# Part IV

# Views

# Chapter 14
# How Do Departments Survive

**William Kirwan**[1]

I am very pleased to have an opportunity to participate on this panel. One of the worst aspects of my present position is the degree to which I have been distanced from direct involvement in issues affecting mathematics.

The subject for the panel is obviously very timely. However, the title has a somewhat more optimistic tone than I believe is warranted. Perhaps I am a bit jaded from my experience with the budget cuts at College Park and at other universities, but for me a more fitting title might be "How Do Mathematics Departments Survive During a Time of Diminishing Resources and Declining Public Support?" Whatever the title, I believe the topic for today's discussion and the work of the AMS Task Force on Excellence are extremely important for the future well being of our discipline.

I would like to focus for a few moments on some of the resource-related issues that we as a community face now and probably will face for the rest of this decade. First, the obvious: we have needs and demands for expanded activities that far outstrip available resources. A recent survey conducted by the American Council on Education determined that 47 percent of public four-year colleges and universities have flat or declining budgets. I am confident that the data specifically for mathematics departments are no better. The stories of resource strain in universities from Maryland to California and from Oregon to Florida are well known, and the situation is not likely to improve in the near term. John Wiesenfeld, Cornell's vice president for planning, was recently quoted as saying, "We are looking at a sea change in the environment for higher education, both private and public. Understanding the implications of these changes," he says, "is now what we must do." So, the first issue the AMS committee must face is the apparent reality that, in terms of available resources, the 1990s are going to be far

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bleaker than anything post–World War II trained mathematicians have yet experienced.

Comparatively speaking, this is the good news in my observations. Let me now turn to a second challenge that we as a community and the committee face. Perhaps the only thing falling faster than our resource base is public understanding of and support for the work we do at research universities. Our situation is perhaps best summarized by the "hearings"— and I use that term advisedly—conducted by Congresswoman Pat Schroeder this past fall on the state of undergraduate education.

There are many advantages to being a research university in the Washington, DC, area. But especially when it comes to congressional hearings on sensitive higher-educational issues, there are also disadvantages. If you want to bash universities, where do you turn? Obviously to the editor of the school newspaper at one of the local research universities—in this case, College Park. Never mind that the testimony that this student and others gave was, at the very least, overstated. The fallout from this hearing and other hearings on the same subject now being planned by Congressman Dingle and likely to be emulated in state legislatures across the country could do considerable further damage to our image, an image that also has been tarnished by research fraud (not, I am proud to say, in mathematics) and by excesses of administrators in the use of research overhead. Charles Vest, president of MIT, said it well the other day in testimony before a White House panel: "Growing out of a sense of disappointment and mistrust, research universities rest on unstable and shifting ground."

The focus of much of the criticism of research universities is the lack of attention given to undergraduate education. For some this gets translated into faculty "teaching loads", so we see legislation in states like Florida, Oregon and, I believe, California, mandating increased teaching loads. In Maryland and in many other states, legislators are asking for information on teaching loads—note I said "teaching" and not "work" loads. Many of our critics do not understand the difference.

But it is not just aggressive and somewhat uninformed legislators who are critical of the quality of undergraduate education. Leaders of our most distinguished research universities also have spoken out on this topic.

For example, in a recent article in *Change* magazine, Derek Bok, president emeritus at Harvard, cited the lack of attention to undergraduate education, primarily at research universities, as the number one issue causing the decline in public trust of higher education. He said, "Until we convince the public, by our actions, that we indeed make education our top priority, that we are committed to the highest quality of undergraduate education, we will continue to be vulnerable to attacks on our curricula, our faculty, our tuition, and all the different issues on which we have been taking punishment the last few years."

Richard Atkinson, a member of the National Academy of Sciences, president of the University of California, and former director of the National Science Foundation, said something similar in an article he published with Donald Tuzin of UCSD. They wrote, "...research universities should lead the way by restoring the balance between teaching and [research]." They go on to say, "...the continued greatness of the American research university depends on ... an equilibrium between the three missions of its charter—the propagation, creation and application of knowledge. When the balance goes awry, the entire edifice erodes. The chances of collapse may be slight, but the dysphoria has gone on long enough. It is time to re-establish equilibrium."

Much the same view is expressed in the just released report of the Presidential Commission on the Advancement of Science and Technology, a commission established under the leadership of science advisor Alan Bromley. The report, entitled "Renewing the Promise: Research-Intensive Universities and the Nation", makes an eloquent case for the role that the nation's research universities have played in the advancement of our society. The report also addresses the issue of instruction at research universities. Among many recommendations, it says that universities must:

- increase direct senior faculty involvement at both the undergraduate and graduate levels and in counseling students;
- balance the contributions of teaching and interaction with students with those of research and service in evaluating and rewarding faculty;
- place less instructional emphasis on graduate teaching assistants;
- develop new pedagogics for undergraduate teaching;
- assist with national, state, and local efforts to revitalize precollege education in science and mathematics; and
- provide incentives for outstanding undergraduate and graduate teachers.

Thus, it seems clear that the AMS Task Force on Excellence must deal substantively with the issue of the quality of undergraduate mathematics education for all students, not just mathematics majors. The general population, who in the final analysis is our source of financial support, is demanding that this happen, and many of our most respected academic leaders concur. We can resist these demands, but, in my view, we do so at great risk to our discipline. Unresponsiveness on our part and further alienation of the general population toward our research universities is likely to lead to even more onerous externally imposed "workload" requirements and further declines in our support base.

There is a third issue, related to the previous one, that I believe the AMS Task Force must consider. This is the role of mathematics departments in reform of K–12 education. This is yet another demand being pressed upon us which, in my view, we cannot avoid. There is a very definite movement sweeping the nation calling for the elimination of the bachelor's degree in education. To a large extent, this movement has been spawned by a group of our nation's best colleges of education. This group, known as the Holmes Group, now numbers more than one hundred. A central principle of the group is that K–12 teachers should get their first degree in an academic department with support work in education. The State Board of Education in Maryland and boards in several other states are presently considering proposals to modify teacher certification along these lines.

Based on what I have heard in Maryland, there is significant public support for such a reform. If carried out, this change would of necessity bring mathematics departments into a much closer working relation with the K–12 sector. To be sure, there are already significant school/university initiatives at many of our research universities. But the change I foresee could lead to substantially increased expectations for our already overburdened mathematics departments. Of course, these expectations also create considerable opportunity for research universities, especially in mathematics because of its central role in education at all levels. There is a chance we can effect positive change and increase public awareness of and appreciation for our discipline and our institutions.

Even if the view of the future I have described is only partially correct, it seems clear that the AMS Task Force has a formidable challenge: providing recommendations in an environment where there will be fewer resources in absolute terms and greater demands on our departments.

How are we as a community to cope with this situation and maintain, as we must, the vitality and evolution of our discipline? Despite the generally bleak picture on resources, there should be incremental funds available for improvements to undergraduate education. First, the science education division is one of the few divisions in NSF with a hefty budget increase. Also, university administrators are under considerable external pressure to demonstrate commitment to undergraduate education. Since failure rates and attrition tend to be high in lower-division science and mathematics courses, proposals to improve the quality of these courses are likely to receive a favorable response. For example, I believe that Indiana University recently invested significant new resources for reforms in the calculus sequence. Of course, it probably helped that the dean of the college is Mort Lowengrub, a mathematician.

Another alternative that deserves consideration is to modify the reward structure at research universities for tenured faculty as a means of encouraging some faculty to devote most of their energies to teaching and curricular matters. Obviously, such a move is an issue for individual institutions and departments to decide. And it is my understanding that several universities are beginning to explore proposals in this direction. In mentioning this idea, I emphasize tenured faculty because I believe a research university must insist that those to whom it grants tenure demonstrate a mastery of some important subdiscipline of their fields.

Do not misunderstand what I am saying. We should continue support for the most talented researchers, especially the youngest of these individuals, more or less as we do at present. But, in my view, we must make it easier for senior mathematicians at research universities to take on with dignity, respect, and reward some of the challenging obligations facing the mathematics community. I believe there is food for thought in a recent address by Don Kennedy, former president of Stanford. He said that “the overproduction of routine scholarship is one of the most egregious aspects of contemporary academic life: it tends to conceal really important work by its shear volume, it wastes time and valuable resources, and it is a major contributor to the inflation of academic library costs.” In the article by Atkinson and Tuzin that I cited earlier, the authors say a similar thing: “Research universities can relieve the strain on resources by honing the research enterprise to redirect the work of individuals whose energies could be better spent in other areas of the university’s mission.”

I believe there is an especially important role in this general area for the AMS. As the primary professional society for research mathematicians, the AMS is in a position to exert great influence on the community. The Society’s support for an expanded reward structure and its recognition of exceptional contributions to mathematics pedagogy would go a long way toward creating an environment where the changes I describe can occur.

There is one final point I would like to make. In my view, as a group mathematicians have done a poor job of explaining to the university community and the general public the value of the work we do. The AMS needs to consider ways in which our, community can better articulate proactively the value we add to the intellectual base of our nation. I fear that we are losing out in the struggle for support between the advocates for “big science” on the one hand and, on the other hand, the proponents of research expenditures tied more closely to the nation’s economic growth. We need to make a better case for the intrinsic value of mathematics and, in particular, mathematics research.

In conclusion, let me say that in comparison to other disciplines I believe the mathematics community has demonstrated a remarkable degree of responsibility and leadership in its willingness to address the difficult issues facing higher education. Among other efforts, the “David Report” and MS 2000 reports, the development of the new NCTM standards, the appointment of the AMS Task Force on Excellence, and the JPBM Committee on Reward Structures are indicative of an academic community responsibly grappling with its future in these uncertain times. These and other efforts make me feel proud to be a mathematician.

# Chapter 15
# A View from Above: Interactions with the University Administration

## Ettore F. Infante[1]

A department of mathematics, as its name implies, is a component of the university of which it is a part. Whereas the mathematical profession transcends institutional—indeed, national—boundaries with its research activities, values, culture, rewards, and means of interaction, the department is local, embedded, and largely dependent on the university of which it is a part for resources and infrastructure support. For a department to be successful it must be able to manage—indeed, to appropriately leverage on each other—the expectations, values, rewards, and resources of the university of which it is an integral part with those of the larger disciplinary world to which its faculty belongs. This is a particularly critical task at research universities, with their dual mission of research, which transcends the particular university, and education, which is more local. It is thus important for a department and its leadership to develop a clear understanding of its institutional setting, of the stated mission of the university of which it is a part, and of its role within it. Effective communication within the administrative structure of the university depends on it.

This brief presentation of a "view from above"—that is, of the context and criteria with which deans, provosts, and senior university administrators interact, view, evaluate, and prioritize resource allocations to a department and its activities—is intended to help faculty and departmental chairs better understand this process.

A useful maquette that captures the essence of the context within which university administrators view a department can be expressed by three words: mission, money, and impact. These words refer to three highly interrelated aspects of a university. The mission of the institution is the basic compact between it and the larger society that provides it with resources and support, and the term "impact" includes the quality, effectiveness, and efficiency with which that mission is discharged through the use of the financial resources that are provided. Deans,

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provosts, and senior university administrators have the tasks of being the conscience of the institution as to its mission and use of resources and of acting as spokespersons for the university to external constituencies as to its values, accomplishments, and resource needs. Perforce, deans and senior administrators are at the center of resource allocation to depart,ments and are the ones most accountable for these resources. Within this context it is their task to see that clear answers are provided to the litany of questions—who pays? who benefits? who should be subsidized? from what sources? for what purpose? and with what impact?—and to see to it that these answers are sustained by the enduring values, ideas, and ideals of education and scholarship.

The mission of the university, intimately tied to the sources of funds that support it, is central to any communication between departments and academic administrators. At research universities the mission is multifaceted, concerning discovery and learning, dissemination and teaching, and the promotion and use of knowledge in society. With notable exceptions, research universities have mission goals in undergraduate education, including general education; in graduate training; and of course in research and outreach. It is essential that faculty and departmental leadership have a clear understanding at their university of institutional expectations within these components of the mission, of the sources of funds that support them, and of the role that is expected from the department. Discussion of mission, roles, and responsibilities is the essential base for appropriate interactions between the department and university administrators. On this base, further interactions center on impact and on the resources needed for appropriate impact.

It is useful to differentiate five aspects of impact: centrality, quality, effectiveness and efficiency, demand, and comparative advantage.

Academic administrators must of necessity pay particular attention to those university activities and structures that rank high in centrality. Mathematics, as a discipline, shares the distinction of a high level of centrality with English and the library, for it plays a very particular role in general education and an essential role in the preparation of a large spectrum of students for further study in the sciences and engineering. This centrality of mathematics results in concerns, expectations, and willingness to invest by deans and provosts that go beyond those directed to units with less widespread academic impact on the entire institution. It also leads to the fact that a dean cannot but have a high level of concern for the performance of her mathematics department in undergraduate education, for it must be noted that the centrality of mathematics is most evident in undergraduate education, much less so in graduate education and research.

Quality, in the eyes of administrators, is the result of an evaluation of the outcomes of the activities of the department. The external reputation of the departmental research activities and of their impact on the national and international research and applications community, the quality of the preparation of undergraduate and graduate students produced as reflected by their professional contributions and accomplishments after graduation, the satisfaction of other departments within the university in the mathematical preparation provided to their students, and the leadership of the department in outreach activities in education and in multidisciplinary research are some of the elements that underpin the judgment of the quality of a department. It is essential that department chairs provide appropriate information to their deans on which appropriate judgments can be made. Not only should information about achievements and successes be provided, but also credible, realistic appraisals of shortcomings together with plans to alleviate them. Impact of high-quality merits reward; its sustenance requires resources.

Quality plays a most important role as a criterion in the evaluation of plans and budgets. So do the criteria of effectiveness and efficiency. How effective is the department in its manifold tasks of undergraduate and graduate education, of research and outreach? What goals and strategies has the department set for student recruitment and retention, for rapid progress through their studies, for the utilization of technology and of innovative teaching methodologies, and for the securing of external support for research and educational activities? Efficiency refers to the cost-effective utilization of resources in the pursuit of goals by the department. Plans and budgets must represent the embodiment of considerations of quality, effectiveness, and efficiency. Discussions centered on planning and budgeting are an opportunity for a departmental chair to engage in meaningful communication with deans and senior administrators as to the assets and needs of the unit.

Finally, a dean, faced with the always difficult choices implied by resource allocations, will want to address issues of demand and of comparative advantage. What demand is there from students and other departments for the instructional services provided by the department? What is the demand for doctoral students, for research activities, and for outreach? Chairs should be prepared to document existing demands, as well as realistic opportunities for the department and the university to undertake new and novel activities in response to felt needs. Comparative advantage, as the term implies, is a judgment on the part of administrators that leads to preferential investments in a particular area or department because of the belief that some sort of benefit-cost ratio will be maximized through that investment. Comparative advantage is most often based on an evaluation of strength, seldom of weakness; on evidence that the department has well-laid plans which it is already implementing through the reallocation of its own existing resources, thus demonstrating high priority; and on how strongly the resources the dean is asked to invest will leverage other activities of high priority.

Planning and budgeting are yearly opportunities for a department to present its case for the centrality of its activities; for their quality, effectiveness and efficiency; and for its plans to respond to demands and opportunities based on its comparative advantages. Discussions between chairs, deans, and provosts on budgets are perforce based on data. University administrators are most knowledgeable about facts and data internal to the institution; much less so about data on mathematics departments at peer universities. It is the essential responsibility of the department and of its leadership to develop such cross-institutional data and to present it to university administrators. Credible “benchmarking” with peer departments on resources and performance should be developed to address the five criteria of impact previously described. Most helpful is the result of an external review of the department, where qualitative evaluations are based on benchmarking data developed as part of a departmental self-study. The most effective comparative data is centered on competitive situations: success in grant activity, in publication of research, in placement and success of graduates, in philanthropic fundraising, and in reputational rankings. But it is most important to provide comparative data on all resources and results. University administrators must make decisions on resource allocations within their own university; in so doing they are driven to comparisons and evaluations of the diverse disciplinary units for which they are responsible, yet they are committed to the competitiveness of these units with their peers at other institutions. It is the task of the chair of the department to provide the data and information so that deans and provosts can reach informed judgments; no one else but the chair, with appropriate help, can undertake this task. For mathematics, with its highly developed and somewhat unique role within the disciplines and the university, this is a crucially important task.

Matters of mission, money, and impact are at the heart of communication between chairs and academic administrators and are central to the evaluation and resource allocation process. There is another element that plays an unusually important role: the perception by administrators and department outsiders of the department's "atmosphere"; of the quality of the interactions within the unit and with other departments; and of the reliability, credibility, and stability of the senior faculty and the departmental leadership. Trust is the golden coin of the academic realm; civility and responsiveness to the needs of the institution are essential to its flow. Often departments have been judged as less than successful and not deserving of resources by being perceived as fractious, isolated from the rest of the institution, unable to set goals and priorities, and unwilling to be guided by long-term leadership. Deans are known to speak of the "culture" of departments, sometimes in negative terms, but also sometimes in admiring ones. A positive, responsive, and civil culture within a department and long-term responsible and foresighted leadership by the senior faculty and the chair are important to the success of a mathematics department within the modern research university.

This said, the five criteria described and the appropriateness of the role of the department within the mission of the university constitute the basic elements that underpin the discussions on the evaluation and resource allocation to the department by academic administrators. Successful discussions are essential to the well-being of the department.

# Chapter 16
# A View from Below

**Doug Lind**[1]

Recently I completed a five-year term as department chair, and I have been reflecting on what I would have liked someone to tell me before I started out. I picked up some of what follows at the BMS chairs colloquia, some from talking with other chairs, some from the Task Force focus groups, and some from bitter experience.

## 1. Work Very Hard at Your Relationship with Your Dean

The relationship between the chair and dean is crucial to the health and success of the department. They should agree, at least in general terms, on the mission and goals of the department and how to measure progress. In case after case, the ability of a department to change and prosper has depended on the dean trusting the chair and feeling that the department was accountable. Striking examples of this are Don Lewis, followed by Al Taylor at Michigan; and Bus Jaco, followed by Brian Conrey at Oklahoma State. The dean at Oklahoma State said he knew "how good the department was in keeping the wolves away from the door in terms of when we talk with the state people." Considering the resources Oklahoma State has to work with, they have done incredible things.

On the other hand, plenty of deans told us about their frustrations with mathematics departments, complaining about their insularity (one dean said that the department doesn't talk among themselves, much less with other departments), their not taking teaching basic courses seriously enough (as evidenced by widespread complaints from students and other departments), frictions between mathematics and applied mathematics (sometimes so disastrous as to cripple the department), and their nostalgia for the good old days which will never return.

It is essential to this relationship that chairs and deans understand each other's needs. It does no good for a chair to push for increased research support if the dean's main worry is precalculus instruction. Fitting the department's goals within the overall missions of the university first requires the department to un-

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derstand what those missions are. This means involvement of faculty beyond the confines of the department (e.g., talking with other departments, the faculty senate, regents' meetings, even the legislature). A chair should meet regularly with the dean to discuss what they are doing and should modify this in light of any new information. This is a two-way street, and a chair should not be an administrative toady.

Deans like named things. So instead of proposing simply to improve precalculus instruction, call it Project PreCalc, with specific goals, faculty, budgets. This is something a dean can brag about to the central administration and other deans. It also serves as a focus for funding. Make the dean look good.

Deans also look for departments to prioritize and make choices. Ending one department activity in order to fund something more important tells a dean that the department is responsible and is willing to take a hard look at itself. Not every new project should involve major new money from the college (you won't get it). Outside funding can be crucial in getting a project off the ground (e.g., Texas Instruments money to start the Mathematics Learning Resource Center at Oklahoma State, later sustained by student fees).

Find out what data the dean is using to judge the department. Is this data shared with the department? How are comparisons with other departments made, and do the chair and dean agree these comparisons are fair? You should also compare notes with other chairs to check for consistency.

Keep the dean informed of potential trouble and how you're handling it (e.g., potential sexual harassment charges, uprisings by undergraduates, threats of lawsuits, etc.). The last thing you want is for your dean to be blindsided by a very unpleasant event.

## 2. Hone Your Negotiation Skills

Your success will largely be determined by your skills at negotiation. Buy and study *You Can Negotiate Anything!* by Herb Cohen. Understand that the three keys to negotiations are time, power, and information. Knowing how these work in a particular situation can go a long way towards success. Strive for "win-win" outcomes.

## 3. Understand the Position of Your Department in the University

Meet people from around campus informally (say lunch) to get to know each other. These could include engineering and education deans, a vice provost for undergraduate education, chairs of other departments, faculty, staff, students, and so on. This can be enormously interesting, and I found it one of the real joys of the job. It also makes it much easier to call someone later to ask a favor or get some key information and for them to do the same with you. One thing you should strive for is a frank expression of how others view the department. If this is favorable, it's good to know, and if unfavorable, it should set off alarm bells that demand attention. It was amazing to me how little departments know about each other and their very different cultures.

It also helps to know how power works in your university. Who controls what resources and how are they allocated? Involvement in the faculty senate or even attending regents' meetings can be quite enlightening.

## 4. Burnish Your Department's Image

Nominate your best faculty and students for awards, both internal and national. Tell them you're doing it. Set up your own awards for students and create a ceremony, which potential donors should be invited to. Be a PR person for mathematics within your community. Learn whom to contact in the local press with story ideas, and build relationships with them (for example, by using the occasion of a conference on campus, I once got a detailed story about the Riemann Hypothesis on the front page of the *Seattle Times*).

## 5. Data and Budget

Good data is a golden currency when making your case. Data that meshes with your administration's is even better. Know your department's budget, and get monthly statements so you have a sense of how it's being spent. Fundraising will be increasingly important to enable you to do those wonderful discretionary things that give you a warm glow inside. It's hard to do and a long-term effort, but your college should help. Find out who's been successful, and how.

## 6. Deal with Stress

Let's face it, chairing a large department of colleagues is a very tough job. You will have to make important decisions about the lives of the people you know and live with the fallout after you've stepped down. The Golden Rule is useful to remember: treat others as you would like to be treated. But the accumulating stress can cause all sorts of problems, and you should be aware of signs when things are getting bad and take steps to manage stress (running, sports, massage, whatever). You are no good to anyone if you're so wound up you can't think straight.

## 7. Take Pleasure in Making Your Department a Better Place

As chair you can play a huge role in making your department a better place for its faculty. In literally hundreds of ways you can bring out the best in your colleagues, providing support, encouragement, ideas, and sometimes constructive criticism. Take pleasure in this, for it will tide you over the rough spots.

# Chapter 17
# Communicating with the Administration


## Alan Newell[1]


Without exception, successful departments have established credibility with the university administration and particularly with the levels of dean and academic vice president. They have done this by recognizing clearly their unique position (the centrality of mathematics) and the awesome responsibility that goes with it. They have not waited to be asked, coaxed, prodded, or coerced. Rather, they themselves have taken the leadership in addressing the enormous range of challenges bestowed on a department in a Research One University, responsible for the literacy, consciousness, and education of a generation of students of widely varying abilities and the propagation of knowledge both within the discipline itself and across disciplinary boundaries. It has often been said that mathematics is far too important a subject to leave to the mathematicians. The successful department gives lie to that statement by accepting the role as quarterback and by clearly defining goals, strategies and plans for meeting the expectations placed upon it by the overall mission of the university.

The other components of the university structure, from central administration to client and other disciplines, do not resent such precociousness. On the contrary, they welcome such initiative with open arms. We cannot overemphasize the enormous leverage a department can gain by establishing its credibility and competence in handling its mission. The palpable and collective sighs of relief coming from the carpeted corridors of power in central administration are clearly audible. They know that failure to provide an effective preparation in mathematics for its undergraduate population is guaranteed to give presidents, vice presidents, and deans endless hours of headaches generated by complaints from students, parents, and state legislators. And we know it too. And therefore we know that by relieving them of the burden of concern over undergraduate mathematics and by establishing a bond of trust that mathematicians can develop strategies to further the overall university mission, deans and academic vice presidents will be predisposed to listen sympathetically to well-argued and sensi-

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ble plans for resources to cover and advance the entire spectrum of departmental goals.

And the beauty of things is that this contract with central administration need not involve a whole lot of new resources. To be sure, we have found that successful departments have needed some additional monies to develop programs that provide more personal attention for students in entry level mathematics and to seed efforts to improve the computational environment. But the most important resource for the mathematics department in a Research One University is people, and the most important currency is positions, to renew the lifeblood of the department with new young faculty and to attract a regular stream of first-rate visitors. To provide these kinds of support requires almost NO NEW MONEY. All it requires is NERVE and a belief in statistics on the part of the dean and academic vice president. A little analysis of most major departments will show that if the university is willing to commit replacements and the use of funds generated by unpaid leaves of absence, then the dean can guarantee the department for the next $N$ years that it can recruit $n$ new tenure-track positions per year and $m$ temporary visiting (with teaching responsibilities) positions. In the case of many of the departments we surveyed, $N$ was five, $n$ was at least two, and $m$ at least four.

A contract which, in return for a clear and sensible departmental plan, guarantees a reliable stream of concrete funds has proven to be invaluable for a multitude of reasons. First, departments can plan ahead. They can actively seek out the best new talent and make concrete offers at any time. They can get the best visitors because they can make their offers early. Second, and most important, the knowledge that there is a stream of openings on line removes from departmental deliberations one of the main ingredients of dissension, namely, the belief that each appointment is the last and that different specializations within the discipline are doomed if they do not capture the positions for themselves. The certainty of positions means that each of the areas declared to be priorities can wait until it has found the very best person rather than push those less-than-perfect cases for reasons of territorial gain. Indeed, we have observed first-hand the presence of a spirit of cooperation in departments which have long-term strategies underpinned by real and concrete financial support. Third, and especially important, it allows a department to adopt genuine change, to make plans to test the waters in new areas. In particular, it helps a department build ties with other disciplines. In one case we know, a mathematics department was willing to use one of its positions to attract a couple of new people in financial mathematics. The other position was supplied by the business school. Each department will immediately gain twice the value of its involvement. Fourth, it enables the department to foster links within the subject itself which promote and celebrate the unity of mathematics. Anachronistic dichotomies such as applied versus pure can be avoided. A broad participation in the hiring process can be encouraged. The advantages of hiring new people who bridge different areas can be clearly seen. In short, faculty members team to support moves which advance the department as a whole and forego the narrow and territorial perspective.

Moreover, the advantages that accrue to a department from a contract guaranteeing resources over the long run directly contribute to the mission of the university as a whole. The department is fully co-opted into providing leadership for all things mathematical that go on in the university, for the education and training of its undergraduates and graduate students, for the provision of an intellectual home for all those colleagues from different disciplines who share common mathematical challenges and intents, and for the advancement of knowledge within the discipline itself.

# Chapter 18
# Advice from a Department Head


## John Conway[1]


A mathematics department with a graduate program has three significant areas of involvement whose combination makes it unique amongst all campus units: precalculus and calculus service courses, the program for the majors and power users of mathematics, the graduate and research programs. Promoting and fostering all three areas and getting the department to recognize the importance of all three are the keys to academic prosperity.

Some other departments, such as English, also have significant low-level service courses. English and mathematics, however, are essentially the only subjects required by every unit across the campus. Of course every unit has a major program and usually a graduate and a research program as well. No unit on campus other than mathematics, however, offers upper-division and graduate-level courses to students majoring in other disciplines.

Indeed, many mathematics departments have advanced courses populated almost exclusively by engineers and scientists. In contrast, it is a rare year that a graduate student in history takes a senior-level course in Shakespeare.

## Service Courses and Calculus

The truth is that if any of these three areas of activity within the mathematics department are ignored, severe consequences are likely to follow. The service program handles so many students that any neglect here is likely to be heard all the way up the administrative food chain. But even though it handles the largest number of students, possibly double the number encountered in the other two parts combined, it cannot be allowed to become the tail that wags the dog.

Having an impact on a great number of people is certainly what this service mission does, though the other parts of the mission, in the long run, also impact large numbers. Placing supreme emphasis on servicing large numbers of students is shortsighted and inimical to the profession and the health of the department.

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The service program, despite its size, is unlikely to obtain tenure-track positions for the department. University administrators recognize that it does not take a Ph.D. mathematician to teach such elementary courses. The department nevertheless must devote energy and resources to this part of its curriculum.

My way of maintaining quality control and improvement in the service courses is to put faculty in charge who consider this assignment as professional development. In our department we are blessed with several instructors, hired without tenure but on a somewhat permanent basis (it's a complicated story), for whom this administrative responsibility is their primary activity outside of teaching. They do a wonderful job of keeping the courses updated and coordinating the various sections of the same course to insure that the syllabus is followed and there is some degree of uniformity. They also alert me and the tenured faculty to problems and their possible solutions, as well as to developments in the approach to this material. Some of these instructors have Ph.D.'s and some do not.

Yes, I do have some tenured faculty who could do this job and would do it well. But I do not have enough of them to fill all the roles needed. For service courses it is important, however, that tenure-track faculty monitor what has been happening and what has developed in the service-level courses. In the final analysis it is the responsibility of the mathematics department to be certain that these courses are taught well. Blending all these elements together requires time and effort from many quarters. There are several pitfalls, and communication is an essential key to a smooth operation.

Having instructors and tenured faculty serve together on the undergraduate committee is one way to foster communication. E-mail chat lines about various courses is another. Having tenured faculty occasionally teach a service course and participate in the coordinating procedure conducted by an instructor are also ways to keep the tenured faculty current in the practices at the freshman level.

Now the core calculus course is an anomaly in all this. I am ambivalent whether this belongs to the service program or with the major program. Core calculus has many of the characteristics of a precalculus service course: it has many sections, many students enter calculus courses improperly prepared, it's taught in some form in the high schools, and the failure rate is higher than courses in the major program. It is, however, the starting point for the mathematics and science majors. So in practice I have chosen to treat it as part of the major program. It is therefore important that it be taught by people who understand the subsequent courses. For me this means only Ph.D. faculty, the GTA who has passed the prelims, or the occasional instructor who has a background with greater sophistication than usual.

## The Program for Majors

If I were asked the primary mission of any department, whether it is mathematics or any other discipline, I would answer that it is the teaching of undergraduates. Sadly, however, the major program is an area often neglected by mathematics departments. I frequently think that this is due to the fact that faculty energy is sapped by focusing on the graduate program and/or the service program. It is just too important for the department to have a well-run program of upper-division courses for its majors and the power users, and the creative energy of the tenured faculty is paramount for this.

There are many interesting facets to the culture of mathematics. One is the concept of the undergraduate major in mathematics held by many research mathematicians. The thinking is that the program is for those destined for graduate school and perhaps future K–12 teachers so they can properly prepare future college-bound students. The word "elitist" is certainly applicable. This narrow definition of the major program is also contrary to the underlying philosophy of modern American higher education.

It seems to me that the profession is ignoring a potential source of majors. There are people who have modest mathematical ability and might major in mathematics rather than history, or sociology, or physics. We should admit the possibility that some of our majors just want a degree and will eventually have a job in which they never use their mathematics A sound degree, say a B.A. in mathematics rather than a B.S., is a definite possibility, one which we should embrace as a concept and begin to recruit undergraduates to pursue.

The best way to maintain the research mission of a mathematics department is to have a healthy major and graduate program. Deans understand arguments that we should hire additional faculty to meet increased demand in upper-division courses. Obviously people without a Ph.D. cannot teach mathematics courses to juniors and seniors. Increasing upper-division enrollments and growing the number of mathematics majors will eventually translate into additional resources.

## Graduate and Research Programs

The graduate and research programs of a mathematics department are every colleague's first love. Faculty scrutinize the graduate program, they contribute to it, and they are very concerned about keeping the program up to date. This is not unique to mathematics, and the department head can rely on the faculty's attention to the organization and conduct of the graduate and research programs.

My contribution as department head in this sphere has been more to encourage faculty to dare break with the traditional approach to graduate education and contemplate innovation in a broad sense. Such change is invariably controversial. So another role of the head in this program is to maintain departmental harmony.

In many departments, including my own, graduate courses are very lightly enrolled. Frequently the number of students in these courses drops below the university's minimum. It is hard to imagine graduate enrollments increasing to the point where they would justify additional resources.

## Summary

It is the combination of these three levels of activity that sets mathematics apart from the other departments. It is also this combination of duties that causes many problems and presents many opportunities. Solve these problems and you bring (relative) prosperity. Fail to solve the problems and you cause many other problems, the least of which is a lack of even relative prosperity.

Since becoming the head of a mathematics department I have learned many things, including the uniqueness of its culture. On the one hand, we teach large numbers of students. This dictates that we become very conscious of our service role and devote energy to seeing that elementary courses run smoothly, are properly staffed, and have sufficient capacity to satisfy the demand. On the other hand, the research culture breeds an attitude of isolation from the rest of the campus and diminishes the importance of teaching elementary courses. When the concept of public service is added to the mix, the possibility of chaos and conflict between the various missions is exacerbated. The ability of a department to resolve these conflicts and pursue all its various missions successfully is the key to having a department that is well received and rewarded by the university administration, that prospers, and that, most importantly, is a pleasant place in which to work.

Most mathematics departments at research universities are large enough to provide a meaningful professional life for everyone. Usually there are faculty in these departments who are interested in each of the three classes of activity: research, teaching, and public service. Mutual respect is the key. Give them all their due, live long, and prosper.

# Chapter 19
# Trends in the Coming Decades

**Mikhael Gromov**[1]

Here are a few brief remarks on possible trends in mathematics for the coming decades.

1. Classical mathematics is a quest for structural harmony. It began with the realization by ancient Greek geometers that our 3-dimensional continuum possessed a remarkable (rotational and translational) symmetry (groups O(3) and R(3)), which permeates the essential properties of the physical world. We stay intellectually blind to this symmetry no matter how often we encounter and use it in everyday life while generating or experiencing mechanical motion, e.g., walking. This is partly due to noncommutativity of O(3), which is hard to grasp. Then deeper (noncommutative) symmetries were discovered: Lorentz and Poincaré in relativity, gauge groups for elementary particles, Galois symmetry in algebraic geometry and number theory, etc. And similar mathematics appears once again on a less fundamental level, e.g., in crystals and quasicrystals; in self-similarity for fractals, dynamical systems, and statistical mechanics; in monodromies for differential equations, etc.

The search for symmetries and regularities in the structure of the world will stay at the core of pure mathematics (and physics). Occasionally (and often unexpectedly) some symmetric patterns discovered by mathematicians will have practical as well as theoretical applications. We have seen this happening many times in the past: for example, integral geometry lies at the base of x-ray tomography (CAT scan), arithmetic over prime numbers leads to the generation of perfect codes, and infinite-dimensional representations of groups suggest a design of large economically efficient networks of a high connectivity.

2. As the body of mathematics grew, it became subject to a logical and mathematical analysis. This has led to the creation of mathematical logic and

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then of theoretical computer science. The latter is now coming of age. It absorbs ideas from classical mathematics and benefits from technological progress in computer hardware which leads to a practical implementation of theoretically devised algorithms. (Fast Fourier transform and fast multiple algorithm are striking examples of the impact of pure mathematics on numerical methods used every day by engineers.) And logical computational ideas interact with other fields, such as the quantum computer project, DNA-based molecular design, pattern formation in biology, the dynamics of the brain, etc. One expects that in several decades computer science will develop ideas on even deeper mathematical levels, which will be followed by radical progress in the industrial application of computers, e.g., a (long overdue) breakthrough in artificial intelligence and robotics.

3. There is a wide class of problems, typically coming from experimental science (biology, chemistry, geophysics, medical science, etc.), where one has to deal with huge amounts of loosely structured data. Traditional mathematics, probability theory, and mathematical statistics work pretty well when the structure in question is essentially absent. (Paradoxically, the lack of structural organization and of correlation on the local level lead to a high degree of overall symmetry. Thus the Gauss law emerges in the sums of random variables.) But often we have to encounter structured data where classical probability does not apply. For example, mineralogical formations or microscopic images of living tissues harbor (unknown) correlations which have to be taken into account. (What we ordinarily "see" is not the "true image" but the result of the scattering of some wave: light, x-ray, ultrasound, seismic wave, etc.) More theoretical examples appear in percolation theory, in self-avoiding random walks (modeling long molecular chains in solvents), etc. Such problems, stretching between clean symmetry and pure chaos, await the emergence of a new brand of mathematics. To make progress, one needs radical theoretical ideas, as well as new ways of doing mathematics with computers and closer collaboration with scientists in order to match mathematical theories with available experimental data. (The wavelet analysis of signals and images, context-dependent inverse scattering techniques, geometric scale analysis, and x-ray diffraction analysis of large molecules in crystallized form indicate certain possibilities.)

Both the theoretical and industrial impacts of this development will be enormous. For example, an efficient inverse scattering algorithm would revolutionize medical diagnostics, making ultrasonic devices at least as efficient as current x-ray analysis.

4. As the power of computers approaches the theoretical limit and as we turn to more realistic (and thus more complicated) problems, we face the "curse of dimension" which stands in the way of successful implementations of numerics in science and engineering. Here one needs a much higher level of mathematical sophistication in computer architecture as well as in computer programming, along with the ideas indicated above in (2) and (3). Successes here may provide theoretical means for performing computations with growing arrays of data.

5. We must do a better job of educating and communicating ideas. The volume, depth, and structural complexity of the present body of mathematics make it imperative to find new approaches for communicating mathematical discoveries from one domain to another and drastically improving the accessibility of mathematical ideas to nonmathematicians. As matters now stand, we mathematicians often have little idea of what is going on in science and engineering, while experimental scientists and engineers are in many cases unaware of opportunities offered by progress in pure mathematics. This dangerous imbalance must be resolved by bringing more science into the education of mathematicians and by exposing future scientists and engineers to core mathematics. This will require new curricula and a great effort on the part of mathematicians to bring fundamental mathematical techniques and ideas (especially those developed in the last decades) to a broader audience. We shall need for this the creation of a new breed of mathematical professionals able to mediate between pure mathematics and applied science. The cross-fertilization of ideas is crucial for the health of science and mathematics.

6. We must strengthen the financing of mathematical research. As we use more computer power and tighten collaboration with science and industry, we need more resources to support the dynamic state of mathematics. Even so, we shall need significantly less than other branches of science, so that the ratio of profit to investment remains highest for mathematics, especially if we make a significant effort to popularize and apply our ideas. So it is important for us to make society well aware of the full potential of mathematical research and of the crucial role of mathematics in short- and long-term industrial development.