Ethics in Science and Engineering
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2

Scientists and Engineers

2.1 Introduction

The scientific and engineering fields are composed of educated and relatively young professionals who have the ability to apply themselves to the problems at hand, either through theory studies or experimentation. To the scientist and engineer, the outcome of this work that offers some form of gratification is: (1) completion of a project and (2) publication of the data in a journal or similar medium for distribution to one's peers. The latter gives the scientist and engineer recognition for their work.

A scientist is a person who has scientific training or who works in the field of science. On the other hand, an engineer is a person who is schooled and trained as an engineer. The practical difference between the two lies in the educational degree and the description of the task being performed by the scientist or engineer. It is widely believed that scientists explore the natural world discovering new knowledge while engineers apply that knowledge to solve practical problems, often with an eye toward optimizing cost, efficiency, or other parameters.

Research in the scientific and engineering disciplines offers the exhilaration of discovery. In addition, researchers have the opportunity to associate with colleagues who have made important contributions to human knowledge, peers who think deeply and care passionately about subjects of common interest, and students who can be counted on to challenge assumptions. Also, scientists and engineers have many opportunities to work with different people to explore new fields and broaden their expertise, especially where disciplines overlap.

However, research in any technical discipline can entail frustration and disappointment as well as satisfaction even when an experiment fails or a hypothesis turns out to be incorrect. Instead of bemoaning the outcome of the experiment, the investigator should determine if the experimental design was correct (or poor), and then determine whether the collapse of a favored hypothesis or a modified hypothesis is more sensible and logical than the previous hypothesis.

Careers in science and engineering are endeavors that can improve people's lives resulting in knowledge that all people can share. As the techniques and products of science and technology have become more central to modern society, a background in science and engineering has become essential to a majority of careers. In fact, degrees in science and engineering are becoming as fundamental to modern life as the traditional liberal-arts degree. The contributions of scientists and engineers extend beyond research and development and reach into sectors of teaching, business, industry, and government.

Graduates with bachelor's, master's, and doctoral degrees in science or engineering are increasingly forming companies, managing businesses, practicing law, formulating policy, consulting, and running for political office. They are forming global communities of common interests that transcend the differences among individuals, corporate endeavors, or nations. Anyone contemplating a career in science or engineering can maximize the potential for success in any one of several ways.

It is important to remember that each science-oriented student is unique. His success will depend on going where his particular interests lead you. If the student is exhilarated by the challenge of a new problem, puzzle, or a need or if the complexity of the natural world prompts a desire for him to understand it better, science and engineering study, rigorous though it is, will provide the tools and concepts that are needed to achieve the goals.

The individual goals of each person will determine which academic degree is most appropriate. Many baccalaureate graduates find satisfying careers in a variety of positions after the bachelor's degree. Other baccalaureate graduates, notably engineers, find that a master's degree equips them well for professional careers. For those who hope for careers conducting research and/or teaching at the higher level, a PhD will likely be required. However, no degree guarantees lifetime employment; like professionals in other fields, it is likely the graduate will change jobs and even careers during his professional lifetime, perhaps even more than once. It is important to remember that science-oriented students are not all alike, any more than all artists or all politicians are alike. Success will depend on going where your particular interests lead you, the scientist or engineer.

A young scientist/engineer must persevere until he discovers whether the rewards and compensations of a scientific or engineering life are worth the disappointments and the toil of daily professional life. Once a scientist or engineer experiences the exhilaration of making new discoveries and the satisfaction of carrying through a really difficult experiment then he may be convinced that there is no other kind of life (Medawar, 1979).

Persons educated as scientists and engineers are meant to provide service to society via their development of original ideas, which are brought to fruition in the teaching, industry, business, and government sectors. Graduate students often exceed the thinking of their professors by creating new schools of thought in their respective fields. Both the students and the professor learn from each other, often the professor gaining the most knowledge.

A cohesive education system is therefore both as important as a source of future leaders in science and engineering, and as a source of new ideas. Countries should maintain the strength of the education system to sustain the creativity and intellectual vigor that will be needed to address a growing variety of social and economic concerns.

The efficacy of most national education systems originated in a series of governmental movements that were prompted by the major role that science and technology played in the outcome of World War II. As a result, in many of these countries, government agencies assumed an important role in funding basic and applied research. Furthermore, through this form of funding, researchers at universities throughout the country become major contributors to the nation's scientific research experts. In addition, programs are conceived that would involve industry as a partner. Research in universities is essential for modern progress, but if it is lacking the focus brought on by the needs of industry; the usefulness of such research should be questioned.

A person does not need to be exceptionally talented in the scientific or engineering disciplines to be a good scientist or a good engineer; however, common sense is a critical component for achieving success. The student's potential also depends on several attributes of good character and work ethic, such as:

1. application to the task at hand,
2. diligence,

3. a sense of purpose,
4. the power to concentrate, and
5. the ability to persevere and not be cast down by adversity (Medawar, 1979).

Individual goals will determine which academic degree is most appropriate for the young person about to enter academia. Many people find satisfying careers in a variety of positions after the bachelor's degree. Others, notably engineers, find that a master's degree equips them well for professional careers. For those who hope for careers conducting research and/or teaching at the university level, a PhD will most likely be required. No degree guarantees lifetime employment. Like professionals in other fields, the young scientist/engineer might still have to change jobs and even careers during his life, perhaps more than once.

Science and engineering are not only the collection of facts but also the treatment of facts to discover their arrangement and government; from this pursuit knowledge arises and as a result its applications. The pursuit of science and engineering requires, above all things, freedom of thought, freedom of interest, and unrestricted communication. The necessity of these conditions is undeniable.

The path to a scientific or engineering career is mentally, physically, and emotionally demanding. Not everyone has the perseverance to complete years of concentrated study, but the experience of doing scientific or technical work is supremely exhilarating for those with sufficient interest and determination. There may be many teachers, mentors, or colleagues who are willing to help the merging scientist or engineer; and to assist them with overcoming difficult hurdles, therefore, enabling them to gain confidence, to expand thinking, and to work independently.

However, adventurous observation and experiment may lead down winding paths, creating new boundaries that have many possibilities of interpretation. The paths in science and technology set by the professionals before us are not merely indications of known ground, but they create a cross-correlation of many observers' experiences.

So it has been the pride and delight of scientists to rejoice in their intellectual independence; which has resulted in an astonishing knowledge of great and little achievements. Very few scientists have capitalized financially on their knowledge because to do so could restrict progress by limiting the use of available information.

The freedom and independence of science and engineering has ordained the formations of societies to enable discussion and exchange of mutual interest. The production of society journals makes carefully digested knowledge available to whosoever will read them and so knowledge becomes disseminated openly for universal use.

It is the purpose of this book to help lay the foundation for a journey into science and engineering, no matter how many turns the path might take. Just how rigorous is the path to a scientific or engineering career? Graduate study, in particular, is demanding mentally, physically, and emotionally. Not everyone has the perseverance to complete years of such concentrated study. But the experience of doing scientific or technical (sci-tech) work is supremely exhilarating for those with sufficient interest and determination. And many people will be willing to help the student along the way and assist him over difficult hurdles as to gain the confidence to think and work independently.

2.2 Definitions

In this book, the term *scientists and engineers* refers to persons who wish to pursue, or those who have already attained, a master's degree or doctor of philosophy degree (or equivalent degree) in science or engineering.

Science is regarded as inclusive of the life sciences, physical sciences, mathematics, and social science (the scientific study of human society and social relationships). *Engineering* is viewed as a field that includes all specialties such as civil, mechanical, electrical, petroleum, and computer engineering. In all cases, the system of education of scientists and engineers should be organized around realistic experience.

Education is basic to achieving national goals in two ways. First, schools and universities are responsible for producing the teachers and researchers. Investigators in academia and industry lay the groundwork for the innovations of tomorrow.

By educating students in the context of research, the systems for the education of scientists and engineers have set national standards for preparing scientists and engineers for research careers in academia, government, and industry. Furthermore, by attracting outstanding students and faculty members (hopefully who have some understanding of the non-academic world) national systems have, to some extent, benefited from an infusion of both talent and ideas.

The increase in scientific and technological knowledge and the ways in which that knowledge is applied are fundamental to the pursuit of many general national objectives, including developing new technologies and industries, combating disease and hunger, reducing environmental pollution, developing new sources of energy, and maintaining the competitiveness of national industry.

Supposedly, at least in Western societies, science and engineering are regarded by many as the ultimate arbiters of objective truth (Ryan, 2002; Brown, 2003). However, there must be an intrinsic accountability that arises in the experimental. Experiments need to be repeated, discrepancies noted, and questions asked but while errors can be attributed to mistakes there is often no contemplation of fraud, either as an afterthought or deliberate. To get beyond such a hurdle, it is always advisable to encourage scientists and engineers to double check, triple check, and check their work *ad nauseam*.

Furthermore, any scientist or engineer who is requested to be a coauthor should ignore the data in next-to-final draft before publication (after the data have been massaged to look presentable) and check the original data.

Persons educated as scientists and engineers are meant to provide service to society via their development of original ideas, which are brought to fruition in teaching, industry, business, and government. Graduate students often go beyond the thinking of their professors and create a new generation of science and engineering thought. The student learns from the professor, but the professor, if he will admit it, also learns from the student.

A cohesive system of science and engineering education, therefore, is important both as a source of future leaders in science and engineering, and as a source of new ideas. Countries should maintain the strength of this system to sustain the creativity and intellectual vigor that will be needed to address a growing variety of social and economic concerns.

The efficacy of most national education systems originated in a series of governmental movements that were prompted by the major role that science and technology played in the outcome of World War II. As a result, in many of these countries, government agencies, assumed an important role in funding basic and applied research. Furthermore, through this form of funding, researchers at universities throughout the country became major contributors to the nation's scientific research expertise. In addition, programs were conceived that would involve industry as a partner. Research in universities is fundamental, but if such research lacks the focus brought on by the needs of industry, the usefulness of it must be questioned.

The dual role of the university-industry partnership was designed to benefit national goals by educating students through the active conduct of cutting-edge research and its application to industry.

With an increased spread of information and the global workforce, guidelines for the theme of the book, "Educating

Scientists and Engineers" can be obtained instantaneously around the world. This brings into question the impact of globalization. Jane Knight described globalization as, 'the flow of technology, economy, knowledge, people, values, and ideas across borders." Globalization affects each country in a different way due a nation's individual history, traditions and priorities.

For the education of scientists and engineers, globalization is an inescapable reality. It increases the flow of students from all parts of the world to get a better understanding of international conditions. Globalization is also visible in the current migration of engineering and science graduates from one country to another in search of better jobs and more affordable learning opportunities. This has created a condition of *brain drain* in some of the lesser developed countries such as India and the Republic of Trinidad and Tobago.

In general, there are two ways to contend with the forces of globalization. First, universities must adopt a defensive approach in order to protect its turf from outside educational forces that could have negative effects on teaching and learning. Second, universities must embrace globalization in an age of new opportunities to advance the outcome of quality scientists and engineers; thereby offering increased value to expertise and talent for national development.

2.3 Scientific Disciplines

Science (Latin *scientia*: knowledge) refers, in the broadest sense, to any systematic knowledge or practice. In a more restricted sense, science refers to a system of acquiring knowledge based on the scientific method, as well as to the organized body of knowledge gained through such research.

Fields of science are commonly classified along two major lines: natural sciences, which study natural phenomena (including biological life), and social sciences, which study human behavior and societies. These groupings are empirical sciences, meaning that the knowledge must be based on observable phenomena and capable of being proved through experimentation by other researchers working under the same conditions.

Mathematics, which is sometimes classified within a third group of science (called formal science), has both similarities and differences with the natural and social sciences. It is similar to empirical sciences in that it involves an objective, which is a careful and systematic study of an area of knowledge. It is different because of its method of verifying its knowledge and does not use empirical methods. Formal science, which also includes statistics and logic, is vital to the empirical sciences; although one should not always place implicit faith in the use of statistics as there may be pitfalls in the use of such methods (Huff, 1954; Gibilisco, 2004). Major advances in formal science have often led to major advances in the physical and biological sciences. The formal sciences are essential in the formation of hypotheses, theories, and laws, both in discovering and describing how things work (natural sciences) and how people think and act social sciences).

The history of science is marked by a chain of advances in technology and knowledge that complement each other. Technological innovations bring about new discoveries, bred by other discoveries, which inspire new possibilities and approaches to longstanding science issues. Investing capital in science and engineering is critical to ensuring a high quality of life.

Scientists and engineers are at the forefront of the development of scientific and technological innovations. The primary objectives of these professionals are to create and develop novel research that can be used to solve problems for both the population at large as well as individual entities such as companies.

Well into the 18th Century, science and philosophy were roughly synonymous. In fact, the preferred term for the study of nature was often *natural philosophy*, while English speakers most typically referred to the study of the human mind as *moral philosophy*. By the early 1800s, science had begun to separate from philosophy, though it often retained a very broad meaning. In many cases, it stood for reliable knowledge about any topic. It was often linked to a set of well-defined laws, not just of nature but among any phenomena. Over the course of the 19th Century, however, there was an increased tendency to associate science with the natural world (that is, the non-human world). This move sometimes left the study of human thought and society (social science) in a scientific limbo by the end of the nineteenth century and into the twentieth century.

Over the 1800s, many English speakers were increasingly differentiating science from all other forms of knowledge in a variety of other ways as well. For instance, the scientific method (i.e., used to explain the events of nature in a reproducible way, and to use these reproductions to make useful predictions) was almost unused during the early part of the nineteenth century. It became widespread only after the 1870s, though there was scarcely total agreement about just what it entailed. Similarly, discussion of scientists and engineers as a special group of people did not always emphasize the attributes of such education. Whatever was actually meant by them, such terms ultimately depicted science as something deeply distinguished from all other realms of human endeavor.

By the 20th Century, the modern notion of science as a special brand of information about the world, practiced by a distinct group and pursued through a unique method was essentially in place. Over the 1900s, links between science and technology also grew increasingly strong. By the end of the century, it is arguable that technology had even begun to eclipse science as a term of public attention and praise.

A *scientific discipline* is a particular branch of science. However, there is more to the definition.

In the early nineteenth century, anyone involved in science was generally labeled a *natural philosopher.* As the century progressed, science evolved into different disciplines and then into its current sub-disciplines that are now known collectively as *science.* At that time, science moved into the universities to avoid being dominated by technologists, who at the same time were enjoying a high degree of social status due to their successes during the industrial revolution. As science moved into the universities, German academics categorized the study of nature into physics, chemistry, biology, and geology (Grau, 1988). The academics also organized their university science administrative units the same way. Other universities worldwide followed Germany's lead and used the same categories to organize their own newly established science departments.

Towards the end of the nineteenth century, the high school science curriculum was developed in Europe and North America. It was only natural that this curriculum would be organized around the university's administrative units of physics, chemistry, biology, and geology. The *sub-disciplines* of science were established in the high school curriculum and they are now over one hundred years old.

Although science evolved into simple batch discipline of chemistry (also included biochemistry), physics, biology (composed of botany and zoology), and scientific disciplines are now much more diverse.

The current definition for a scientific sub-discipline is an academic discipline, or field of study, it is a branch of knowledge which is taught or researched at the university level. Disciplines are further defined and recognized by the journals in which research is published, and the learned societies and academic departments or faculties to which their practitioners belong. The *fields of study* usually have several sub-disciplines or branches, and the distinguishing lines between these are often both arbitrary and ambiguous.

In medieval Europe, there were typically four faculties (or colleges) in a university: *theology*, *medicine*, law, and arts. Arts had a somewhat lower status than the other three faculties. Modern university faculties have their beginnings in the mid- to late-nineteenth century popularization of universities, when the traditional curriculum was supplemented by non-classical languages, non-classical and literature, and by disciplines such as chemistry engineering, physics, and biology.

In the early twentieth century, new disciplines such as education, sociology, and psychology were added. In the 1970s and 1980s, there was an explosion of new disciplines focusing on specific themes, such as *women's studies* and *environmental studies* as well as a host of studies related to the ethnic origins of the various peoples of the world. Finally, the visibility of such interdisciplinary scientific fields as biochemistry and geophysics increased, as their contribution to knowledge became widely recognized.

Currently in academia, it is a growing practice to incorporate fields of study that are created by extending the ideas, theories, and methods of more traditional disciplines. Also, new times and revolutionary thinking can enhance or renew existing disciplines, or even create new disciplines altogether.

2.4 Engineering Disciplines

Engineering is the discipline of acquiring and applying scientific and technical knowledge to the design, analysis, and/or construction of works for practical purposes. Alternatively, engineering is also "the creative application of scientific principles to design, develop structures, machines, apparatus, manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design; or to forecast their behavior under specific operating conditions; all as respects an intended function, economics of operation and safety to life and property." (ECPD, 1941)

One who practices engineering is called an engineer, and those licensed to do so have formal designations such as Professional Engineer (PE) or Chartered Engineer (CE). The broad discipline of engineering encompasses a range of specialized sub-disciplines that focus on the issues associated with developing a specific kind of product, or using a specific type of technology.

Just as scientific disciplines can be said to span the alphabet, engineering disciplines also are many-fold and offer a wide choice of options. New sub-disciplines such as bioengineering, which combines biology and engineering, are thriving. Bioengineers work closely with biologists and medical doctors to develop medical instruments, artificial organs, and prosthetic devices.

The history of the concept of *engineering* stems from the earliest times when humans began to make clever inventions, such as the wheel, the pulley, and the lever. The exact meaning and origin of the word *engineer*, however, is a person occupationally connected with the study, design, and implementation of engines (Latin: *ingenium*, innate quality), especially mental power for the purpose of a clever invention. Hence, an engineer, essentially, is someone who makes useful or practical inventions.

From another perspective, a now obsolete meaning of engineer, dating from 1325, is "a constructor of military engines." Engineering was originally divided into military engineering, which included construction of fortifications as well as military engines, and civil engineering, involved in non-military projects, such as bridge construction.

One of the largest branches of engineering, civil engineering is a field that deals with buildings, bridges, dams, roads, and other structures. Civil engineers (who evolved from the ancient military engineers) plan, design, and supervise the construction of facilities such as high-rise buildings, airports, water treatment centers, and sanitation plants. Civil engineers will need to design the special rail beds for the magnetic levitation trains of tomorrow.

With the rise of engineering as a profession in the nineteenth century the term *engineering* became more generally applied to fields in which mathematics and science were applied to the industrial applications. Similarly, in addition to military and civil engineering the fields then known as the *mechanical arts* became incorporated into engineering.

2.5 Expert Witness

An *expert witness*, in the context of this book, is scientist or engineer who is called upon and agrees to present testimony to a court or other legal body.

Scientists and engineers increasingly are asked to serve as consultants who provide expert testimony in adversarial or potentially adversarial contexts (Speight, 2009). The focus of the case might be on the past, as in explaining the causes of accidents, malfunctions, and other events involving technology. Usually the scientist or engineer is hired by one adversary in the dispute, and that raises special ethical concerns about their proper roles.

Because of the complexity of science and engineering, the court system must rely on experts who earnestly try to be impartial in identifying and interpreting complicated data. Ideally, expert witnesses would be paid by the courts, rather than opposing attorneys, in order to counter potential biases. In practice, the high costs require that parties to the disputes pay for expert witnesses.

Some people are uncertain of the function of expert witnesses; do they play the role of an impartial communicator of truth or as the *hired gun*, who is a witness paid to tell only one side of the story? The role of the expert witness is to present the truth to the courts and not to act as an advocate for one side or the other and certainly not to act as a partial witness telling only that part of the truth that supports the arguments of the side paying him. Some scientist and engineers believe that the role of the impartial analyst (who states and assesses facts) and the advocate (who makes recommendations about responsibility and preferable options) is not altogether precise. This is a false belief.

Although the scientist or engineer might feel responsibilities to the attorneys who hire them, they have obligations to represent their qualifications accurately, to perform thorough investigations, and to present a professional demeanor when called to testify in court. Equally important, they have a responsibility of confidentiality, just as they do in other consulting and other related jobs. The guiding rule is to present the truth to the court. The truth is based on facts and the facts presented to the court are based on the ethics of the expert witness. Any scientist or engineer who cannot abide by such a rule is well advised not to take on the role of an expert witness or, if taking on the role, better understand the meaning of the word *perjury*, and be prepared to suffer the consequences.

It would be unethical for an expert witness to divulge the contents of their investigations to the opposing side of a controversy until required to do so by the courts or by the attorney who hired them. Most important (as previously mentioned) when called as a witnesses the scientist or engineer is not required to volunteer evidence favorable to the other side. They must answer questions truthfully, but it remains the responsibility of the attorney for the opposing side to ask pertinent questions.

Codes of ethics have only recently begun to clarify the roles of scientist and engineers in legal adversarial contexts, and as a result there has been some light shed upon the appropriate role of the scientist or engineer (Speight, 2009). It follows from the various codes of ethics that scientists and engineers must not take on the role of the *hired gun* who engages in distorting facts according to who pays the consulting fee.

Merely being paid by one side can exert a slight bias, which might influence the investigations, testimony, and even the presentation of qualifications of the scientist or engineer. The bias would increase substantially if the scientist or engineer was hired on the basis of contingency fees paid only if the case is won. The various codes of ethics notwithstanding, it is perceived that contingency fees in adversarial contexts would tend to bias the judgment of the expert witness.

In summary, as expert witnesses, the scientists and engineers should be completely impartial. Not only should the scientist or engineer conscientiously avoid any taint of bias and favoritism, but they should avoid any form of advocacy. The role of the expert witness is to identify all options and analyze the factual implications of each option (Speight, 2009).

2.6 Professionalism

Science and *engineering* are the disciplines of acquiring and applying scientific and engineering to the design, analysis, and/or construction of works for practical purposes.

A profession is any occupation that provides a means by which to earn a living. In the sense intended here, the scientific and engineering professions are those forms of work involving advanced expertise, self-regulation, and honesty (Martin and Schinzinger, 2005). Scientific and engineering professionals play a major role in setting standards for admission to the profession, drafting codes of ethics, enforcing standards of conduct, and representing the profession to others. Professionals should maintain high ethical standards and to do so brings the recognition traditionally associated with the word *profession*.

With the rise of science and engineering as professions, the terms became more generally applied to fields in which the sciences and mathematics were applied to the industrial applications. Similarly, in addition to military and civil engineering the fields then known as the *mechanic arts* became incorporated into engineering.

Professionalism entails a multiplicity of tasks and a variety of new roles; not all individuals occupying these roles of trust have been adequately prepared for and socialized to them. Actions are often collective, i.e., via team approaches to problem posing and problem solving, which can undermine individual responsibility. Indeed, the importance of recognizing the role of the society in contributing to incidences of research misconduct was noted during conference discussions (Chalk et al., 1980; Chalk, 2005). All of these potentially conflicting factors may make it difficult for a researcher to know with confidence what is ethically expected of him or her (Gorlin, 1986; Davis, 2002).

From another perspective, a now obsolete meaning of engineer, dating from 1325, is "a constructor of military engines." Engineering was originally divided into military engineering, which included construction of fortifications as well as military engines, and civil engineering, involved in non-military projects, such as bridge construction.

One of the largest branches of engineering, civil engineering is a field that deals with buildings, bridges, dams, roads, and other structures. Civil engineers (who evolved from the ancient military engineers) plan, design, and supervise the construction of facilities such as high-rise buildings, airports, water treatment centers, and sanitation plants. Civil engineers will need to design the special rail beds for the magnetic levitation trains of tomorrow.

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Chemical engineering, like its counterpart *mechanical engineering*, developed in the nineteenth century during the Industrial Revolution. Industrial scale manufacturing demanded new materials and new processes. By 1880 the need for large scale production of chemicals was such that a new industry was created, dedicated to the development and large scale manufacturing of chemicals in new industrial plants. The role of the chemical engineer was the design of these chemical plants and processes such as processing and treating of liquids and gases. Many chemical engineers work with petroleum and plastics, although both of these are the subject of independent disciplines. The sub-discipline *environmental engineering* also applies to certain areas of chemical engineering, such as pollution control.

Just as scientific disciplines can be said to span the alphabet, engineering disciplines also are many-fold and offer a wide choice of options. New sub-disciplines such as bioengineering, which combines biology and engineering, are thriving. Bioengineers work closely with biologists and medical doctors to develop medical instruments, artificial organs, and prosthetic devices.

The scientist and/or engineer may be required to establish that he has performed better insofar as the work can be established as better than that of any predecessor. Then the definition of "better" becomes an issue that detracts from the real issue – getting the best out of scientist and engineers. Put simply, "better" can mean: "a process for producing an improved product," "completion of a project under budget," or anything in between these two limits.

Therefore, the fundamental basis for deciding on achievement may be lost because of a complete misunderstanding of the nature of the work and its importance to the university or to the company. The fell effect of the contribution is lost in the argument of word definitions.

For the purposes of evaluating a scientist or engineer, there should be two critical objectives of an evaluation and these are recognition of the significance of the contribution and any ensuing objectives and the magnitude and significance of the impact of the contribution.

Suddenly, the young scientist or engineer sees that his work is being recognized as meaningful. Morality develops and the young professional is satisfied, for the moment! However, the issue remains of the means by which the impact of the contribution can be assessed.

The scientific and engineering fields are composed of educated and relatively young professionals who have the ability to apply themselves to the problems at hand, either theory studies or experimentation. To the scientist and engineer, the outcome of this work that offers some form of gratification is the completion of a project and the publication of the data in a journal or similar medium for distribution to one's peers. The latter gives the scientist and engineer recognition for their work.

In general, the professionals who are biased towards theory tend to produce data that are often abstract and the intellectual contribution is expressed in the form of theories with proof. As a result, publication on the proceedings of a conference may be the only outlet for their efforts after which publication in a reputable journal may be possible but only with considerable efforts, for various reasons, may not be possible at all. For the non-academic scientist and engineer, there is the medium of publication of their field's material compiled as a *company report*. This can be a worthwhile method for circulating one's work throughout the company. But, the importance of the work to the young scientist and engineer can, again, be diminished and the names of a supervisor and any other persons higher up the food chain should be included as co-authors.

Publication of data in the proceedings from a conference often results in a shorter time to print. This follows from the opportunity to describe completed or partly completed work before peer scientists and/or engineers and to receive a more complete review than the type of review that is typical for a journal. At a conference, the audience asks general and specific questions to the presenter that often provides recommendations for further work or a new line of investigation. Overall, this will help the presenter to finalize the document for publication in the proceedings (where the proceedings are published post-conference). On the other hand, one has to wonder of journal reviewers really pay attention to the salient points of the potential publication or do they merely look for errors in style and grammar. An answer that several readers may relate to is "all of the above." However in many academic reviews, statements are made that publication in the proceedings of a prestige conference is inferior to the publication in a prestige journal; without realizing or admitting that data presentation and publication, in many conferences are superior to an established journal.

Yet, publication of research data is not an open form of recognition for all scientists and engineers. Scientists and engineers employed in industry may be prevented from publishing their work because of a company policy related to proprietary material, which is a justified reason, or an arbitrary decision by a supervisor or a member of the company review committee, which is not a justified reason.

On the other hand, in academia, the young professional enters a department at the Assistant Professor grade. At this level, the Assistant Professor has little choice in terms of choosing teaching assignments and has administrative work thrust upon his shoulders, while the older tenured members of staff have the right to refuse such work without fear of reprisal. Yet, this is not the reason behind tenure.

Tenure was introduced to protect academic freedom in educational settings from the whims of politics – whether this is in the form of meddling from the outside or from the inside. Tenure was thus introduced to preserve academic autonomy and integrity because it was recognized that this was beneficial for the state, for society, and for academia. Tenure was not designed to allow faculty to refuse work!

A professor who holds tenure is virtually an impregnable fortress and cannot (without considerable effort and expense) be dismissed from his appointment. The appointment is essentially for life. Tenure has come under attack over the past three decades by those who want a more business-like approach to universities, including ending tenure, accountability, performance review, audits, and performance-based salaries (Hacker and Dreifus, 2010; Taylor, 2010).

In addition, the young Assistant Professor also has to acquire research funding and may even have to pass his reports/papers through a review committee prior to publication. This review committee will be made up of senior members of staff who, for many reasons that are often difficult to follow, can give the young professor a glowing performance report or a report that is somewhat less than glowing. It is at this time, if the latter is the case, that the young professor can feel that he is suffering rejection by one's colleagues.

The educated young professional scientist and engineer wonders if he is merely a pair of hands (for a overbearing supervisor, an overbearing department head or jealous colleagues) who is not supposed to be given credit for the ability to think and solve a problem. Performance suffers and, with repeated negativism towards publication, the young professional starts to lose interest in the organization.

Lack of recognition for hard and intelligent work is a killer and getting the best out of any such scientists and engineer becomes an impossible dream.

Publication of data in the proceedings from a conference often results in a shorter time to print, resulting in a partly completed review that is typical for a journal. At a conference, the audience asks general and specific questions to the presenter that often provides recommendations for further work or a new line of investigation. Overall, this will help the presenter to finalize the document for publication in the proceedings (where the proceedings are published post-conference). On the other hand, one has to wonder if journal reviewers really pay attention to the salient points of the potential publication or do they merely look for errors in style and grammar. An answer that several readers may relate to is all of the above. However in many academic reviews, statements are made that publication in the proceedings of a prestigious conference is inferior to the publication in a more prestigious journal, without realizing or being willing to admit that in relation to data presentation and publication, many conferences are superior to an established journal.

For the purposes of evaluating a scientist or engineer, there should be two critical objectives of an evaluation; these are (1) recognition of the significance of the contribution, and (2) the magnitude and significance of the impact of the contribution.

Finally, in addition to the traditional business-like approach, many universities would do well to adopt one of the most widely printed and quoted statements of business ethics in the world, *The 4-Way Test* from Rotary International (Dochterman, 2003). The *4-Way Test* was created by Rotarian Herbert I. Taylor in 1932, when he was asked to take charge of the Chicago-based Club Aluminum Company, which was facing bankruptcy. Taylor looked for a way to save the struggling company mired in depression-caused financial difficulties. He drew up a 24-word code of ethics for all employees to follow in their business and professional lives. The *4-Way Test* became the guide for sales, production, advertising, and all relations with dealers and customers, and the survival of the company was credited to this simple philosophy. The *4-Way Test* was adopted by Rotary in 1943 and has been translated into more than 100 languages and published in thousands of ways. The message is known and followed by all Rotarians and is as follows:

1. Is it the TRUTH?
2. Is it FAIR to all concerned?
3. Will it build GOODWILL and BETTER FRIENDSHIPS?
4. Will it be BENEFICIAL to all concerned?"

These four questions can act as a guide to dealing within academia and they also afford a means of consolidating one's ethical beliefs; whether it is in science, engineering, academia, or business.

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