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Academic Leadership Strategies for Engineering Faculty

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The faculty member of today confronts some unique challenges in order to succeed. The attainment of tenure and subsequent career advances call for excellence in the triple missions of higher education, viz., research, teaching, and service. Although these responsibilities appear to be in conflict, it is indeed possible to succeed in all three missions by appropriate management of strategies and time. This paper provides one faculty member's personal perspective on achieving success in the research, teaching, and service missions, primarily in a doctorate-granting research university environment.

INTRODUCTION

ONE OF the major professional paths for engineering graduates with a doctoral degree is in academia as a faculty member. An engineering faculty member of today has to perform equally well in the triple missions of higher education, viz., research, teaching, and service. This new paradigm is a significant change in emphasis from the academic expectations of yesteryear. Various internal and external forces are now closely interacting to provide a new face to engineering academe. The major forces propelling these new directions are the new demands of the patrons, changing attitudes and make-up of students, new employment strategies, rise of new technologies for education and outreach, and private-sector entry into the hitherto uncharted academic environment [1]. The increased demands for better education delivery, coupled with budgetary reductions in most colleges and universities, have forced faculty in all areas, including engineering, to take a fresh look at their priorities, expectations, and goals. A conceptual framework for the description and analysis of academic work for engineering faculty has been eloquently provided in a recent paper [2]. Striving for excellence in all three missions of higher education is thus a natural outgrowth of the new pressures on an engineering faculty member.

Each of these missions requires a different type of approach to succeed, and in most cases, these different approaches appear to be in conflict. For example, a faculty member striving for excellence in teaching by spending extra time preparing for lectures feels that he/she is doing so at the cost of writing research papers or proposals. This perceived conflict of interests frequently causes frustration and disappointment among tenure-track faculty during their eagerly awaited early years in the academic profession. While pursuit of tenure is the primary goal of newly hired faculty, other major expectations include the intellectual growth and maturation of students, and the performance of high quality research based upon personal convictions [3]. Unfortunately, few sources of information or training are available for new faculty to take advantage of, and they traditionally have had to learn by themselves [4]. The problem is compounded due to lack of suitable mentoring as well as the presence of conflicting signals from senior faculty and administrators. Under these circumstances, tenure-track faculty frequently strive to excel primarily in research activities, followed by above-average teaching accomplishments, with service activities relegated to a distant third. Although this philosophy generally finds favor from department heads and deans, continuation of this approach does not augur well for engineering education needs of the future.

While the needs of the changing role and nature of engineering education are best fulfilled by concerted action by all stakeholders, including the institution itself, industry, professional societies, government at all levels, as well as the accreditation authority [5], it ultimately rests with each individual faculty member to initiate the necessary changes from within. This paper describes and develops a strategy for optimally combining the three missions of higher education in a manner that success in one reinforces success in the other two, based upon the experiences of the author. The concept of academic leadership is first defined within the context of an engineering faculty member's roles and responsibilities. The following sections enunciate some concepts for success in research, teaching, and service activities. Next, the manner in which all of the above techniques

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can be synergistically combined is described. Conclusions are presented at the end.

ACADEMIC LEADERSHIP DEFINED

The author defines an Academic Leader as a faculty member who excels in all three missions of higher education, namely, research, teaching, and service. Although it is widely considered that attainment of excellence in each of the three missions is mutually exclusive, the author feels that it is indeed possible to excel in all of the above three missions simultaneously. Since these three missions work together as gears that drive the engine of engineering education, success in one synergistically reinforces the momentum in the other two.

Over the past many years, changes in emphasis placed on teaching, research, and service in promotion and tenure decisions have significant impacts on the academic environment. Two studies of accounting faculty indicate that the increased emphasis on research productivity has decreased the relative emphasis on teaching performance, while emphasis on service activities has generally remained nominally constant at doctorate-granting institutions [6, 7]. This scenario is also generally valid for engineering faculty over the past few decades, leading to disproportionately higher amounts of time spent by faculty performing research at the cost of teaching. Academic leadership in the past was therefore synonymous with research productivity.

Recently, the relationship between research productivity and teaching effectiveness is being revisited in various disciplines. Since innate ability is assumed to be important for both activities, it has been suggested that faculty who have the ability can be good researchers as well as good teachers. A recent study investigated the breakdown among faculty into different categories based on high performance in research and/or teaching and/or service [8]. Eight potential faculty types were defined, ranging from All Stars (those showing high performance in research, teaching, as well as service) to Uninvolved (those showing mediocre performance in all of the three missions). The study found that at doctorate-granting institutions, almost 23% of Associate Professors could be classified as All Stars, compared to 1% or less at the Assistant and Full Professor levels. When all faculty ranks were considered together, All Stars constituted a respectable 11%, or one in nine. These All Stars are what I define to be Academic Leaders.

It may be tempting to consider pursuit of academic leadership as defined above for purely self-serving reasons, such as higher salary raises, better visibility, and higher allocation of resources. However, there are other reasons for pursuing excellence in all three missions of higher education. Primarily, it has been argued that academic freedom enjoyed by faculty comes with the solemn responsibility of what is termed as academic duty [9]. Academic duty, which is expected of all faculty, encompasses teaching, mentoring, university service, discovery, publication, integrity, and outreach. Thus, performing one's 'academic duty' well automatically leads to the attainment of academic leadership.

SUCCESS IN RESEARCH

Research is an important mission of an engineering faculty member's career. However, success in research comes after a great deal of time, patience, and frustration, especially during the initial tenure-track years. Research success depends primarily upon possessing a positively persistent attitude, in addition to being knowledgeable in the faculty member's area of expertise. While the exact nature and type of research activity varies with individual strengths and weaknesses, it is my opinion that a harmonious amalgam of computer simulation, theoretical analysis, and experimental validation provides the essential ingredients for success as a researcher.

Research program initiation

It is very essential for tenure-track faculty to get a good and early start in the funding game, preferably during their first semester at their institutions. Since the teaching load during the first year or two is greatly reduced for new faculty, an early start in obtaining research funding will greatly impact the attainment of academic leadership. Identification of potential sponsors at funding agencies is the first step, followed by establishing personal contact, and submission of short (3–4 page) pre-proposals (also referred to as 'white papers' or 'quick looks'). It is also important to be aware of institutional support mechanisms in place, such as matching support from departments or colleges, proposal review assistance, assistance in locating relevant calls for proposals or requests for proposals (RFPs). In some institutions, internal funding sources are available, for which new faculty are usually given preference. It is generally desirable for tenure-track faculty in the process of initiating their research funding to primarily develop individual single-investigator proposals [10], although it is not uncommon for them to sometimes be part of a multi-investigator proposal led by a senior faculty member. One of the commonly-accepted methods used for initiation of research is by spending summers at government laboratories [11], such as NRL, AFRL, LLNL, ONRL, GSFC, etc., whereby a faculty member can establish personal contacts and become aware of the agency's funding priorities from an insider's perspective.

Research program development

In the area of research, it is important for engineering faculty of today not only to engage in the traditional form of 'basic research', but also to work on 'applied research' projects. Engineers are considered to be applied scientists, but engineering faculty frequently lose sight of their important role in not merely unearthing and studying fundamental phenomena, but also in harnessing this phenomena for betterment of humankind. Thus, faculty need to aggressively pursue funding from both traditional sources of support (such as NSF, NASA, and DoD), and from industry, although the algorithm for pursuit of funding differs in both cases. It is a well-known fact that a vast majority of engineering students ultimately end up as engineers in industry, rather than as research scientists and educators. Thus, engineering faculty must also develop the appreciation as well as the capability for performing applications-oriented research, the results of which will percolate to industry through the vast majority of their graduating students. However, it must be borne in mind that funding from industry usually comes with some strings attached, such as strict deadlines, onerous reporting requirements, censorship or delay in publication of research results, and restriction from pursuing research avenues that do not appear to be of immediate interest to the sponsor. Despite these limitations, the author has found it rewarding to pursue research funding from industry sources in addition to the traditional governmental sources of research support.

Since a large portion of an engineering faculty member's funding is likely to be derived from federal funding agencies, it is important to understand their individual funding mechanisms in some detail. Among federal agencies, the proposal review process and the selection of funded projects differ significantly [12]. Some agencies, such as NSF and NASA, rely upon external peer review of proposals, followed by an internal decision panel appraisal, to select and reject proposals. Other agencies, notably ONR and AFOSR, generally rely on manager discretion to select projects for funding. Most other agencies, such as ARO, practice a combination of the above two methods. Personal contact is thus more important for agencies that use manager discretion, but this does not guarantee support for weak or poorly written proposals. For industry funding, manager discretion is almost always the norm.

The primary factor that influences the attainment of research funding is the quality of the research proposal, whether the agency relies on the peer review or the manager discretion method of project selection. There are numerous resources available on writing quality proposals. The essential elements of a proposal are: (1) Cover page, usually in a prescribed format, with spaces for signatures, (2) Table of Contents, (3) Proposal Abstract, (4) Introduction, (5) Research Objectives, (6) Research Approach, (7) Project Timetable, broken down by year, (8) Expected Outcome of the Proposed Research, (9) Relevance to Funding Agency, (10) Project Budget, usually on agency-provided forms, (11) Budget Explanation, (12) Curriculum-Vitae of Investigators, not more than 2–3 pages per investigator, and (13) other information required by the agency. Since the Proposal Abstract almost invariably is the single page of text that program managers and reviewers read to form the initial opinion on the quality of the proposal, it is desirable for the abstract to be forceful and persuasive for favorably influencing the reviewers [13]. The abstract, usually written last, should include a clear and unambiguous statement of the project, the research objectives, the anticipated results and benefits, the qualifications and track record of the investigator, and a statement of relevance to the funding agency's programmatic objectives. The Research Objectives section is also crucial, as this indicates that the investigator has developed the strategy for successful completion of the proposed research. Both primary and secondary objectives must be listed: primary objectives being broad goals, while secondary objectives are specific components that will help attain the primary objectives. The Research Approach is, by far, the most important section of the proposal, and must explain in detail how the research objectives will be achieved within the project duration. This section must include the work plan, methods and procedures, and the justification for the proposed methods. It is desirable to include tasks and sub-tasks by year in the Project Timetable section. Finally, it is my experience that a brief one-paragraph section on Relevance to Funding Agency is helpful in linking the proposed research to the overall goals of the funding agency, and it is important to show here how the proposed research complements, but does not duplicate, currently funded projects. This is motivated by the fact that agency funding decisions are determined primarily by their values and needs [14]. A recent study examined engineering faculty perceptions of the major factors involved in attracting research funding [15]. The most important factors for success in proposal efforts were considered to be: (1) relevance to agency's larger goals, (2) direct and personal contact with funding agency officers, and (3) meticulous following of the agency RFP guidelines. While few faculty felt necessary to utilize relevant writing resources for generating successful proposals, most felt that it was more important to learn from their successful peers and colleagues.

Research results dissemination

One of the primary measures of a successful research program is the extent to which the research results are disseminated via peer-reviewed journal papers, presentations in conferences and workshops, and technical reports. Effective technical writing ability is essential not only for publication of research results, but also for research proposals. Thus, it is important for some careful thought to go into when to publish, what to publish, and how much to publish. Usually, a journal publication is justified when some primary research objective has been attained, and the material can be considered stand-alone without being predicated on research to follow. In addition, since the funding scenario is extremely competitive, it is important for exciting research results to be published first in order to lay one's claim as the pioneer in the research area. Since the peer-review process for journal papers can take anywhere from six months to almost two years, it is important to develop an outstanding first submission so as to minimize the chances of undue delay due to rejection or protracted revision requests.

Writing is an important part on a faculty member's work that has perhaps the maximum impact on his/her professional career. The importance of clear and succinct writing cannot be overemphasized. The essential ingredients of good writing are: (1) logical arrangement of material, (2) good grammar, (3) correct spelling, (4) short sentences, and (5) avoidance of big or uncommon words [16]. Paragraphs within the text are used to form a cogent thought-unit, and such a thought-unit is well grasped when it is between 75 and 200 words. It has been determined that maximum retention occurs of material presented at the beginning or the ending of a section, chapter, or paragraph.

The generally accepted format for journal papers containing N number of sections is: (1) Introduction, (2) to $(N - 1)$ Body of the paper, and (N) Conclusions. The Title and the Abstract precede the text, while the Acknowledgments, References, and Appendix (if any) sections follow it. The title must be short (5–15 words) and must capture the interest of the reader without being conclusional. The Abstract and the Conclusions sections are usually the first to be thoroughly read in order to judge the usefulness of the entire paper. Thus, it is important to spend some time perfecting the presentation of technical material in these beginning and ending sections, and have these support the core inner sections of the paper [17]. The Introduction is usually the best place to start, where the case to study the problem presented in the remainder of the paper must be justified. It is also important to include in this section, or in the one immediately following, the current state of knowledge in the form of a literature review. This allows one to place one's research in proper perspective, and show how it is linked to the global body of knowledge already available. It is important to ensure that the literature review includes the research of potential reviewers of the manuscript. The Introduction should conclude by listing the organization of the remainder of the paper. The Conclusions may be drafted next, with the proviso that it will be fine-tuned after the paper is completed. Writing the conclusions at the very beginning ensures that the rest of the paper will contain material that will support the conclusions, and no more. The Abstract, often the hardest part to write, is undoubtedly the most important. It is suggested that the abstract be written last, since abstracts provide an overview of the entire paper from the beginning to the end. It must be emphasized that the abstract is not the same as the conclusions.

Most engineering data are better presented in graphics or visual form, either as figures or images, or even tables, thereby avoiding the need to write many sentences of prose. It is important to realize that graphics supplement the written text, but do not replace it [18]. While it is not my intent to describe and discuss all forms of graphical presentation formats, the general suggestion is to make these as uncluttered as possible. This suggests avoidance of too much detail (e.g., not more than 10–12 blocks in a block diagram), small lettering (especially on graphical axes), use of too many confusingly similar symbols, etc. One needs to ensure that graphics do not distort the text by their number or size. Graphics that occupy more than one-third the size of a page generally dominate, rather than supplement, the text [18], although in some exceptional cases, large graphics cannot be avoided. A generally-accepted rule-of-thumb is to use a maximum of two visuals for a standard journal page, containing approximately 1000 words of text. Since a visual typically replaces about 150 words of text, a journal page may contain up to two figures [16]. A 6-page journal paper may therefore contain a maximum of approximately 12 visuals to ensure clarity of presentation.

SUCCESS IN TEACHING

Teaching is an important component of an educator's career, and some argue that this is indeed the single activity in which the faculty member must truly excel. Teaching generally encompasses efficient transfer of knowledge to both undergraduate and graduate students, although the needs and requirements may differ in each case. The impartment of knowledge for engineering students presents its own unique challenges and opportunities for faculty. While classroom and structured laboratory instructional requirements are well defined and the goals well-understood, graduate student thesis or dissertation supervision needs vary from student to student and project to project. Good teaching involves the following five components: (1) instructional methods geared toward student involvement, (2) right content, (3) strategies to maximize teaching efficiency and student learning, (4) good attitude, and (5) promotion of lifelong learning skills [19]. The concept of teaching *efficiency*, often overlooked, is very important in enhancing teaching *effectiveness*. Teaching efficiency encompasses various factors, such as course organization (developing appropriate course objectives, selecting appropriate delivery methods such as lectures and laboratory demonstrations), student assessment (preparing appropriate homework and tests), lecture preparation (ensuring reasonable and appropriate coverage of material), and time management [20].

Instruction techniques and assessment

The goal of engineering education is to provide a firm foundation upon which the student can build professional competence after graduation [21]. In the process of learning basic principles, students must develop the scientific approach to identify problems and formulate cost-effective ethical solutions. Since much of engineering education deals with 'real-world' concepts, engineering faculty frequently need to resort to the use of instructional aids to reinforce fundamental theoretical concepts. These can include models, prototypes, charts, videos, and demonstrations, and can usually be obtained from industry contacts. At times, this may include a visit to a nearby company. However, the use of such aids must not be excessive so as to cut into instructional quality. During the class lecture session, it has been found that student interest is highest at the beginning, low during the middle, and peaks again during the end [22]. The basic concepts must therefore be reinforced and emphasized during these periods. One way to accomplish this objective is to allocate the first 10% of class period to a recap of the last lecture, and the last 10% to a summary of the current lecture.

There is always the question if notes should be handed to the students so they are free to concentrate on the learning without being distracted by note taking. I have found that providing notes to senior undergraduate and graduate students helps as it frees them from spending excessive time taking notes, and allows them to participate more pro-actively in the learning process. However, it is my opinion that junior undergraduate and lower grade students learn better when they take notes during class as writing reinforces listening comprehension. The pace of the lecture delivery has to be adjusted based upon whether the instructor hands out notes or not. In engineering courses, it is often necessary to discuss an elaborate block diagram or a complicated machine drawing. Rather than expend the time and energy drawing this on the blackboard, and perhaps making errors, the instructor is recommended to hand out copies to the class, and use an overhead or a slide projector to explain the same. This saves time and makes it easier for the students to follow through and insert comments if necessary. Detailed mathematical derivations are to be avoided except when absolutely necessary; it is preferable to show the major steps and discuss the significance of the end results. However, students must be encouraged to work out the details of the derivations after class.

As regards undergraduate students, the major challenge is in getting them interested in courses requiring advanced concepts in mathematics, such as electromagnetics or finite element analysis. To achieve this objective, educators should take advantage of computer software and graphical aids primarily to supplement, but not replace, the old-fashioned development of equations. The goal is to provide students with an appreciation of the mathematics, rather than an aversion. One technique that appears to work well is to have problem sessions outside of class hours, and have students themselves go up to the board to solve problems in front of their peers, making errors and learning as they do so.

The importance of undergraduate research experience to identify and nurture creativity in engineering students has been established [23]. Research and creative thinking are concerned with identifying, defining, and solving problems. The University of Nebraska's Department of Electrical Engineering offers a technical elective course ELEC 399, Undergraduate Research, in which students may enroll between 1 and 3 credits in a specific semester, with the approval of a faculty member. The course catalog provides the following course description: 'Research accompanied by a written report of the results.' Similar courses may be available at other institutions. In order for the undergraduate student to succeed, privileges similar to those accorded to graduate students need to be provided. These include desk space, laboratory access, computer accounts, use of the instructor's personal research resources, and active participation in seminars and discussions. Participation in this form of creative activity at the undergraduate level also encourages a large percentage of such students to enroll in the graduate program, and can thus be used as a graduate student recruitment method [24].

In the area of teaching, engineering faculty need to also explore novel techniques to enhance the learning experience for students so as to prepare them well for post-graduation employment. Engineering students typically work in teams or groups when they enter the industry work force upon graduation. Teaching of senior level undergraduate and graduate courses needs to be tailored to help them succeed in this environment. One such technique is the concept of Cooperative Learning (CL) in which student teams work non-competitively on a two-semester long capstone design project in their senior year [25]. It forces students to practice team and small group communication skills, and prepares them for the real world environment. An appropriate assessment methodology was implemented that permitted cooperation while simultaneously rewarding good performers. The students responded positively to the CL experience, although preparation time was felt excessive. A variation of this technique for enhancing the group working skills is by splitting the class into competing teams, and having them develop a winning design for a fictitious contract written up by a sponsor from a funding agency

[26]. The instructor selects the students in each team so as to balance their expertise, interests, and personalities. Students decide how the individual tasks are divided among themselves. Students are encouraged to consider cost versus performance analysis in their designs, and are required to specify off-the-shelf components if at all possible. A joint preliminary report submitted two weeks before the end of the semester allows the instructor to review progress and suggest final changes. A professional final report, and a professional group presentation in front of the instructor and the project sponsor are used to assess each group's and each individual member's performance. While the learning experience was useful, students felt that the amount of time spent on such a course was excessive.

Instructors have the freedom to set appropriate standards for student assessment, and to specify the weights for homework assignments, quizzes, mid-term tests, project reports, term papers, and final examinations. It is not my intention here to recommend any guidelines for this purpose, but to share some ideas that have worked for me. One of the factors that is frequently subject to abuse is homework assignments. In most cases, solutions of problems in the text assigned for homework are available to students, either from their seniors or from the cognizant student organization. This gives some students an unfair advantage in credit for homework. A technique I have used is to assign homework problems from the text, and to make the solutions available in the library. Students are encouraged to try to work the problems on their own, and use the library if they get stuck. They are required to turn in the worked homework problems, even if they have merely copied the solutions. In addition, a ten-minute closed book quiz is given to the students on the day the homework is collected. The quiz is based upon the assigned homework, and may be a homework problem with numbers changed. This encourages students to learn the material in order to score well on the quiz, and ensures that no individual student has an advantage over the others. Grading for the entire homework is split equally between the solutions turned in and the quiz score.

Test problems also need to be prepared with a view not only to rate individual students according to their mastery of the subject, but also to provide appropriate encouragement to the hard-working and average student. A technique I have learnt from my colleague Professor Don Nelson that works for me is to assign three problems on each mid-term test. One problem is usually very simple, and is a minor variation (e.g., changed numeric values) of a homework problem. Most students who attend class and study regularly do this problem correctly, and thereby derive encouragement on their performance. The second problem is generally a non-trivial extension of a homework problem, which causes little difficulty to and rewards those who have been more thoroughly reviewing the material and may perhaps have sought some help from the faculty member during office hours. The final problem is a difficult one designed to differentiate between those who have thoroughly understood the material and mastered the fundamental concepts, from those who have not. Such a strategy generally places the class average around 70–75%, a number that somehow seems to be psychologically satisfying to most students, without compromising on the ability of the instructor to effectively rate the students and assess their learning.

Graduate student supervision

One of the major responsibilities of a faculty member who succeeds as a researcher is the supervision of graduate students, both at the master's (M.S.) and the doctoral (Ph.D.) levels. While both types are engaged in research activity leading to theses or dissertations respectively, the quality and scope of the research differs significantly, calling for slightly different supervision methods. Most M.S. students graduate in two years, while Ph.D. degree students can take between three to five years for graduation. While both types call for original research work, the requirement for significant and lasting contribution is somewhat relaxed in the case of M.S. students compared to Ph.D. students. Most M.S. students plan to work as engineers in industry upon graduation, while most Ph.D. students seek careers as faculty or research scientists in government or industry. Furthermore, M.S. students are generally fresh out of the undergraduate program, and encounter the demands of research for the first time as graduate students. Thus, they are likely to get overwhelmed with the requirements of simultaneous research and course-work, and usually get frustrated with research disappointment. They therefore need more attention and encouragement in order to develop and mature in successfully performing research activity. Ph.D. students have already seen research as M.S. students, and thus are better able to manage their time and resources in graduate research. They too need supervision and guidance, albeit at a more modest level of commitment.

The need for a close relationship to exist between the graduate research assistant and the faculty supervisor is very essential [27]. The two major aspects of supervision are: (1) creativity, resulting in the ability to select suitable problems, to enthuse the student, and to provide a steady stream of ideas, and (2) management, for ensuring that the student is making good research progress. The primary reasons for delay in completion of the thesis or dissertation are: (1) slow start in research, due to the student's relative inexperience with research activity, (2) pursuit of perfectionism, resulting in the research never nearing completion, and (3) distraction from main line of enquiry, caused by the need to explore every avenue available. The faculty member needs to be on guard and take corrective measures as soon as a problem is perceived. It is imperative that weekly meetings be held at a regularly scheduled time to review the past week's progress, discuss solutions to problems, and formulate specific goals for the following week.

It is very important to make graduate students frequently present their research results in front of small groups in informal seminars. Typically, the group may consist of faculty and graduate students working in the same area. This provides practice to graduate students, and improves their presentation skills for conferences and job interviews. The faculty member must take the effort to provide constructive comments about presentation style and diction, quality of slides or transparencies, and technical aspects. Seeking comments from other members of the group in a positive manner will also help the graduate students improve their presentation skills.

It is also desirable, especially for Ph.D. students, to also present a critique of someone else's research in front of a group. This ensures that the student is able to review and thoroughly assimilate research results in the same or a closely related area, and then disseminate his/her knowledge of the topic to a group of individuals. This activity is especially useful for those considering faculty positions upon graduation.

SUCCESS IN SERVICE

Service activities have traditionally been ill defined, and thus poorly conceptualized and erratically expressed [28]. There is no consensus on what is meant by 'service,' and which constituencies must the faculty member 'serve.' However, over the years, service activities in the engineering faculty profession have come to include institutional service and professional service, both drawing upon the technical experience and expertise of the faculty member concerned. Other types of service, such as civic, altruistic, and humanitarian, are generally not considered important for career advancement of engineering faculty. Service activities are therefore those that directly benefit individuals or organizations outside the academic community, while simultaneously reinforcing teaching and research.

Institutional service

During a faculty member's career, he/she will be called upon to serve on various departmental, college, as well as university committees. It is important to recognize that participation is these activities is required, usually to the extent of 25% of a faculty member's time during the semester. While most committee assignments are made with the consent of the concerned faculty member, at times one may have to serve on a committee with minimal interest. In any case, it is important to serve conscientiously and collegially in such tasks. Tenure-track faculty usually serve on departmental committees at the beginning of their careers. Soon before or soon after attainment of tenure, they may be asked to serve on college-wide or university-wide committees. They soon discover that matters move much more slowly in these committees compared to departmental committees. Nevertheless, service on such committees is important to make contacts with colleagues from other departments and colleges, who might possibly provide letters of reference for career advances within or outside one's institution. Furthermore, service on such committees provides a chance to make personal contacts with higher-level administrators, such as deans, vice-presidents or vice-chancellors, which in turn may be beneficial during one's professional career. By serving on various committees, the faculty member has the opportunity to make a significant difference in how matters are perceived or done within the university, while simultaneously broadening one's horizon about widely varying perspectives from different departments and colleges.

One aspect of institutional service that merits special attention is student advising. This includes overseeing the number of credits taken per semester, ensuring adequate fulfillment of prerequisites, and meeting of graduation requirements. Since this activity takes time and is not perceived as being important in career advancement, faculty frequently pay less attention to their advising duties. However, it is perhaps the single major responsibility that a faculty member can fulfill in order to make a significant impact in the academic experience of undergraduate students. One suggested method is to take the time and the trouble to elicit information from students about their academic life even if they come in to see the faculty member for a mere signature. The goal is to encourage the student to view the faculty member as a friend and mentor.

Professional service

Professional service is an important component in an engineering educator's career. This service is beyond the normal committee activities within the department, college, or university. This could involve some volunteer activity in the major engineering society catering to the faculty member's discipline, such as IEEE, ASME, or ASCE. This allows the faculty member to have a broader perspective and voice on important technical as well as policy matters. Since many funding agency administrators and program managers from agencies such as NSF, NASA, and DoD also serve in these societies in various capacities, participation in professional service also provides good contacts with technical leaders within funding agencies. Typical professional service assignments include serving as a member of task forces, society administrative committees, conference technical committees, funding agency review panels, editorship of society journals or newsletters, etc. Two important points must be borne in mind in this regard. First, rather than have someone recommend the individual, it is suggested that the concerned faculty member take the initiative and seek to serve on the committee of interest. Second, some amount of travel may be required (usually 2–3 times a year), and the faculty member must find the travel funds to attend the meetings.

Outreach service to industry is especially important for engineering faculty, and can be used as an important mechanism to keep abreast of the latest technological innovations. This can be broadly classified into: (1) uncompensated consulting, and (2) compensated consulting. Uncompensated (i.e., free) consulting is recommended when the amount of work involved is minimal (less than 4–8 hours), or when the need to earn some goodwill is paramount (e.g., possible bigger grant at a later date, or free press publicity). Compensated consulting is called for if the amount of work involved is significant, and the faculty member has to take time off from other activities, including leisure. It is important to realize that this type of activity has strict deadlines and deliverables, and thus differs from the normal research grant activity. However, this provides a unique opportunity to work with technical personnel from industry, and thereby learn some new concepts that can ultimately benefit students. In addition, contacts and close working relationships with industry personnel are useful in developing joint university-industry proposals that many federal agencies provide support to. One such example is NSF's Grant Opportunities for Academic Liaison with Industry (GOALI) program.

PRIORITIZING AND PUTTING IT ALL TOGETHER

The Academic Leader is one who can combine his/her successes in research, teaching, and service activities together in an effective manner for continued professional growth and development. This activity has been defined as 'the scholarship of *integration*', which combines the scholarships of discovery, teaching, and application [29]. Many of the criteria required for achieving leadership in each of the three missions of higher education are also important factors in evaluating total faculty performance by department heads and deans. Criteria which generally rank as major factors in doctorate-granting universities as well as comprehensive universities and colleges include effective classroom teaching, quality of publications, number of publications, personal qualifications (such as professional experience), creative activity (independent of publications, and presumably including conference session chairing, etc.), and supervision of graduate student research [30]. Factors that are considered minor, albeit significant, are college and university service, professional society activities, undergraduate student advising, and public and community service. While the weights assigned for each criterion used in faculty evaluations may differ from institution to institution, there is general consensus on the methods for evaluating teaching, research, and service activities [31]. For assessment of teaching performance, student appraisals and rating forms are primarily employed, although their interpretation must be done carefully to avoid misuse. Peer evaluation of teaching is slowly gaining acceptance, and this includes assessment of course syllabi and contents, class handouts, and make-up of examinations and homework assignments. Research performance is frequently judged by the sheer number of journal publications and conference presentations, amount of grant and contract funding awarded, and number of graduate students supervised. There is some debate as to the procedure for judging research quality, as opposed to research quantity, but currently it is still the numbers that count. Service performance is difficult to assess, since most faculty participate in some manner or other in various committee activities within the institution. Thus, professional service activities, especially at a leadership level (such as editor of a major research journal, or office holder in a professional society) are considered good indicators of excellence in the service mission.

It is clear from the above that activities that guarantee professional growth, such as tenure and promotion, are the same that can help one achieve success as an academic leader. Thus, new tenure-track faculty are advised to seize the opportunity during their early years [32]. Suggestions for enhancing teaching skills include possessing genuine interest in student learning and welfare, serving as advisor to the student organization (such as HKN, or student sections of IEEE, ASCE, ASME), using innovative and non-traditional methods for knowledge transfer, and making up examinations that serve all students well (i.e., not too easy or too difficult). Research and scholarly activities can be enhanced by seeking research funding in a pro-active manner (e.g., visiting funding sponsors), exploring new areas for research (rather than competing with one's advisor), and publishing papers on a regular basis, even during the tenure-track years. Service activities can be enhanced by serving on review panels and professional committees, and seeking to bring positive recognition and visibility to self and the institution.

It is important to emphasize here that the type and scope of activities that will ensure success has to generally complement and support the strategic plans of the department, college, and institution [33]. It is vital to be aware of the missions, objectives, and priorities, so that the faculty member's accomplishments are appropriately recognized as supportive of the institutional mission. At the same time, one needs to develop personal long-range plans and objectives, as well as an annual plan and goals at the beginning of each academic year. Record keeping and reporting accomplishments are also considered important for both career advancement and attainment of academic leadership.

A recent book written exclusively for potential and current faculty in science and engineering offers numerous insights on teaching, and research [34]. The characteristics of good teachers include a positive attitude about students, well-paced lecture delivery in a relaxed style, evidence of seeking advice about teaching methodology from peers, careful course planning, use of innovative technology-based pedagogical techniques, and development and refinement of a teaching portfolio. Good faculty researchers need to recognize that they will spend a small fraction of their time 'conducting' research, and a larger fraction of their time 'directing' and 'managing' research. Primarily, the latter activity involves seeking research grants, ensuring research progress, disseminating research results, and reporting research outcomes.

Thus, the pursuit of academic leadership entails continual and concurrent accomplishments in research, teaching, and service activities. The most important resource required for this purpose is effective time management and budgeting skills, and the ability to accomplish multiple tasks concurrently [35]. Various strategies can be adopted for guarding against time wastage [36]. These include: (1) assigning a place for everything and keeping it in its place, (2) maintaining a regularly updated 'to do' list, (3) completing tasks in a timely manner without procrastination, (4) recognizing and desisting from performing meaningless and insignificant tasks, (5) tuning one's reading technique to quickly comprehend the gist of the material, (6) effectively managing interruptions from visitors and telephone calls, and (7) delegating less important tasks to subordinates such as graduate students. It is important to understand that, after steady state has been attained, time management process must come naturally and must not be contrived.

It is also important to recognize that some advice about career advancement skills for engineers also applies for faculty [37]. While determining the formal (i.e., written and documented) criteria for promotion and tenure is relatively simple, every institution has unwritten informal criteria by which faculty are judged. It is thus very important to determine what they are, and how to use them. It may also be helpful to identify a mentor among the more senior faculty who can provide guidance on both the formal and informal criteria for career advancement. However, the relationship between the mentor and the protégé must be based upon mutual respect involving cooperation and certainly devoid of competition. I therefore suggest that the mentor be a faculty member who is not competing for the same grant funding, but is one from a different technical area and worthy of emulation as an academic leader.

Based upon the above, the following strategy is one that may be followed to attain academic leadership in a doctorate-granting institution. During the initial tenure-track years, a faculty member is advised to spend a large percentage of his/her time identifying and pursuing research funding, while also spending a moderate amount of time enhancing teaching skills. It is also important to spend some time on professional society activities on a modest scale so as to make professional contacts. The suggested time allotment is 60% for research, 35% for teaching, and 5% for service. At the mid-point of the tenure-track period, it is recommended that journal publications be submitted, not only to enhance one's tenure portfolio but also to improve one's chances of obtaining research support. By this time, one must strive to attain steady state conditions for acquiring effective teaching strategies. It is also important by this time to serve on at least one college-level committee so as to be able interact with other department heads and the dean. During the second half of the non-tenured period, I suggest allocating 50% for research, 40% for teaching, and 10% for service. Once tenure has been attained, the level of external professional service may be expanded in order to interact with technical leaders from other institutions who may be willing to write supporting letters for further career advancement. It may also be useful at this time to disseminate any novel pedagogical technique learnt and perfected in an educational journal, such as the International Journal of Engineering Education. During the tenured years, a suggested time allocation algorithm may be 40% for research, 35% for teaching, and 25% for service. However, these percentages may be modified based upon specific faculty personalities and institutional culture.

CONCLUSIONS

While the ideas and principles enunciated above are all worthy of exploration and experimentation, it must be stressed here that each individual situation is unique. Every academic institution has its own culture developed and nurtured over many decades by assimilation of the diverse philosophies of its faculty and students, as well as those of the city, state, country, and geographical region in which it exists. For example, a doctorate-granting research university may place maximum emphasis on the research mission, while an undergraduate college may primarily prioritize undergraduate education (although research may also be expected). Thus, the expectations of faculty at these institutions will be entirely different, and the appropriate balance between the three missions will doubtless vary. In order to succeed in a particular setting, the reader is cautioned to consider the suggestions in this paper as a starting point, and fine-tune his/her individual approach to synergistically reinforce the needs and expectations of the home institution. As a simple guide for a primarily undergraduate college, approximately 30% of the time suggested in the above section for research activities may be moved as follows: 25% to teaching and 5% to service.

Resources are widely available for faculty members who seek to enhance their skills and attain academic excellence. These include peer-reviewed journals in the broad area of engineering, such as *International Journal of Engineering Education, European Journal of Engineering Education, Global Journal of Engineering Education*, and *Journal of Engineering Education*, as well as proceedings of conferences, such as *ASEE*, *FIE*, and *SEFI*. In addition, numerous workshops are also routinely organized by successful academic leaders, such as the SUCCEED faculty development (FD) program [38], and the National Effective Teaching Institute (NETI) workshop held each year in conjunction with the annual ASEE Annual Meeting. I strongly recommend taking advantage of such resources.

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