4

Education of Scientists and Engineers

4.1 Introduction

Education is basic to achieving personal and national goals in science and engineering. Universities lay the groundwork for the scientists and engineers of tomorrow, but, in practice, this is not always the case as many universities do not make any great effort to teach the practical aspects of the various science and engineering courses (ACCN, 2003). The universities educate, to a point, future teachers and researchers but the extent of this education is often insufficient for life in the non-academic world. However, graduate scholarship and research are (supposedly) key contributors to meeting broad national goals of technological, economic, and socio-economic development (Knight, 2002).

Yet, academic cheating is a common phenomenon in middle schools, high schools, and colleges (Cizek, 1999; Evans and Craig, 1990a, 1990b; Leveque and Walker, 1970; Schab, 1991). In 1987, the California Department of

Educational groups labeled cheating an epidemic after finding that 75% of secondary school students reported that they had at some time cheated on school work (Schab, 1991). In addition, from the early 1960s through the 1990s, cheating among students increased (Baird, 1980; Schab, 1991), as if accompanying the tendency for parents to litigate against the school or university when a student is reprimanded for any unsocial or illegal activity.

Indeed, university students often report that they cheated more in high school than in college (Baird, 1980). There is also evidence that cheating is more widespread in high school than during middle school (Brandes, 1986; Evans and Craig, 1990b). This is unacceptable at any level of education, whether it be at the pre-high school level, the high school level, or the university level.

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.

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.

In spite of the examples presented below, some students do not cheat. Students, high in measures of honesty, report that they would feel an extreme level of guilt if they cheated. There appears to be a general consensus between students and teachers/professors as to reasons for ignoring cheating, which suggests a general impression of denial (Staats et al., 2009). This attitude of non-reporting is, in itself, a form of cheating.

It is the responsibility of the teacher/professor to confront cheating and misconduct head-on. It is these people, who are in the position of responsibility, who should recognize cheating and misconduct, and who must offer a suitable punishment as a deterrent.

4.2 The High School Experience

Evidence indicates that cheating is very common during adolescence (Anderman et al., 1998). A number of studies indicate that middle school environments are more focused on grades and performance than are elementary schools (Midgley and Urdan, 1995; Anderman and Midgley, 1997). As students move from elementary schools into middle schools, the increased focus on grades may lead some students to cheat (Anderman et al., 1998). In addition, the data also indicates that cheating was most prevalent among white males attending private schools. Furthermore, students who felt alienated from school were more likely to cheat (Calabrese and Cochran (1990).

On this basis, by the time the student reaches high school the tendency for cheating and misconduct may be a set pattern. The issue is related to the nature of the punishment, if any, for the student proven guilty of cheating. If there is no form of punishment or punishment is very light, such as a slap on the wrist, (and the records are usually dim or non-committal on this subject) the student enters or continues in high school knowing that he can progress through the school system using whatever means he choose. Fair means or foul.

Many students start thinking about the possibility of a career when their interest is ignited by a high-school or undergraduate teacher or some other role model (Sadler et al., 2006). This is the time to start meeting and talking with scientists and engineers in fields of interest. Science and engineering fields are prestigious fields of education and as they bring greater financial rewards to the graduates than arts and humanities and even the social sciences. These early contacts can be crucial in helping the students to navigate the terrain of science and engineering as they move through their career.

The standards of education require that students increasingly engage in inquiry-based, collaborative learning experiences that emphasize observation, collection, and analysis of data from student-oriented experiments. They also stress the importance of helping students learn about the relationships among the sciences and the relevance of science, mathematics, and technology to other realms of inquiry and practice.

Students from the United States have demonstrated a steady decline from the 4th through the 12th grade in their mathematics and science performance. By the 12th grade, American students rank near the bottom of every category for knowledge of both general and advanced levels of science and mathematics, compared with their counterparts in countries around the world.

Students who do arrive at college with what traditionally has been considered good preparation in science and mathematics may not have actually developed a real conceptual understanding or the ability to solve problems; particularly in mathematics and the physical sciences, when compared with students in other countries with similar educational backgrounds. Yet, at the present, in the United States, students with high exam scores in hand can sometimes avoid taking any further science or mathematics classes at the postsecondary level; therefore, allowing them to think about the subject matter more deeply.

If the mission of post-secondary education is to provide students with opportunities to experience and think about subject matter more deeply than they could in high school then allowing some students to complete or waive specific graduation requirements on the basis of high examination scores alone could be self-defeating to that mission, compared to awarding them credit toward the total number of credits required for graduation.

Requiring all students to complete introductory, interdisciplinary, or higher level courses, regardless of their intended major, would enable some of the best students in the university to experience and appreciate the wealth and breadth of the sciences that they otherwise might have missed during their high school years. In collaboration with the University Office of Admissions, departments should make clear how the various departments will regard students with high scores on these examinations; especially those who wish to use these scores to avoid taking college-level mathematics or science courses.

In the near future, students who have had a standards-based education at the pre-college level, where they engaged in inquiry-based, collaborative learning experiences, will expect to receive more of the same in their undergraduate science and mathematics courses. Postsecondary institutions that take the lead in offering undergraduate curricula of high value to all of their students not only will have highly successful graduates but also will attract the highest quality incoming students.

However, by the time the student enters the university system the trend for misconduct may have been initiated and even set. In spite of the care and attention supposedly showered on students in school, a recent survey shows that cheating in school continues to be rampant. In a survey of 30,000 students across the United States (Josephson Institute, 2009), the results showed that young people are almost unanimous in saying that ethics and character are important on both a personal level and in business, but they express very cynical attitudes about whether a person can be ethical and succeed. Moreover, an alarming number of students admitted to recently lying, cheating, or stealing.

A substantial majority, 64 percent, cheated on a test during a high school year, while 38 percent did so two or more times, up from 60 percent and 35 percent, respectively, in 2006. Students attending non-religious independent schools reported the lowest cheating rate (47 percent) while 63 percent of students from religious schools cheated. Responses about cheating show some geographic disparity: Seventy percent of the students residing in the southeastern United States admitted to cheating, compared to 64 percent in the west, 63 percent in the northeast, and 59 percent in the midwest. More than one in three (36 percent) said they used the Internet to plagiarize an assignment. In 2006 the figure was 33 percent (Josephson Institute, 2009).

In addition, more than one in four (26 percent) of high school students confessed they lied on at least one or two questions on the survey, and dishonesty on surveys usually is an attempt to conceal misconduct. Furthermore, despite these high levels of dishonesty, the respondents have a high self-image when it comes to ethics, 93 percent said they were, "satisfied with their personal ethics and character," and 77 percent noted that, "when it comes to doing what is right, I am better than most people I know" (Josephson Institute, 2009).

It can be argued that there are a variety of reasons why young people still engage in unauthorized use of published material, but one of them is that they just do not believe that copyright laws are morally justified. Instead, they see the benefit and the opportunities presented in easier sharing and distribution of works.

Such thinking is just an easy way out of hard work. Cutting and pasting material from the Internet or from a work by someone else is much easier than having to think through the problem and use individual thoughts to reach meaningful conclusions.

The social cost of such activities is high and the pathway is made for cheating in adult life, through the baccalaureate experience and various advances degrees to work as a professional (Carpenter et al., 2004). There are also implications for the next generation of scientist and engineers.

In a society that is currently (and may always have been) saturated with cynicism, it is easy for young people to justify faulting copyright laws and other forms of misconduct on the basis that everyone else does it – although it does seem that females students are less likely to engage in misconduct than male students (Becker and Ulstad, 2007). Perhaps these are the same young people who criticize the older generation for laxity and the onset of global climate change.

As a final note on the issue of cheating and misconduct at the high school level, cheating on an assignment and/or during an examination hinders learning. While many students cheat on assignments their actions are not looked upon as cheating but as means of learning (Kohn, 2007). Surely this is a meager excuse and only a poor means of justifying cheating. On the other hand, cheating in an examination may also be considered a means to an end that will cease once the student is entrenched in the university system – but this is not the case.

4.3 The Baccalaureate Experience

The baccalaureate degree is the bachelor's degree and carries a, designation related to the broad subject area such as BSc (Bachelor of Science), BEng (Bachelor of Engineering), and so on. In many European countries, the majority of Bachelor's degrees are now honors degrees. Until the mid-20th century, some candidates would take an *ordinary* degree, and then be selected to go on for a final year for the *honors* degree.

A first degree course is usually three years, but it might be reduced to two either by direct second year entry (for people who have done foundation degrees or changed subject) or by doing compressed courses (which are being piloted by several newer universities).

Ordinary degrees are unclassified degrees awarded to all students who have completed the course and obtained sufficient marks to pass the final assessments and examinations. Although ordinary degree courses are often considered to be easier than honors degree courses, this is not always the case, and much depends on the university attended and the subject being studied. Some modern universities offer the opportunity for ordinary degree students to transfer to an honors degree course in the same subject if an acceptable standard is reached after the first or second year of study.

Honors degrees are of a superior academic standard and is awarded in one of four classes depending upon the marks gained in the final assessments and examinations. The top students are awarded a *first class degree*, the next best, *an upper second class degree* (usually referred to as a 2:1), the next a *lower second class degree* (usually referred to as a 2:2), and those with the lowest marks gain a *third class degree*. An *ordinary* or *unclassified* degree (which does not give the graduate the right to add *(Hons)* may be awarded if a student has completed the full honors degree course but has not obtained the total required passes sufficient to merit a third-class honors degree. Alternatively a student may be denied honors if he has had to retake courses.

Many universities in the United States award bachelor's degrees with Latin notifiers, usually (in ascending order): *cum laude* (with honor/praise), *magna cum laude* (with great honor/praise), *summa cum laude* (with highest honor/praise), and the occasionally seen *maxima cum laude* (with maximal honor/praise). Requirements for such notations of honors generally include minimum grade point averages

(GPA), with the highest average required for the *summa* distinction (or *maxima*, when that distinction is present).

Baccalaureate degrees in the United States are typically designed to be completed in four years of full-time study, although some programs (such as engineering or architecture) usually take five, and some universities allow ambitious students (usually with the help of summer school) to complete them in as little as three years. Some universities have a separate academic track known as an *honors* or *scholars* program, which is generally offered to the top percentile of students (based on the grade point average), that offers more challenging courses, more individually-directed seminars, or research projects in place of lieu of the standard curriculum. The students are awarded the same bachelor's degree as students completing the standard curriculum, but with the notation *in cursu honorum* on the degree certificate. Usually, the above Latin honors are separate from the notation for this honors course, but a student in the honors course generally must maintain grades worthy of at least the *cum laude* notation.

If the student has completed the requirements for an honors degree only in a particular discipline (e.g., Chemistry), the degree is designated accordingly (e.g., BSc with Honors in Chemistry). In this case, the degree candidate will complete the normal curriculum for all subjects except the selected discipline. The requirements in either case usually require completion of particular honors seminars, independent research at a level higher than usually required (often with greater personal supervision by faculty than usual), and a written honors thesis in the major subject.

Advances in technology and expanding roles create complex ethical and moral dilemmas for many professionals, especially scientist and engineers (Martin et al., 2003). Having come through a high school system where unethical behavior may be rampant, modification of personal values and of professional scientific and engineering values are both important parts of ethics development in university education. Course content related to essential moral and ethical dilemmas is not routinely included in formal scientific and engineering curricula, but may be taught informally through unplanned discussions with various professors and, even then, individual professorial insights into ethical and/or unethical behavior would vary.

Teaching or instilling values of research ethics ideally falls at the department level and some universities offer a stand-alone course for students to meet federal standards for grant (funding) applications. However, it is often the case that no one assists the students and trainees to understand the subtler and more common ethical problems, especially when the focus of the course is the extreme behavior that counts as research misconduct (Ritter, 2001).

The academic culture of a department is a combination of intended and unintended outcomes that emerge from each of the facets of departmental organization. The nature of the ethical environment depends on how this impacts at the individual level. Academic leaders are basically mandated to enforce policies, rules and regulations. The manner in which that is done depends on the administrative style of academic leaders.

Despite the various theories of management, management in practice can be conceptualized as: (1) operational, focusing, and monitoring of day-to-day activities, and (2) coordinating objectives, strategies, resources and evaluation in a manner that would enhance individual-level competencies and performance. In the absence of such a focus, individual and departmental level activities can become caught in a quagmire of routine activities that may/may not be punctuated by individual-level achievements amidst deteriorating levels of staff morale.

In another scenario, communication and decision making procedures are important. For both of these functions, the formal and informal dimensions must be woven together.

Any attempt to peripheralize one dimension would provide space for a simultaneous: (1) resistance and a hardening of views, and (2) space for the other dimension to blossom.

The values of the scientific and engineering professions are found in their relevant professional code of ethics, but students at the baccalaureate level are not introduced to such codes of ethics until they graduate and decide to become members of their respective societies.

The universities, colleges, and engineering institutes in the United States enroll a larger proportion of young adults than in any other nation. Half of these students will eventually receive bachelor's degrees. For the last three decades, approximately one third percent of bachelor's degree recipients (that is, about 15 percent of each high school graduating class) received their degrees in science or engineering. In recent years, about one-tenth of these bachelor's-level scientists and engineers have gone on to earn science or engineering doctorates. But the question is, outside of religious institutions, "how many of these students have received any formal training in ethics, honesty, and moral behavior as applied to the practice of their scientific and engineering disciplines?"

Many baccalaureate students lack any form of competency in ethical decision making, as it is not an identified expectation of the baccalaureate degree graduate. Values, both personal and professional, do not provide a systematic foundation for ethical decision making. An understanding of ethical principles and theories as well as application of them to the role of the professional scientist and engineer is lacking. The simplest format for presentation of such a course could include ethical theories and principles and their application to the practice of science and engineering.

Placement of separate required ethics courses remains an issue because of the overwhelming amount of content in baccalaureate degree curricula. If ethics content is integrated throughout the curriculum, it should be presented early with continual reinforcement and with the use of a specific ethics textbook. Research indicates that students who have completed an ethics course not only know the correct ethical action but are more likely to implement it. In fact, an understanding of ethical principles and theories as well as application of them to the role of the professional scientist and engineer is essential to ethical decision making in professional practice (Gaul, 1989).

Although 30 percent of baccalaureates are awarded in science and engineering, the relative popularity of different fields has shifted substantially with events in the job market of the last three decades. Increasing college enrollments meant more science and engineering baccalaureate recipients. In contrast, the proportion continuing on to PhD study reflects market demand, the availability of research and development funds, and direct student support.

Most fields of graduate study in the sciences, as distinguished from engineering, are oriented toward the academic as well as the industrial job market; somewhat less than half of PhD scientists work in academic institutions. The PhD is the basic professional degree in most fields of science, and most science students seek research or teaching positions. Despite growing undergraduate enrollments from the late 1960s to the present, a stagnant academic job market and slower growth in federal and commercial research funds have left many young PhD awardees underutilized.

Full-time graduate enrollments in science and engineering have grown in the past decades at many universities, but if not for the influx of foreign graduate students these enrollment increases would have been substantially less. Retirements and turnover of faculty in the mid-1990s, combined with resurgence in undergraduate enrollments later in the decade, offered some relief to these pressures. As a result, the attractiveness of an academic career is still the path forward for many students.

In addition, many institutions, beset by a tenured faculty, continue to hire faculty, even in difficult economic times, which turns into a job for life and involves teaching only a few hours a week and routinely take off an entire year in the name of sabbatical leave while being paid $100,000 or more per year (Shea, 2010).

In engineering and some fields of science, the bachelor's or, increasingly, the master's degree is the most important professional degree. The employment markets for these fields are dominated by industry rather than academia. Because their periods of training are shorter, enrolled students can react more quickly to employment opportunities. These fields, not coincidentally, have been the ones that experience enrollment and employment booms, and subsequent downturns. When there is a downturn, faculty shortages develop. However, foreign faculty have proven vital to maintaining teaching capacity in these fields since US citizens have generally seek high-paying baccalaureate-level industrial employment, rather than graduate study in pursuit of faculty positions.

The undergraduate-baccalaureate years are probably the best chance for the student to take a broad variety of classes outside the primary discipline that might be useful later; such classes could include subject matter related to ethics, honesty and moral behavior during the practice of the profession be it in industry or academia. In addition, classes in sociology, history, philosophy, English (with emphasis on composition), foreign language, and psychology, spread through the undergraduate years are useful in helping a student to acquire understanding, different experiences, and professional maturity.

Students are inundated with ethical questions and choices, the most frequent are whether or not they should behave ethically during testing, participate in unauthorized group homework, and/or plagiarize from the Internet (Szabo and Underwood, 2004). Many factors influence students' decision making processes. Variables related to cognitive development and environment affect how they choose to behave (Bandura, 1991; Love and Simmons, 1998).

An effective way for students to learn about undergraduate education in ethical issues is to join (or form) a study group to share concerns (Nadelson, 2007). In a university setting, the student will meet with undergraduate students, graduate students, and postdoctoral researchers and gain valuable insights. The students can also join student chapters of scientific and engineering disciplinary societies, such as the American Chemical Society and the American Institute for Chemical Engineers. These can help the students gain leadership and communication skills and can often assist in networking with senior members who can provide advice and possibly an ethical understanding of what professional practice involved.

Evaluating behavior also means dealing with attitudes. Some faculty members and students are assigned to lower status non-research jobs for people who have PhD degrees. As a result, PhD students who plan for such jobs might be told that they are wasting their education or letting their advisers down. That attitude is less prevalent in some professions, notably engineering and some biology-related fields, where non-academic employment is the norm. Also, negative attitudes toward nonacademic employment are often less evident during times of job scarcity. Given this scenario, it is necessary to remember that a wide variety of positions can be as ethically challenging and gratifying for PhD scientists and engineers as traditional research positions.

Furthermore, changes have swept through the universities. For example, there are strong public pressures for universities to shift their emphasis toward teaching and toward the teaching-learning process and developing critical thinking skills. The number of positions for permanent faculty has decreased, professors are no longer required to retire at a particular age, and more part-time and temporary faculty are being employed as adjunct professors or as visiting professors. As this occurs, the temporary faculty members bring with them a view of the outside world that may be an ethical eye-opener to many undergraduate and graduate students.

At the same time, the student should be introduced to the concept of teamwork, the concept of people working together cooperatively as a team in order to accomplish the same goals/objectives. Projects often require that people work together in order to accomplish a common goal. Although critics often argue that in the corporate world teamwork has become an empty buzz-word or a form of corporate-speak, effective collaborative skills are necessary to work well in a team environment.

Teamwork aligns mindsets in a cooperative, and usually selfless manner towards a specific business purpose, and it involves sacrifices, sharing of rewards, sharing the blame and punishments, true uniformity, suppression of personal opinions, etc., which is not very palatable to many. Businesses and other organizations often go to the effort of coordinating team building events in an attempt to get people to work as a team rather than as individuals. Universities are less conscious of teamwork where every professor is his own island with much authority but willing to accept little responsibility.

Thus, there can be instances where work submitted by a candidate for assessment contravenes the standard academic practice of clearly acknowledging all ideas and words of other persons without the candidate having made a deliberate attempt to gain an unfair advantage. For example, where a candidate has not used some means of indicating a quotation, but has cited the source of the text in the bibliography or in a footnote. This may be designated as a case of this type of an academic infringement and not unethical practice. Unethical practice can be designated as behavior that results in, or may result in, the candidate or any other candidate gaining an unfair advantage in one or more assessment components.

Malpractice or misconduct (OSTP, 1999.) includes the following:

1. plagiarism, which is the representation of the ideas or work of another person as the candidate's own,
2. collusion, which is supporting malpractice by another candidate, as in allowing one's work to be copied or submitted for assessment by another,
3. duplication of work, defined as the presentation of the same work for different assessment components and requirements, and
4. any other behavior that gains an unfair advantage for a candidate or that affects the results of another candidate. For example: taking unauthorized material into an examination room, misconduct during an examination, falsifying a record, or disclosure of information to and receipt of information from candidates about the content of an examination paper within twenty four hours after a written examination.

Throughout all of this, it must be recognized that the faculty can exert significant influence in the classroom environment and thus influence student behavior (Mandelson, 2007). Both internal and external factors influence the decision-making processes relating to inappropriate behavior (Pulvers and Dierkhoff, 1999). Dishonest students found their classes to be impersonal and less satisfying; they also felt that they received less individual attention than more honest students. It is quite possible that such lack of attention from the professor reduces the interest of the student in the professor and the course and gave the students the means to justify misconduct.

The primary reasons for cheating include lack of motivation, desperation, and the pressure to obtain good grades. Statistical analyses show that although students with a grade-point average in the range of 2.4 to 3.0 were more likely to cheat on assignments (Vician et al., 2006).

It might be added, that the professor who is not fully engaged and is teaching under pressure is the causal agent or the initiator of such behavior, but the tendency for misconduct was probably already lurking in the nether regions of the student's mind. Perhaps it is the lack of interest and lack of motivational speaking leads the student to cheating. There are reasons to indicate that relationships do exist between motivational variables (or lack of motivation) and cheating (Newstead et al., 1996).

However, the real issue remains, although not often publicized, which is the fate of students who cheat and the university's policy towards cheating.

In the pre-internet days at the university copying a paper directly from a book was looked down upon to the same extent as cheating on an exam.

Cheating on an exam was frowned upon to the extent that if the exam was a minor subject the student was given a failing grade with an option to take the exam again at a future date. If the student refused the option, he was expelled from the university. If the exam was on a major subject, the student was immediately expelled from the university. Excuses were not accepted (cheating was cheating) and there was no second chance to take the exam again.

In summary, the scientist and engineers are unique professionals, and as such are faced with ethical decisions of professional practice that are derived from and are relevant to that role.

4.4 The Graduate Degree Experience

A Master's Degree is an academic degree granted to individuals who have undergone study demonstrating a mastery or high-order overview of a specific field of study. Within the area studied, graduates possess advanced knowledge of a specialized body of theoretical and applied topics, the ability to solve complex problems, and to think rigorously and independently.

The two most common types of master's degrees, in the current context, are the Master of Science (MSc or MS) and the Master of Engineering (MEng or ME), which may be course-based, research-based, or a mixture of the two.

A master's degree generally entails two years of coursework and, hopefully, some laboratory work although some universities offer the master's degree by course work without practical or laboratory work. Some master's degree programs require a research thesis, others do not. In the latter case, the master's degree is not so much a terminal degree as recognition of the coursework and qualifying examinations completed after about two years in a doctoral program.

The typical PhD program constitutes a two-part experience of great depth and intensity that should last four years. The first part consists of about one to two years of course work while the second part focuses on a doctoral dissertation based on original research that might take two or three years or more to complete. The dissertation, as a demonstration of ability to carry out independent research, is the central exercise of the PhD program. When completed, it is expected to describe in detail the student's research and results, the relevance of that research to previous work, and the importance of the results in extending understanding of the topic.

A properly structured requirement for demonstrated ability to perform independent research continues to be the most effective means to prepare academically-inclined motivated people for research careers. Original research demands high standards, perseverance, and a first-hand understanding of evidence, controls, and problem-solving, all of which have value in a wide array of professional careers.

In the course of their dissertation research, doctoral students perform much of the work of faculty research projects and some of the university's teaching. Therefore, institutions and individual professors have incentives to accept and help to educate as many graduate (and postdoctoral) researchers as they can support on research grants, teaching assistantships, and other sources of funding.

By the time a student receives the PhD degree, many science and engineering graduate students have been research assistants while others have been teaching assistants. This system is advantageous for institutions, to which it brings motivated students, outside funding, and the prestige of original research programs. In addition, it is advantageous for the graduate students, for whom it supports an original research experience as part of their education.

Although the research component of the doctoral experience is dominant, other components are also important. They include a comprehensive knowledge of the current state of knowledge and techniques in a field and an informed approach to career preparation. Because of the recent trend toward large group projects in some disciplines, in which a research topic is divided among a number of students, postdoctoral fellows, and faculty, a PhD candidate can become so focused on a particular technique that there might be little opportunity for independent exploration of related fields or career options. When a graduate student becomes essential to a larger research project, completion of the degree can be unduly (perhaps unnecessarily) delayed.

However, this system is very advantageous for the professor/mentor who realizes (or even plans) that he has a pair of hands top do the work while he receives the accolades that go with the publication of many research papers. As a result, the student might find that the requirement for getting this work competed become prolonged and may take as much as 7 years in total. When this happens, one does have to wonder what kind of ethical behavior if being broadcast to the students not only in the department but also on campus.

On the other hand, the ethical motives of a PhD student who takes nine or more years to complete the work and submit the thesis must also be questioned. Questions to be asked might be: Is the student really up to the work? Is the student concerned about entry into the outside non-academic world? Is the student hanging on for a permanent position in academia?

Of course, every professor/mentor worth his salt can verbally justify why a PhD is taking six to eight years to complete instead of three to four years. But the ethics of such verbal or written justification must be examined closely to determine what ulterior motives are at play.

In many fields, non-research jobs are accorded lower status by faculty. Students who end up in such jobs, especially outside academia, often regard themselves as having failed (that is less true in chemistry and engineering in which non-academic employment is often the norm). If the number of academic-style research positions continues to level off or contract, as seems likely, a growing number of PhDs might find themselves in nonacademic careers for which they have been encouraged to give little respect by their respective professors/mentors. Surely this is a breach of ethics and honesty. But does anyone every questions such attitudes?

In fact, over the last 50 years, the average time it takes graduate students to complete their doctoral programs, called the *time to degree* (TTD), has increased steadily. One measure is the median time that each year's new PhDs have been registered in graduate school. Many professors, as already noted, consider these students to be a source of cheap labor to provide research data for the furtherance of the professor's publication career. As a result, many students now spend five or more years (with the professor's encouragement) to obtain the degree, rather than a more presentable three years.

The lengthening of the period of graduate work is accompanied by another trend. It has become more common for new PhDs in many fields to enter a period of postdoctoral study, to work in temporary research positions, and to take one-year faculty jobs before finding a tenure-track or other potentially permanent career-track position. However, *registered time* is the amount of time actually enrolled in graduate school (thus, it might be less than the time elapsed from entry into graduate school and completion of the PhD).

The time to master's degree does not seem to have increased beyond eighteen months to two year. But abuses can and do occur there too.

Take the example of the professor who heads an MSc-by-course program. The students have eighteen months to two years to complete their work, including a written problem that is, supposedly but not always, relevant to industry. The students take ten courses and failure in one means the degree is not awarded, or so the regulations indicate. The program professor monitors the progress of the students. If a student, who for some reason is considered friendly by the program professor, fails a course, then the teacher of the course is berated, threatened, and forced to change the marks from fail to pass.

In addition, several of the students came from industry and have jobs to awaiting them at the completion of the master's degree. But what of those others who get jobs in industry? Those who failed a course and should not have been awarded a degree work on projects. While it may not be an issue if they blow their own fool heads off, it is an issue if they harm someone else.

Or there is the student who failed and is offered a job by the program professor as a research assistant and then goes on to a PhD where he (finds out about the past record of failure) then believes that there is no harm in bending the data, and is encouraged to complete a thesis, resulting in the award of the PhD degree.

It is significant that spending relatively more time in doctoral or postdoctoral activities might not be the most effective way to use the talents of young scientists and engineers, for most employment positions. Furthermore, because of the potential financial and opportunity costs, it might discourage highly talented people from going into or staying in science and engineering.

Some researchers explain the increase in time to degree by pointing to the increasing complexity and quantity of knowledge required for expertise in a given field. Another possible explanation is the tendency of some faculty to extend the time that the students spend on research projects beyond what is necessary to meet appropriate requirements for a dissertation. As already noted above, supervisors/mentors do not always honor time arrangements and in some institutions they use students to conduct research related to the supervisor's own personal preferences and needs.

4.5 Postdoctoral Education

The postdoctoral population has increased faster than the graduate-student population. Part of the growth can be assumed to reflect the legitimate need for postdoctoral study and exploration to prepare for the increased complexity of modern science; in biology, chemistry, and physics, for example, postdoctoral study has become the norm. In fact, there are indications that postdoctoral appointees are extending their studies because permanent positions in academic or industrial research are not available.

However, surveys do not determine the extent to which young scientists and engineers take postdoctoral positions because they cannot find regular employment. One measure of the impact of employment market problems on the growth of the postdoctoral pool would be an increase in the length of postdoctoral time before a permanent position is found or an increase in the percentage of scientists and engineers who take second or third postdoctoral positions. Another indication would be an increasing percentage of scientists and engineers taking postdoctoral appointments at the institutions where they received their doctorates; this would indicate that professors are retaining their former students as research assistants when they cannot find regular jobs.

Regardless of the proportion of postdoctoral appointees who are in a vocational holding pattern, their numbers are increasing, and each year they vie with the new class of graduating PhDs for available positions. The postdoctoral appointees have an advantage in being able to offer more research experience and publications in competing for available research positions. That competition, in turn, increases the trends among new PhD graduates toward postdoctoral study and nontraditional jobs.

Training in ethics is often absent during post-doctoral education but it is necessary for such courses to focus on the discussion of ethical issues in seminars whenever appropriate. The training should identify ethical problems first through the instructor or supervisor, although the postdoc fellow should be able to identify ethical problems for discussion.

Although most people believe that PhD graduates work primarily as tenured research professors in academe, long-term trends show otherwise. Fewer than half are in tenure-track positions and almost half are in non-research positions.

Similarly, many PhD scientists have found success in moving beyond the laboratory bench onto a wide range of careers. Within companies, they might move into marketing, production, manufacturing, sales, or management. Or they can move into such related fields as environmental science, public policy, education, journalism, scientific translation, law, banking, medicine, patent law, public service, and regulation. PhD biologists might move to those and other careers, such as biotechnology, pharmaceuticals, biochemical processing, ecology-policy analysis, and patent law.

Engineers, of course, have long moved transparently between academe, industry, and business. All scientists and engineers potentially have the opportunity to use non-research skills within science- and engineering-oriented organizations by managing other scientists, developing budgets, and producing plans for new research and development activities.

Such examples reflect a fundamental shift in the conduct of research. Increasingly, the most interesting work is being done at the interfaces between science and engineering, and the associated sub-discipline.

4.6 Morals and Values

Teaching students morals and ethical values begins at home! In the education system it begins in schools, where unfortunately cheating is not unknown. If the tendency for students to cheat is not curbed, the concept of cheating become ingrained in the students' psyche as a natural phenomenon and continues at university and thence unto adult life.

It is necessary for educators/universities to promote values within science and engineering fields that fit the needs of modern industries. The efforts of developing countries to achieve developed status, with a focus on science and technology, and the initiation of industries along with other economic and political institutions has opened the doors for new values and challenges in the field of science and engineering. It is integral that university curricula examine these challenges and educate scientists and engineers to confront and present solutions for them.

A main objective promoting morals and values education for scientists and engineers is to encourage universities to implement academic and other activities related to teaching, research and extension programs embracing values and culture such as: seminars, conferences, workshops, and orientation programs for both science and engineering lecturers and their students. In addition, universities can also produce materials related to morals and values education.

However, universities themselves are rife with dishonesty and misconduct (Sykes, 1988) and in many universities students admit to having engaged in academic dishonesty at least once during their college career (McCabe and Trevino, 1993). Academic dishonesty among students takes several forms (Martin and Schinzinger, 2005):

Cheating: the student deliberately violates the rules of fair play, such as copying from another student during a test.

Fabrication: the student intentionally falsifies or invents information, such as faking the results of an experiment.

Plagiarism: the student intentionally or negligently submits work by another person as his, such as quoting the words of others without using quotation marks and citing the source.

Facilitating academic dishonesty: the student helps another student to engage in a dishonest practice, such as loaning work for copying.

Misrepresentation: the student gives false information to an instructor – such as fabricating a reason (lying) for missing a test.

Failure to contribute to a collaborative project: the student fails to do participate in a joint project but claims credit for doing so.

Sabotage: the student prevents others from doing their work, such as disrupting a laboratory experiment.

Theft: the student steals library books or the property of others.

No matter how well the causes are explained, there is no justification or rationalization for any of the misconduct as outlined above.

Dishonesty in any form, let alone academic dishonesty, is a serious offense. In the world of academia, dishonesty violates all procedures by giving some students an unfair advantage. But it does not stop with the students.

Using an example cited above (briefly repeated here for convenience and for relevance) there is the professor who heads the MSc-by-course program. The program professor monitors the progress of the students and decides that some of the students who failed the course merit a pass mark and the professor takes it upon himself to change the marks so that a *fail* mark for the course become a *pass*. Such actions are untruthful and violates trust that the professor is given and it renders dishonest any achievement or recognition based on the cheating.

Universities, as organizations, need to create and maintain a culture of honesty. Honor codes, which set forth standards and punitive actions for those who do not stick by the honor code, should make a difference, even though they may not be sufficient to curb cheating (Martin and Schinzinger, 2005). In addition, a university must support professors and students who report cheating and refuse to bend before the university administrators who may be concerned about losing a fee-paying student (or more likely, the parents of the student) by merely giving the miscreant a, "stern talking to," or a slap on the wrist with a note to run along and behave. By doing this, the morals and ethics values, if they existed at the university, were thrown out of the window.

To combat such behavior, universities need to maintain a climate of respect, fairness, and concern for students (universities are not rest homes for those who could not hold down a job in the outside world) and honor codes need to be explained clearly (Martin and Schinzinger, 2005). Opportunities to cheat should be minimized with firm and enforced disciplinary procedures applied to those caught cheating.

Ready access to the Internet has made cheating easier but detecting plagiarism has also been made easier (Decoo, 2002). Furthermore, inclusion of classes related to academic integrity can be a valuable way to integrate an ethics component into courses (Martin and Schinzinger, 2005).

Academic integrity is much more important than simply guaranteeing that students adhere to rules of test taking and plagiarism avoidance and is linked inextricably to transmitting general ethical values to students (Bornstein, 2007). The ethical scandals that plague academia, businesses, politics, and professional sports reflect the erosion of integrity in American society. Universities must show that they are concerned that students do not cheat on exams or engage in plagiarism.

Frequently students perceive what faculty and college administrators say about academic integrity and plagiarism as unrealistic and generally unnecessary moralizing. This cynical view indicates that cheating is an acceptable way of university life (Callahan, 2004).

A recommendation worthy of consideration is the implementation of a foundation course for scientists and engineers. This course can be designed for students to gain conceptual clarity and respect for norms and values such as freedom, fraternity and, justice along with their ethical and political dimensions. Students can become engaged in presentations and discussions on pertinent themes such as spiritual, moral, societal, cultural and environmental values, as well as values of democracy, scientific temper and communication skills in the workplace. This foundation course may serve the needs of scientists and engineers who battle with serious work issues.

Research undertaken by scientists and engineers can incorporate value issues of contemporary relevance in public and professional life. Findings through fieldwork can suggest reasonable ways of resolving these value problems. Hence, the research could involve a combination of conceptual and empirical data.

University seminars/workshops and other initiatives to promote values education for scientists and engineers could also be extended to members outside the university, such as science school teachers, industry engineers, and corporate executives. These initiatives can provide a platform for a collective body to engage in value related discussions to share ideas and experiences.

A university is a community of students and teachers committed to the pursuit of learning, accumulation of knowledge, the transmission of this knowledge to succeeding generations and the development of new knowledge. Hence, good science and engineering students must be lifelong learners.

A university combines teaching, research and discovery as well as community service. In this combination lies a community of scholarly scientists and engineers which can give a university unique strength.

Over a century ago, the German universities first arrived at a consensus that teaching and research are complementary activities: the maximum success in each area is only attained within an environment in which both are encouraged. This signifies that science and engineering students must work together with fellow students, and cultivate close and meaningful contact with their teachers. In addition, there must be a close link between undergraduate and post graduate work, scientists and engineers, students and academic staff, and those who have a wealth of experience in the respective fields at different levels of the university. Cooperation and collaboration for the pursuit of knowledge is an instrumental means to strengthen the quality of scientists and engineers. This collaborative atmosphere may impart valuable lessons for workplace and community needs. Thus, it may contribute towards the transmission and development of new knowledge to meet the needs of succeeding generations.

4.7 Evaluating Scientists and Engineers

The processes by which scientists and engineers are evaluated in academia and in industry are probably the most detrimental effect that can decrease the will to perform at an adequate level. Most of all, the evaluation process should involve knowledge of the education of scientist and engineers as well as being able to *speak their language*. However, there are other aspects to getting the best out of scientists and engineers and this relates to the evaluation process.

In addition to the scientist or engineer who may not appear to fit the academic or company mold, the evaluation process may seem to focus on the, "do as I say,"dictum of the immediate supervisor, department head, or academic senior colleagues. In academia, the additional dictum of, "publish or perish," is also operative, insofar as "publish" has the standard academic meaning of publish in recognized journals.

Relying on journal publications, as the "do as I say" syndrome or the academic *"publish or perish"* syndrome, as the sole demonstration of scientific or engineering achievement is a sad state of affairs and needs a thorough re-evaluation.

In the first instance (i.e., the "do as I say," syndrome), the young professional may find that he is up against a brick wall. The supervisor/department head is all powerful and the scientist or engineer has little or no recourse for appeal.

Equally, "the do as I say" syndrome is also fraught with pot holes for the young scientist and engineer. Production of patentable work requires acknowledgement of the supervisor and any other designee as co-authors, is also ruinous to the young scientist and engineer. But where are these worthies if the work does not produce patentable ideas and the project is terminated. Where is blame assigned? To the young scientist and engineer! The supervisor and other potential designees have backed away and are not evident by any form of presence or support.

Counting the number of publications in recognized journals ignores the quality of any particular publication as well as the potential for benefit through ownership (by the university) of intellectual property. For example, publication of work in a patent followed by publication of the work in a conference proceedings are tangible means of conveying ideas and insight that relate to intellectual property. Obligating scientists and engineers to be evaluated without giving true credence to intellectual property is a handicap and is often directly ruinous of a true method of evaluation.

Neither of these scenarios is a way to encourage either academic achievement or industrial achievement in science and engineering.

4.8 Intellectual Property

One aspect of educating scientist and engineers that is lacking in institutes of learning is teaching about intellectual property rights. Most scientist and engineers learn of this after the fact.

Intellectual property is a legal field that refers to creations of the mind such as musical, literary, and artistic works; inventions; and symbols, names, images, and designs used in commerce, including copyrights, trademarks, patents, and related rights. Under intellectual property law, the holder of one of these abstract "properties" has certain exclusive rights to the creative work, commercial symbol, or invention which is covered by it.

Intellectual property rights are exclusive rights over creations of the mind, both artistic and commercial (WIPO, 2000; Moore, 2004). The former is covered by copyright laws, which protect creative works such as books, movies, music, paintings, photographs, and software and gives the copyright holder exclusive right to control reproduction or adaptation of such works for a certain period of time.

The second category is collectively known as *industrial properties*, as they are typically created and used for industrial or commercial purposes. A patent may be granted for a new, useful, and non-obvious invention, and gives the patent holder a right to prevent others from practicing the invention without a license from the inventor for a certain period of time. A trademark is a distinctive sign which is used to prevent confusion among products in the marketplace.

An industrial design right protects the form of appearance, style or design of an industrial object from infringement. A trade secret is non-public information concerning the commercial practices or proprietary knowledge of a business. Public disclosure of trade secrets may sometimes be illegal.

Intellectual property rights give creators exclusive rights to their creations, thereby providing an incentive for the author or inventor to develop and share the information rather than keep it secret. The legal protections granted by intellectual property laws are credited with significant contributions toward economic growth.

Intellectual property rights are considered by economists to be a form of temporary monopoly enforced by the state (or enforced using the legal mechanisms for redress supported by the state).

Intellectual property rights are usually limited to non-rival good which can be used or enjoyed by many people simultaneously (The use by one person does not exclude use by another.). This is compared to rival goods, such as clothing, which may only be used by one person at a time. For example, any number of people may make use of a mathematical formula simultaneously. Some objections to the term intellectual property are based on the argument that, "property," can only properly be applied to rival goods (or that one cannot, "own," property of this sort).

Since a non-rival good may be used (copied, for example) by many simultaneously (produced at zero marginal cost in economic terms), producers would have no incentive to create such works, a clear loss to society. Monopolies, by contrast, also have inefficiencies in which producers will charge more and produce less than would be socially desirable.

The establishment of intellectual property rights therefore represents a trade-off, to balance the interest of society in the creation of non-rival goods (by encouraging their production) with the problems of monopoly power. Since the trade-off and the relevant benefits and costs to society will depend on many factors that may be specific to each product and society, the optimum period of time during which the temporary monopoly rights exist is variable by country.

Intellectual property in the form of patents protects an invention and the rights of the inventor. Patents provide inventors or those deriving title from them the right to prevent others from making, selling, distributing, importing or using their invention, without license or authorization, for a fixed period, normally 20 years from the application date. Patents are subject to an examination by the Patent Office before grant and to the payment of renewal fees thereafter. In return, the applicant for the patent is required to disclose the invention in the patent specification and to define the scope of the patented invention in claims. Patents normally have to relate to technology. There are three further requirements for an invention to be patentable: novelty (normally over anything disclosed publicly anywhere), inventive step or non-obviousness (the invention would not have been obvious to a person skilled in the art at the time the application for a patent was filed) and industrial applicability. Patents are limited to the country for which they have been granted. Granted patents can be contested in the Courts or (sometimes) patent offices in validity proceedings or as a defense to an allegation of patent infringement.

To be patentable, inventions must be novel. In most countries novelty is destroyed by any public disclosure by any means (oral or written) anywhere. In some countries, including the US and Japan, such a disclosure can be made without prejudicing a patent application if the patent application is made within 3 months to 12 months of the disclosure (the grace period). There are in fact many forms, and potential forms, of grace period. For instance, because the US system is a "first to invent" rather than a "'first to file'" system, an inventor has the possibility of producing evidence that she/he made the invention before a prior publication of somebody else. This right leads to so-called 'interference' proceedings, challenging an applicant's right to a patent on the grounds that the subject matter had already been invented. If a grace period were introduced in Europe, it would be necessary to agree on its specific characteristics.

On the other hand, *copyright* grants exclusive rights to creators of original literary, scientific and artistic works, computer programs and (with overlapping database rights) databases. It protects the form of expression of ideas, but not the ideas, information or concepts expressed which can be freely available or protected in other ways. Examples of potentially copyright-protected works in the field of science include books, lab notebooks, articles, conference papers, teaching materials and certain databases of information (both electronic and hard copy). The requirement for originality is low – some degree of the author's own work will be sufficient if there is no large amount of copying.

Copyright in itself does not create a monopoly – there is no infringement if another author independently comes up with an identical work. Infringement is typically by copying the work and/or making an adaptation. Copying need not be exact or whole – it need only be of a substantial part in qualitative terms: if the amount taken is small but nevertheless central to the work, it could still be infringing. The first owner of copyright is the author, but employers generally own the copyright for employees' work done as part of their employment obligations. Authors' "moral rights" also encourage proper attribution and prevent changes to a work that would prejudice the honor or reputation of an author.

Databases, collections of data organized in a systematic way, play an important role in scientific research. It is an increasing role. For example, developments in the last decade have made databases essential for much biomedical research.

Databases are of many kinds. They can be traditional encyclopedias, books of data or some teaching materials, through to electronic databases available on the Internet. The access to data and the ability to extract and re-utilize those data have always played an important part in the scientific process. As in copyright, digitization and the potential for instant low-cost global communication have opened up tremendous opportunities for the dissemination and use of scientific and technical databases. There has more recently been a proliferation of both public and private databases, which has started to create tensions between free access and economic models. As always in intellectual property law, it is a question of achieving a balance between a sufficient incentive and adequate protection of investment to encourage the creation of new databases which are necessary and useful to researchers, and the rights of scientific users to access those databases on reasonable terms and to advance scientific knowledge.

Guidelines setting forth acceptable standards of behavior in relation to such issues as; fabrication or falsification of data, protection of human subjects, confidentiality, accurate reporting of results, and plagiarism, have evolved over the years; with many societies embracing the value of education, development, and norm setting. Some societies also have mechanisms for investigation and enforcement.

While scientific societies are paying increased attention to research conduct, little is known beyond impressionistic observations about the nature of their role and impact. In general, research on research integrity is a very small specialty within the scholarly traditions of science policy, sociology of science, and ethics and values in science. In recent years, especially with the support of the U.S. Office of Research Integrity, this arena of scholarship is attracting greater interest and visibility. Yet, there is scant systematic, empirical knowledge on the effects of scientific societies on research integrity and misconduct in science.

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