a living as they gained a useful skill. More recently in many countries, there has been an explosion of engineering education and enlightenment on the part of government officials and funding agencies that national professionals need to be trained and hired in larger multinational and governmental projects. Rather than having outside professionals come in and provide a service, countries want to see their own professionals educated, trained, experienced and working. Thus in recent years there has become a need for more national engineers in many developing countries and a corresponding increase in the number of engineering colleges to train this new manpower pool. The last decade in Nepal has shown a rapid increase in the number of schools of engineering. Until 1992 there was only one bachelor level engineering school in the entire country of Nepal. By early 2002 there were more than six engineering colleges just in Kathmandu Valley. In India the number of colleges offering architecture on the curriculum has increased more than five fold in the last ten years. There are now over 100 schools of architecture in India.

Globalization, industrialization, rapid rural to urban migration, and rapid growth of economies are reasons for the increased need for engineers in developing countries. The fact that national engineers are increasingly used in development projects funded by outside organizations is another reason that more national engineers need to be trained.

Much of the increase in engineering education in these developing countries has come through private colleges. This may be that governments are usually not as quick to read the times as private institutions. Most of these are for-profit institutions which shows the market demand for this type of education. In many countries these private colleges have permission from the government to hire professionals from overseas though the number of outside professionals may be restricted and monitored. So we see in recent years an increased demand for engineering educators in the 3rd World.

Present Mission Realities

Most difficult entry to least reached nations.

Globally we generally find the most restricted access for Christian missionaries to the least evangelized countries. Newer national governments are not as open to foreign Christian missions as their colonial predecessors. This is only to be expected. Those countries that traditionally have small Christian populations naturally have large numbers of their population adhering to other major religious groups. In a primarily Muslim country, for example, the people and the government are not going to be anxious for an influx of Christian missionaries. Thus the simple fact remains that the countries with the fewest Christian believers generally have the fewest missionaries and also have the most restrictions on entry of Christian missions.

India is a prime example. During the days of British colonization, India was open to western missions because of the rule of the British Raj, not because of the desire of the Indian people. When the elected national government got their feet on the ground and the economy began to grow, the government was quick to begin restricting the entry of non-Hindu missionaries. Though there are a few exceptions, generally new missionary visas have not been available in India since the 1960's.

Some of the least reached peoples are the most wealthy and educated.

A second mission reality (evident in Nepal, but also generally in many Third World countries with new Christian growth) is that much of the response to the Gospel message is among the lower social and economic sectors of society. The Gospel has not successfully penetrated the higher castes and economic groups.

New Ministry Paradigm for Engineering Educators

Summary of the situation. The majority of the world's poorer countries are generally also places with small Christian populations. Access for Christian missions is generally restricted to these countries though there are considerable physical needs. And, in these countries the greatest spiritual need (by this I mean the greatest percentage of unresponsive people among the people groups of the country) is among the higher economic and social groups. Because of rapid economic growth and a slightly reduced use of foreign engineers, there is an increased need for national engineering professionals. This need for national engineering professionals has given rise to a growing number of engineering schools and a corresponding increase in the need for qualified engineering educators. So we see that in the very place ordinary missionaries are having increased difficulty in gaining entrance, engineering educators have increased opportunities.

Preview of the prospects. In the midst of these new mission realities, let me give you one exciting new ministry paradigm that will both provide access to difficult to enter countries and help you reach the least reached social segments of society in developing nations. In the colonial era of missions and following into recent times, missionaries and mission agencies have come into a country, just as our colonial mission forefathers, with a superiority as well as a service mentality. We felt good about giving out aid and using our professional expertise to help those in need. However, in providing people with fish, we did not teach them how to fish to provide for themselves. Just as teaching people to fish is a

good mission strategy in a spiritual ministry (making disciples who can reach others rather than just making converts who are dependent upon you) it is also a good strategy in professional engineering service to developing countries. As we teach nationals to become competent engineering professionals, we provide them with usable skills that can help them to provide engineering services to their own people. In the close teacher-to-student relationship over four-year training period for a professional degree, we also have the opportunity to share our lives and the gospel that can bring real improved "quality of eternal life".

Personal Benefits

Besides just being a service and a ministry to others, teaching in a third world situation can provide many benefits for the Christian Engineering Educator as well. You will very like find that you will gain more than you give as you live and work in a Third World situation. It will help you to really think through and re-evaluate many aspects of your life. The contacts you gain teaching overseas can provide opportunities for your U.S. based students to visit Third World countries for study or ministry or service. Teaching overseas will also open opportunities for student and faculty exchange which can greatly benefit the sending as well as the receiving institutions.

In summary we see the following opportunities for Engineering Educators in the Third World:

Engineering Education opportunities in 3rd world not new but are increasing

- Teaching in the field of Engineering Education can provide access to restricted countries
- Teaching Engineering can allow close relationships with students from the least evangelized sections of society

Teaching in a Third World environment can rejuvenate your own North American Engineering programs:

- Own experience is enhanced; world view, appropriate technology
- Opportunities for your students to go overseas
- Opportunities for foreign students to come to your college
- Opportunities for faculty exchange between colleges

Though there are many opportunities for teaching engineering in Third World countries, there are many practicalities which may influence your desire or ability to teach overseas.

Practicalities Teaching Internationally

Language. One very good question you may have is, "What language would I have to teach in?" English very common as teaching medium in even non-English speaking countries. Some countries using English as a major language in teaching of technical subjects include: India, Pakistan, Nepal, Sri Lanka, Myanmar, Malaysia, Philippines, Hong Kong. Even Thailand has at least one English language speaking technical university. Most countries in Africa use either English or French as the language of instruction in university. English is the most used language of instruction for technical education in the world.

Financial Considerations. In many of the poorer countries your salary as a full-time teacher will not be on par with your North American salary. My personal experience in Nepal was that my full salary as a senior professor barely covered just my rent for housing. By the way I was staying in an upstairs flat with the landlord on the ground floor – not a palace by any means. There are some countries that would be classified as major mission targets that also have good economies and remuneration for a western trained engineering educator could be even higher than what you are getting now. Examples of these types of countries would be several Middle Eastern countries (Saudi Arabia, Kuwait, etc.) and East Asian countries with oil or money like Brunei or Taiwan. It would be fair to say that few developing country opportunities would be a break-even financial situation.

Finding Opportunities. You will need to look for specific opportunities that meet your expertise, availability and interest. In much of the world it is not just what you know, but who you know. One good place to start is asking international students on your campus about education opportunities they know about in their home countries. Another source is talking with nationals from different countries at conferences or writing to them when you read journal articles by them. Of course the Internet is always a good place to start. Even educational institutions in Nepal have information that can be found online.

Finding the time: Short-Term or Long-Term. How long should you plan to stay? In recent years short-term mission opportunities have been a major benefit to those seeking to find out what missions is all about. In a teaching position you can go from as short as one or two days to several years and be of help to others as well as learning much yourself. For many it may be beneficial to go initially for a short-term experience, possibly two to four weeks, and then after evaluation consider a longer term teaching position in the future. For many professors sabbatical time is a great opportunities for investing your experience in areas of greatest academic need.

Family Considerations. Should your family go with you? This certainly is dependent upon many personal considerations and different family situations. I would certainly encourage you to take your family whenever possible as a Christian family ministers more effectively in a cross-cultural situation than just an individual. Because of language limitations and cultural misunderstandings, many times *who you are* communicates much more forcefully than what you say and the witness of a family speaks louder than the voice of an individual. Going overseas is not a death warrant for the life of your children. It is, rather, a broadening educational experience.

Political, Social or Economic Factors. One thing you will find is that most of the educationally and economically needy countries of the world are not very stable politically or socially. Many of the countries I have already mentioned are not always politically stable or safe. Recently there has been a major kidnapping and recent death of western and national missionaries in the Philippines, a nuclear war threat between India and Pakistan, the bombing of American consulate in Pakistan, on-going civil wars in Nepal and Sri Lanka, and this does not begin to touch the AID's problem and civil strife in many African countries. In many of these countries you cannot necessarily make long term plans without planning to be flexible

God is not a God who can be out given. The more we give of ourselves and our possessions to God, the more He gives back to us. He says that the measure we use to give is the same measure that He uses to give back to us shaking it down, pressing His blessing down in the measuring cup to make sure that He is giving back more to us that we give to Him. (See Luke 6:38) As we give of ourselves in this type of ministry, even to our financial detriment, the Lord will give back to us far more than we ourselves give.

May God bless you as you consider how you can personally be involved in seeing the extension of God's Kingdom around the world.