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THE MULTIDISCIPLIPLINARY IMPERATIVE IN HIGHER EDUCATION

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ABSTRACT

Disciplines codify related knowledge and have developed powerful approaches that enable both solutions to a wide variety of problems and efficient further extension of knowledge. Individual disciplines have translated into individual departments within universities. Academic departments tend to turn inward, deepening the knowledge within the discipline. Because of this inwardness, the differing methodological approaches among disciplines, and the reward systems within disciplines and universities, it is difficult for faculty to reach outside their disciplines and departments, so as to share knowledge and/or mine knowledge at the intersections of disciplines. However, world needs and opportunities are increasingly complex and require integrated, in-depth contributions from multiple disciplines for progress. Means for universities to encourage and facilitate multidisciplinary activities include organizational structure, incentive budgeting, and leadership and resources that enable directors of multidisciplinary units to negotiate effectively with academic department chairs. Major competitive initiatives involving large resources have proven particularly effective. New universities have opportunities for multidisciplinary research and teaching that would be much more difficult within existing universities. Today's university graduates must be able to work effectively with persons from other disciplines and understand enough of the basic vocabulary and methodologies of other disciplines to enable that collaboration. A liberal undergraduate education addresses those needs, where the definition of "liberal" encompasses courses reflecting many different disciplines, including the natural sciences and even some engineering. Professions are properly placed at the graduate level, built upon a foundational liberal education. Engineering should join the other professions by changing to that structure.

A. INTRODUCTION

Historically, as knowledge developed at an ever-increasing pace, it became desirable to classify and codify it and to seek efficient means for generalizing and extending it. This situation gave rise to disciplines and sub-disciplines within them. Disciplines provide powerful methodologies for advancing and conveying knowledge and also powerful means for utilizing knowledge in a wide variety of applications.

In their early days universities sought to provide a general education, under rubrics such as "natural philosophy". As knowledge grew and disciplines became established, the mode of education became one whereby students majored in a discipline or profession, preceded by what was commonly known as general education. More recently, the general-education content has changed in the direction of becoming distribution requirements – a specified number of courses from different areas, but often not specifically designed for general education. At the postgraduate level, specialization has become even greater and education narrower. Thus we produce graduates who are versed in a specific discipline with general education or distribution requirements that are modest at best. In some instances, such as engineering, there is very little in the way of general education or distribution requirements.

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The organization of universities has followed the disciplinary model, with academic departments corresponding to specific disciplines. Departments are the focus and base for academic appointments, budgeting, governance, curricular organization, and faculty obligations in general. The stature and hence the market value of a faculty member has to do with her or his standing within the discipline. Thus the academic life of a faculty member centers very much on his or her department and discipline.

By contrast, world issues, needs and opportunities are becoming increasingly complex and outstrip the capabilities of any one discipline. In order to make good progress, the powers of several, or even many, disciplines need to be brought to bear on subjects such as international finance; climate change; energy generation, storage, transmission and utilization; poverty; social unrest and war; healthcare; water supply; safe uses of biotechnology; and other world and national needs. On the local level, more and more issues bring together simultaneously technical and social needs, issues of public policy, and political interests. The complexity and multi-dimensionality of these issues require the full depths of disciplines. Whereas individual persons with interdisciplinary expertise have effectively tackled such issues in the past, this is less and less possible. Thus teams of persons versed in different disciplines are increasingly needed.[1]

The departmental structure of universities and the means of gaining national and international stature within disciplines inhibit multidisciplinary research, teaching and other activities. There are many ways in which this happens. Qualifications for promotion and salary increases are usually judged by standards within the discipline. Research across disciplines or at the edges of the discipline can be judged by those within a discipline to be of lower quality and, in a sense, belonging to no discipline. Faculty members with appointments in multiple departments typically must undergo evaluation by faculty from each of those departments, with standards and values that may vary considerably from department to department.

Teaching and service activities, institutional budget allocations, and usually research space are all assigned to faculty members at the department level. Departments are likely to see activities outside the department as reducing the value of a faculty member to the department. On the national and international levels, award and recognition structures are by discipline. The larger and more central the discipline, the greater and wider the recognition will be.

There are more fundamental obstacles as well. Methodologies and approaches differ from discipline to discipline, particularly between the natural and social sciences and among the social sciences. In the natural sciences and engineering research occurs through teams involving graduate students, postdoctoral researchers, and faculty members, whereas in the humanities and many social sciences the tradition is for the individual, rather than a team, to carry out the research.

The purposes of this paper are to present observations on ways in which multidisciplinary activities can be encouraged and enhanced, and to examine consequences for the educational systems within universities.

B. HOW UNIVERSITIES CAN NURTURE MULTIDICIPLINARY ACTIVITIES

My thoughts are based on 48 years with the University of California, including a variety of academic administrative positions at both the Berkeley campus and system-wide levels. More specifically, in 2006-07 I carried out a study of structural, governance, budgeting, and other institutional issues surrounding multidisciplinary initiatives for the Berkeley campus. A number of insights come from that study, and I will use examples from Berkeley and from within the University of California to illustrate them.

First and foremost, if faculty members really do want to get together for multidisciplinary research and teaching, they will find a way to do so, independent of what structures exist. A recent example from Berkeley illustrates this fact in a very positive way. When Berkeley faculty members from several different disciplines found themselves brought in on the analysis of the damages caused by Hurricane Katrina (2005) on New Orleans, they discovered a strong common interest in catastrophic risk management and recognized that expertise from a number of different disciplines was needed in order to approach the issues effectively. What is interesting is that it took service on the various Hurricane Katrina panels and committees in order for these faculty members to find one another; they did not intersect naturally on campus.

On their own and without university budget for initiating it, they created a Center for Catastrophic Risk Management[2], which has blossomed and has been of substantial use with regard other disasters and potential disasters, such as the Deepwater Horizon offshore platform collapse and oil release in the Gulf of Mexico (2010), and the risks associated with antiquated levees on California's Sacramento River delta. The collaboration has also led to co-teaching of multidisciplinary courses on management of risks of potential catastrophes.

Where there is a will there is away. What is needed is sufficient incentive and facilitation. Therefore many of the ways in which a university can encourage multidisciplinary activities involve organizational structures, governance, and budgeting.

One might ask why not simply assign faculty members from different disciplines to work together in research and teaching. This would, of course, be counter to the traditions of the great universities, whereby faculty members follow their own leads and interests and thereby select and define their own research. There are good reasons for that tradition. The faculty member knows more about his or her field than anyone else in the university, and thereby has the most intellectual resources for finding promising leads and defining how best to pursue them. The well honed system that assesses and rewards outstanding creativity through reputation and salary provides ample incentive for the faculty member to excel. Outstanding quality and striking innovations come from this tradition. It is part of the reason why large corporations have wound down in-house fundamental research activities that typically involved assigning research.

Organizational Structures

One of the best-known methods for facilitating multidisciplinary research is to set up cross-matrix organizational structures dealing with specific, topical areas of research. For years the University of California and many other universities have used variants on the concept of Organized Research Units (ORUs)[3]. ORUs provide space for research and interactions, administrative services, and in many cases some institutional budget. Within the University of California, in some cases (e. g., UCLA) portions of faculty positions have been allocated to such units, while at some other campuses (e. g., Berkeley) that is not done.

When multidisciplinary activities and/or would-be ORUs are started, they need a source of support services. Rather than investing a full array of such services in a nascent unit, one useful approach is to provide support services from another, established unit or parent organization. Another approach is to combine support services for a number of different units. Going much further in that direction, the Berkeley campus of the University of California has recently combined administrative services (personnel, purchasing, accounting, etc.) for nearly all ORUs and some related units, over 80 in all, in one Research Enterprise Services unit[4]. It is too early yet to ascertain how well this will work in practice.

On a grander scale, since the days of Ernest O. Lawrence and his cyclotron Berkeley has had a national laboratory adjacent to the campus. The Lawrence Berkeley National Laboratory (LBNL) receives much programmatic support from the Department of Energy. Since many of the projects undertaken are application- or problem-oriented, LBNL is an effective mechanism for bringing faculty and others together in multidisciplinary projects.

Another Berkeley move towards multidisciplinary academic programs occurred in 1994, when reviews of the School of Library and Information Studies, a rather classical library school, resulted in decisions to close that school and open a new School of Information Management and Systems (now called the School of Information[5]). The new school recognized the growing importance of information technology throughout society and includes faculty members with backgrounds in economics, law, computer science, business, sociology, political science, regional analysis and planning, and the information technology industry itself. The proposal that led to formation of the School[6] spells out the rationale. At the time this move was pioneering. Now a number of other universities have made similar changes, and a new professional field has taken shape. Professional schools in general have the characteristic of being multidisciplinary, at least to some degree, because they bring the methods of different fundamental disciplines to bear on a common professional application.

Establishment of a new school necessitates a high degree of confidence that the subject is appropriately chosen and will stand the test of time. However, for the most part the structures chosen for new multidisciplinary activities should be fluid and subject to modification or even elimination through subsequent reviews.

Governance, Budgeting and Empowerment

Given all the valued items that come to faculty through the academic departments, it is important to devise mechanisms whereby multidisciplinary organizations can deal with academic departments on a more nearly even basis. In management terms, the structure must be brought close to a true cross-matrix model.

One essential requirement is effective and tested leadership. Typically chairs of academic departments and deans are chosen through a process that has much input and gives much consideration to demonstrated leadership ability. A similar process should be followed with respect to directors of multidisciplinary units, so that they can deal with chairs of academic departments and other administrators effectively.

Also for reasons of leverage with respect to the academic departments, the director of a multidisciplinary unit should have continual access to sufficient resources of budget and space. This includes the ability to participate in start-up packages for recruited faculty members, so that the department in which the academic appointment may occur doesn't have to see the matter as a need to come up with the entire start-up package.

At Berkeley an experiment was carried out in which ten of twenty new faculty positions resulting from a budget increase in the early 2000s were dedicated to multidisciplinary research initiatives, and a competition was held among proposed initiatives. The winning initiatives were given faculty positions with which to work, but the faculty appointments had to be in academic departments or fractionally divided among multiple academic departments. There were multidisciplinary, multi-departmental search committees for the faculty members to be hired.

The resultant faculty appointments were reviewed and approved at the department and central campus levels, and the initiative director determined the allocation of the faculty FTE among the departments. This gave the directors of the new multidisciplinary initiatives considerable leverage in negotiations at the time that the new faculty members were hired, but that leverage did not continue once the assignments were made. It is important that the multidisciplinary unit director have continual, rather than one-time, resources, or the ability to swing continual resources, as the multidisciplinary unit and the department in various ways compete for the attention and involvement of the faculty member.

Special Initiatives

California Institutes on Science and Innovation.

One effective way of incentivizing faculty members to join together in well designed multidisciplinary initiatives is for there to be a competition with high monetary stakes. An example of such an approach was the establishment of the California Institutes on Science and Innovation, an initiative of former Governor Gray Davis of California[7]. The goal was to set up three (later four) premier research centers that would address opportunities for technological innovation that would enhance the future economy of California. The institutes would be on the campuses of the University of California, the official research arm of the state. $100 million (U. S.) in capital (i. e., building) funds were made available for each institute, with a requirement that the institute should demonstrate another $200 million of raised funds, so as to provide a 2:1 match.

We held a competition in which we encouraged that, in addition to serving important areas for the economic future of California, the proposed institutes should preferably be multidisciplinary in nature, have substantial industrial interest and participation, and involve multiple UC campuses. The subject matters of the institutes were not specified and were left to be part of the competition. This feature greatly aided the raising of industrial matching funds, since companies knew that a winning proposal in their area of corporate interest would provide then with a useful source and support for technological innovation. The competition was coordinated from the UC Office of the President, and involved distinguished external reviewers, both individually and in panels. The four institutes ultimately selected dealt with wireless communication [Cal (IT)^2][8], nanotechnology [CSNI][9], quantitative biotechnology [QB3][10], and information technology research in the service of society [CITRIS][11]. All of these institutes are highly multidisciplinary. As one example, CITRIS combines engineering with natural and social sciences.

Energy Biosciences Institute.

In 2006, the multinational energy company BP, Inc. established a world-wide competition to create an Energy Biosciences Institute, in conjunction with one or more major universities[vii,12]. After preliminary explorations, BP invited five universities to form teams to submit proposals to join with BP in an Energy Biosciences Institute, to be funded at the level of $500 million, spread over ten years. This institute would bring BP researchers together with university researchers and would emphasize novel means and underlying science for producing fuels from biological sources. By its nature, this project called for a well organized and highly effective multidisciplinary effort. The winning proposal came from a team led by the University of California Berkeley campus and also including the Lawrence Berkeley National Laboratory and the University of Illinois at Urbana-Champaign. The final contract[13] and other further information[14] are available on-line.

For the purposes of this paper, it is important to note that the final proposals had to be prepared in 60 days, start to finish. The Berkeley team was greatly aided by the fact that the California Institute for Quantitative Biosciences, one of the California Institutes on Science and Innovation described above, had been in existence for five years at the time of the proposal competition. This gave the proposal an excellent home, with strong support services. As well, the QB3 team supplied a sound core group for bringing people together and putting together a strong multidisciplinary proposal.

Shortly after the competition for the BP Energy Biosciences Institute, the U. S. Department of Energy held a competition for three Bioenergy Research Centers[15]. It was a short step from QB3 and the BP Energy Biosciences Institute for a team led by the

Lawrence Berkeley National Laboratory and including Sandia National Laboratories, the Berkeley and Davis campuses of the University of California, the Carnegie Institution for Science, and the Lawrence Livermore National Laboratory to win one of the three spots, forming the Joint BioEnergy Insitute[16]. This sequence of events illustrates that, in a very real sense, success breeds success.

Elements key to the quality of these initiatives have been substantial funding and competition. The funding serves to secure the interest of the most capable and creative faculty researchers and is, of course, needed to enable development of the research institute to its full potential. The competition serves to enhance the quality of the proposal.

New and Reorganized Universities

Newly established universities have no entrenched existing interests or structures and hence can favor multidisciplinary approaches from the start. A prime recent example is the King Abdullah University of Science and Technology (KAUST)[17] in Thuwal, Saudi Arabia. The contrast of the higher-education situation in Saudi Arabia with that in China is striking. China has many people, a diverse and booming economy but still a low GNP per capita, a tradition of high respect for higher education, and a massive need to develop and expand universities. Saudi Arabia has many fewer people, a single-element economy, a high GNP per capita, and a relatively weak recent history of higher education Saudi Arabia seeks to diversify its economy and provide a model of higher education within the country that fits the worlds of today and the future.

KAUST has an endowment of $10 billion or more, is modeled after Caltech, and is restricted to natural science and engineering at the M. S. and Ph. D. levels Research that is competitive with the best universities in the world is a principal goal. Another aim is that KAUST research and the highly trained scientists and engineers that KAUST produces will stimulate and feed into a national system of innovation and development that can bring important added components to the Saudi Arabian economy, beyond petroleum.

KAUST has fostered multidisciplinary activities within science and engineering in two ways. First, it has followed the model of a cross-matrix structure, with (currently) nine research centers, emphasizing areas of research potentially significant to the economic future of Saudi Arabia and/or unique to the geographic location of KAUST. Some examples are solar voltaic engineering, Red Sea research (e. g., unique coral reefs), water desalination, and plant stress genomics. Second, the organization of the university departs from conventional structures in three significant ways. First, there are no departments. Second, science and engineering are combined in each of the three divisions – Chemical and Life Sciences and Engineering, Mathematical and Computer Science and Engineering, and Physical Sciences and Engineering. Third, KAUST has no tenure; instead there are five-year contracts for faculty. It is still too early to judge how well these innovations will work.

Another example of innovation in structuring new universities is the new Merced campus of the University of California[18], where there are also no departments but only three divisions, each with deans – Natural Science; Engineering; and Social Sciences, Humanities and Arts. Academic majors and research are broad and multidisciplinary.

Teaching

A general rule is that multidisciplinary research collaborations are among the most effective precursors to multidisciplinary teaching collaborations. The faculty members to be involved have to find one another and want to work together, and collaborative research is a good way of bringing that about.

Multidisciplinary courses, almost by definition, belong to no academic department. It is important to allocate teaching credit for such courses fractionally to the home departments of the faculty members concerned and/or to have a source of funds that can be used by the departments for replacement instructors.

One mechanism that has been used at the University of California for multidisciplinary and interdisciplinary degrees is the Graduate Group. There are about 35 of these on the Berkeley campus, each empowered to give the doctorate and/or a master's degree. These Graduate Groups are composed of faculty members from multiple departments and typically have no budget; i. e., the degree programs are composed of courses already in existence. It is the mix of courses for the degree that is different. In a very few cases the Graduate Groups are Augmented Graduate Groups, which means that they do have budget, which was given as a way of encouraging the effort and/or enabling the Group to development and offer entirely new courses. An example is the Energy and Resources Group[19], which has faculty positions and staff, as well as a large number of affiliated faculty members from a wide variety of academic departments.

C. IMPLICATIONS FOR THE CONTENT OF HIGHER EDUCATION

A world of multidisciplinary challenges means that university graduates must be able to work effectively with persons from other disciplines and understand enough of the basic vocabulary and methodologies of other disciplines to enable that collaboration. The classical American concept of a liberal undergraduate education addresses those needs. The American Association of Schools and Colleges defines a liberal education as:

> "an approach to learning that empowers individuals and prepares them to deal with complexity, diversity, and change. It provides students with broad knowledge of the wider world (e.g., science, culture, and society) as well as in-depth study in a specific area of interest. A liberal education helps students develop a sense of social responsibility, as well as strong and transferable intellectual and practical skills such as communication, analytical and problem-solving skills, and a demonstrated ability to apply knowledge and skills in real-world settings."[20]

This definition fits the need well.

A liberal undergraduate education encompasses courses reflecting many different disciplines and combinations of disciplines, including the natural sciences and even some engineering. It should consist of more than just the introductory courses from a number of different disciplines. There should be specially designed courses bringing together different disciplines – the sort exemplified by teaching derived from collaborative multidisciplinary research experiences, such as the example in Catastrophic Risk Management mentioned above.

Disciplinary specialties should then be built upon the foundations of that broad, liberal undergraduate education. Professional degrees are properly placed at the postgraduate level, built upon a foundational liberal education. Engineering is the one major profession that does not have this structure in the United States and much of the rest of the world. Engineering should join the other professions by changing the professional degree to the postgraduate level and basing it on a liberal undergraduate education[21]. This change in engineering education may well happen in much of the rest of the world before it happens in the United States. For example, in Europe the Bologna Process is bringing about a restructuring of degrees to fit a common format, so as to enable students to move interchangeably among European universities. In the degree restructurings associated with the Bologna process the most common result for engineering is to make the professional degree a second-cycle degree[22], analogous to the Masters degree in the United States.

In Australia, the University of Melbourne has gone a step further, instituting what is known as The Melbourne Model[23] for undergraduate education. With this change there are only six undergraduate majors available, most of them quite general. The six majors are Arts, Biomedicine, Commerce, Environments, Music, and Science. All professional education, including engineering, is at the second-cycle, or Master's, level. The Bachelor of Commerce is considered to be an entry point for graduate professional degrees in areas such as Engineering, Law, Architecture and Commerce (Business) itself. The Biomedicine degree is one entry point into areas such as Medicine, Public Health and Bioengineering as possible graduate degrees.

ENDNOTES

[1] I define and contrast multidisciplinary and interdisciplinary as follows. Interdisciplinary refers to a situation where a single person utilizes more than one discipline. Multidisciplinary refers to a situation where multiple persons representing multiple disciplines work together to address a given problem, need or opportunity.

[2] http://iber.berkeley.edu/ccrm/

[3] See, e. g., http://www.research.uci.edu/centers/guidelines_oru.htm

[4] http://res.berkeley.edu/res/

[5] http://www.ischool.berkeley.edu/

[6] http://www.ischool.berkeley.edu/about/history/1993proposal

[7] C. J. King, "University Roles in Technological Innovation in California", Chapter 15 in *Globalization's Muse: Universities and Higher Education Systems in a Changing World*, J. A. Douglass, C. J. King & Irwin Feller, eds, Berkeley Public Policy Press, Institute of Governmental Studies, University of California, Berkeley, 2009.

[8] http://www.calit2.net/.

[9] http://www.cnsi.ucla.edu/.

[10] http://www.qb3.org/.

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[11] http://www.citris-uc.org/.
[12] Eli Kintisch, "BP Bets Big on UC Berkeley for Novel Biofuels Center", *Science*, 315 (February 9, 2008), pp. 746, 790.
[13] http://www.energybiosciencesinstitute.org/images/stories/pressroom/FINAL_EXECUTED_11-14.pdf.
[14] http://www.energybiosciencesinstitute.org/index.php?option=com_content&task=view&id=51&Itemid=90.
[15] http://www.science.doe.gov/News_Information/News_Room/2007/Bioenergy_Research_Centers/index.htm.
[16] http://www.jbei.org/.
[17] http://www.kaust.edu.sa/.
[18] http://www.ucmerced.edu/
[19] http://erg.berkeley.edu/
[20] http://www.aacu.org/leap/What_is_Liberal_Education.cfm.
[21] National Academy of Engineering, "Educating the Engineer of 2020: Adapting Engineering Education to the New Century", National Academies Press, Washington DC, 2005. J. J. Duderstadt, "Engineering for a Changing World", Millenium Project, Univ. of Michigan, Ann Arbor, December 2007. http://milproj.dc.umich.edu/publications/EngFlex_report/. C. J. King, "Let Engineers Go to College", *Issues in Science and Technology,* 22, (4), pp. 25-28. (Summer 2006). http://www.issues.org/22.4/p_king.html. N. R. Augustine, "Re-engineering Engineering", *ASEE PRISM*, 18, No. 6, pp. 46-47, 2009. http://www.prism-magazine.org/feb09/last_word.cfm.
[22] J. O. Uhomoibhi, "The Bologna Process, Globalisation and Engineering Education Developments", Multicultural Education and Technology Jour., 3, No. 4, 248-255, Emerald, 2009. www.emeraldinsight.com/1750-497X.htm.
[23] http://www.learningandteaching.unimelb.edu.au/curriculum/melbourne_model