

**Self-Study Report on
the Computing and Information Environment at Dartmouth**

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Computing and Information Environment

I. Executive Summary

Dartmouth has a strong reputation for developing accessible computing systems and incorporating them into its academic environment. This reputation is helpful to the College in numerous ways. We will need a bold strategy that builds on our unique strengths in order to retain a leadership position in the information technology area. There are enormous opportunities in both computational research and the application of computing to the learning process. They will require a significant investment for Dartmouth, but we believe that computing is an area in which development opportunities are considerable, provided we have a strong vision.

In this report, we address two fundamental aspects of computing: 1) computing as an academic area of study (computational science, i.e., computer science and allied disciplines); and 2) the campus-wide computing services necessary for research and teaching support (academic computing support and services). Dartmouth cannot maintain a leadership position in computing without excelling in both of these areas.

Accordingly, we propose two principles that should guide Dartmouth's planning in computing.

- First, Dartmouth should develop outstanding academic programs in the computational sciences focused on emerging interdisciplinary connections between computational sciences and other fields.
- Second, Dartmouth should provide a nationally recognized academic computing environment, including a strong support system for research activity and curricular innovation, as well as seamless access to networked computing.

Together these two related principles form an overall vision for computing at Dartmouth.

Our first guiding principle, developing nationally recognized academic programs in the computational sciences, will require a substantial initiative involving new faculty and new space. Dartmouth has made some outstanding faculty appointments in the Computer Science Department, Mathematics Department, and the Thayer School of Engineering, and grant activity is steadily rising. We have in place a strong base on which to build, but we need to focus and intensify our efforts with a strategic plan. The opportunity for Dartmouth lies in recruiting faculty members whose computational research is applied to other disciplines in which we have strength and in which computational approaches are on the rise. Consequently, the initiative should be interdisciplinary. We propose creating a Center for Computational Science to focus this initiative. The Computer Science Department is under-staffed, as evidenced by severe enrollment pressures and large student interest, and its faculty should be expanded as part of this overall initiative. Additional positions should be created in collaboration with other schools and departments, with particular attention to emerging interdisciplinary computational approaches to the life and physical sciences. We envision that the Center will quickly become a focal point of the intellectual life of the campus, attracting undergraduates, graduate students, postdoctoral fellows, faculty, and visitors interested in emerging interfaces between computer science and other disciplines. It will also foster interdisciplinary grant proposals, which are increasingly solicited and favored by funding agencies and foundations. This initiative will require new space. The Kemeny building currently being planned seems to be the logical place in which to house the Center, given its location and John G. Kemeny's own contributions to both mathematics and computing. We propose the creation of a task force to develop a plan for this initiative.

Our second guiding principle, developing a nationally recognized academic computing environment, will require Dartmouth to strengthen computing support for research and teaching, evolve universal access to state-of-the-art network services, and improve support services to help faculty and students with the universal basics of computing. Dartmouth's investments in administrative computing have outpaced its investments in academic computing. We recommend that computing support for the institution's academic mission, across all disciplines, receive greater attention. Research computing support is best provided by IT staff who have some academic training in the particular research area. The second guiding principle also entails increased collaboration between faculty and IT staff in the development of curricular applications. Dartmouth should promote the development and understanding of new ways in which information technology can enhance the learning process, principally through inquiry-based interactive learning. Dartmouth is better positioned than its peers to achieve this goal, being a research university with a faculty dedicated to undergraduate education. In order to be successful, faculty who wish to explore curricular innovation using IT must receive sufficient incentives and support, including sufficient availability of support professionals, a steadily improving classroom environment, and a commitment to maintain tools and applications after implementation. Successful curricular projects should be assessed and evaluated to ensure that they further Dartmouth's commitment to student learning, and they should be promoted as products of Dartmouth's curricular innovation. Limited forms of distance learning may be offered to Dartmouth alumni and possibly others. We also should continue to ensure a state-of-the-art computing environment and seamless access to computing – Kemeny's credo – to unleash innovation among faculty, students, and staff. In order to promote greater access, students have asked for more computer clusters around campus. Even though all students have computers, there is a demand for computer clusters as places to work (akin to library reading rooms) and as facilities for upper class students whose computers have become obsolete. To pursue the second principle, we propose that the senior officers commission Computing Services to work with the faculty and others to submit a plan of action to the Provost.

These steps are necessary if Dartmouth is to reassert its leadership in computing.

II. Computing at Dartmouth

A. Description

The charge to this committee mentions that "Dartmouth has been a pioneer both in the evolution of computer systems and in their application to academic and network use." This pioneering role was due largely to the vision and efforts of John Kemeny¹, Professor of Mathematics and President of Dartmouth College. In the early 1960s, Kemeny predicted that computing would transform research, education, and society in general, and he sought to design systems that would make computing universally accessible. Kemeny and Professor of Mathematics Thomas Kurtz, together with a group of students, developed the Dartmouth Time-Sharing System (DTSS) and the programming language BASIC, both designed to bring computing to non-technical users. By 1964, these efforts expanded to serve several New England secondary schools, eventually linking as many as 20 secondary schools and 42 colleges and universities in the United States and Canada, and hundreds more on a local call basis. DTSS was used by General Electric in 1966 to build the largest commercial time-sharing system, and was adopted in

¹ John G. Kemeny. (1964). *Random essays on mathematics, education, and computers*. Englewood Cliffs, NJ: Prentice-Hall. John G. Kemeny & Thomas E. Kurtz. (1968). *Dartmouth time-sharing*. Washington, DC: American Association for the Advancement of Science. John G. Kemeny. (1972). *Man and the computer*. New York: Scribner. John G. Kemeny & Thomas E. Kurtz. (1985). *Back to BASIC : the history, corruption, and future of the language*. Reading, Mass.: Addison-Wesley.

1971 by the U.S. Naval Academy at Annapolis. In 1972, DTSS became a taxable corporation – owned by the Trustees of Dartmouth College – to market DTSS software.

DTSS inspired a wide range of uses, both on and off campus, including scientific, medical, legal, artistic, and pedagogical applications that were ahead of their time. Over the years, Dartmouth hosted numerous conferences and received grants from government agencies and private foundations to fund work on computing systems and their potential applications. Official delegations came from other countries to see this emerging culture of computing. By the mid-1970s, computer use on campus was broad-based, and included the humanities and arts. Faculty members had developed computer programs with a wide range of research and teaching functions, including elementary logic, drill and practice in language instruction, textual analysis, music composition, and multimedia instruction in government. In 1979, Dartmouth was recognized by former President Gerald Ford on behalf of the Academy for Educational Development for “leadership in raising educational effectiveness including the advanced applications of computer technology for learning as well as management.” In 1990, EDUCOM and IBM presented John Kemeny with the first annual Louis Robinson Award for a lifetime of innovative achievement and leadership in the advancement of computing in higher education.

When personal computers arrived on the scene, Dartmouth was quick to integrate them into its network, and developed much of its own network hardware and software. By 1986, all dorm rooms and offices were wired into the network. The Apple Macintosh, with its revolutionary graphic user interface that simulated a desktop, was quickly embraced because its innovative design was congruent with the philosophy of accessible computing. A grant from the Alfred P. Sloan Foundation led to active faculty involvement in developing course materials and educational software on the Macintosh. Roughly 70% of the incoming students in 1986 bought Macintoshes. 1987 saw the release of the home-grown program BlitzMail, which revolutionized how people at Dartmouth communicate. As of 1991, all entering students were required to own a personal computer, and until this year, the recommended computer was a Macintosh. Meanwhile, the campus network has been upgraded steadily, and computing support for research diversified to include UNIX and other environments. Dartmouth recently received a grant from the National Science Foundation to design, install, and manage its partnership in Internet 2.

Recent developments on campus have continued the tradition of broad-based application of, and interest in, computing. The Women in Science Project began an E-Mentoring program, which enables students to interact with their mentors on-line. The Lectures on Demand project allows students to access video-taped lectures of some class meetings over the World Wide Web. Last year, the Dartmouth Humanities Research Institute sponsored The Tangled Web Conference: Ethical Dilemmas of the Internet. Dartmouth’s C. Everett Koop Institute has created an integrated health-care delivery system, using the Internet to “promote lifetime learning, outcomes research, and practice guidelines” by making information accessible to health-care providers, educators, and private citizens.² Organizations such as EDUCAUSE and its predecessor EDUCOM have recognized the software development of many Dartmouth faculty and administrators over the years. The Computing Technology Venture Fund was launched in 1993 to support programs that “promote innovative and generalizable uses of computing in direct support of the curriculum.” In 1997, Dartmouth began offering free, permanent e-mail addresses and personal home pages to all alumni.

The Tuck School of Business Administration has made substantial recent investments in its computing infrastructure and the application of IT to its programs. Its newly constructed Whitmore Wing was dedicated to the creation of a flexible, technologically advanced learning space. The Tuck School has ventured into interactive distance learning, including a conference

² *Dartmouth Medicine*, Summer 1994

area on the Internet, for current MBA students and Tuck alumni, and an interactive video conferencing program that enables Japanese executives to take Tuck summer classes.

The Baker-Berry Library building, currently under construction, will result in the library and most of Computing Services being in the same building. This design recognizes the increasingly important role of technology in providing information that was traditionally provided through print media. The design also recognizes that information technology is a tool in the service of the academic mission of the institution – to provide information resources for research, teaching, and learning.

Research and teaching in computing was originally focussed in the Department of Mathematics, which later became the Department of Mathematics and Computer Science. A separate Department of Computer Science was formed in 1994 in the newly renovated Sudikoff Laboratory. The relatively late formation of an autonomous Department of Computer Science perhaps reflected Kemeny's view that computing is not an isolated discipline. In recent years Dartmouth has succeeded in recruiting some outstanding computational scientists in the Department of Computer Science, the Thayer School of Engineering, and the Department of Mathematics. The Department of Computer Science currently has twelve tenure-track faculty members organized into the following research groups: parallel computing, mobile software agents, robotics, image processing, algorithms, computational biology, and multimedia. The Thayer School of Engineering has seven tenure-track faculty members working in computational science and engineering, encompassing the following areas: parallel and distributed discrete event simulation, mobile software agents, network analysis, VLSI, numerical scientific and engineering algorithms, wireless networks, and communications. The Department of Mathematics has several faculty members doing computational work and expects to recruit more. Research and teaching that is computationally intensive continues to thrive in other departments and schools, including the Program in Electro-Acoustic Music in the Department of Music, the Center for Evaluative Clinical Sciences at the Medical School, and the Department of Psychological and Brain Sciences.

B. Recommendations

Dartmouth's reputation as a leader in computing has been a significant factor in admissions, faculty and staff recruitment, and alumni relations. Indeed, it has been part of Dartmouth's public persona and its self-image. We believe that Dartmouth should capitalize on its historical position and persistent reputation by making continued leadership a priority.

This will not be an easy task. IT is advancing at an exponential rate. Many more educational institutions are staking out leadership positions today than was the case five to ten years ago. Dartmouth will have to define and implement a renewed vision of its leadership role in a national IT environment that is much more competitive and professionalized - and much better capitalized - than was the case during the Kemeny years. The large research universities have moved much faster and have made more substantial investments in computer science and engineering than Dartmouth has. While we once were unique in having computing accessible to an entire campus, this situation is now fairly common. And while we were innovators in instructional computing, many other organizations -- educational and for-profit -- are now at least as active as we are.

However, our past reputation, coupled with a string of extremely strong faculty appointments in recent years, suggest opportunities for reaffirming a leadership position if we develop a focused strategy and make the necessary investments. The challenge will be to carve out leadership areas where we have reasonable chances of success, and to do this, it will be necessary to define a niche that is congruent with Dartmouth's unique characteristics.

During the formative days of computing and networking at Dartmouth, fundamental developments in computing went hand in hand with educational applications and innovations. The development of BASIC (and the time-sharing system D1) occurred within the context of a contribution to computer systems but also as an innovation that would make computers accessible and user-friendly to students and faculty generally. Since then, computer science has become a highly specialized area of research, and the technology used to make computing accessible has become commercially available. There is now a clear distinction between computer science and computer services – between those who teach computing and those who provide the IT resources and services for the campus. In theory, an institution can have a good general purpose computing environment for the campus but a weak faculty in computing (which is the case at some small colleges), or the reverse (which is the case at some large research universities). Dartmouth’s unique niche as a small research university with a strong commitment to undergraduate education requires that we excel in both. To do any less would be to fail to live up to the Kemeny vision that has served the institution so well. The educational experience of our students is best served by building an outstanding faculty and providing the students and faculty with outstanding facilities.

In the recent past, Dartmouth has been better known for its computing environment than for computer science and allied disciplines. But in terms of our trajectory, we have moved ahead in computer science (as evidenced by rising departmental rankings) and lost some of our lead in our computing environment since the advent of the Internet has revolutionized access to computing. It would be a mistake to forego either the long-lasting reputation we have had for our computing environment or the recent momentum in computer science and allied disciplines. In any case, Dartmouth’s reputation among the public at large is amorphous, and often carries over from computer use in general to computer science. Prospective undergraduates interested in computer science often cite Dartmouth’s reputation. The undergraduate members of the Computing Council cite Dartmouth’s reputation in computing as a factor in their attending Dartmouth and majoring in computer science. The Department of Computer Science succeeds in attracting and training outstanding students who go on to the top graduate schools. Computer Science majors have been over-represented as valedictorians in the last few years, and last year several majors won national awards. We thus have a strong foundation – both in substance and in reputation - on which to build for the future in both the academic study of computing as well as our computing environment. In each case, we should define our leadership position in ways that build on existing strengths and on the unique characteristics of the institution. In both cases, the vision should be driven by the academic mission of the institution.

We have thus settled on two principles that should drive Dartmouth’s efforts to maintain its leadership position in computing.

- First, Dartmouth should develop outstanding academic programs in the computational sciences focused on emerging interdisciplinary connections between computational sciences and other fields.
- Second, Dartmouth should provide a nationally recognized academic computing environment, including a strong support system for research activity and curricular innovation, as well as seamless access to networked computing.

In the remainder of the report, we will discuss computing at Dartmouth in terms of these principles.

III. Computational Science

A. Description

Given Dartmouth’s size, the best strategy for developing computing as an academic area of study is to focus the faculty talent that is currently scattered in several departments and schools

(principally in Computer Science, Mathematics, and the Thayer School of Engineering), and make new faculty appointments that create synergies with other disciplines in which computational approaches are emerging. The Computer Science Department, the Thayer School of Engineering, and the Mathematics Department have made some important appointments in computational science and engineering in the last few years. Many of the research areas currently within Computer Science are inherently interdisciplinary (in particular, mobile software agents, robotics, image processing, computational biology, and multimedia), and several collaborative grants and projects are already underway. There are faculty members who serve as bridges between the Department of Computer Science and each of several other departments and schools, including the Departments of Biology, Mathematics, Music, and Psychological and Brain Sciences, the Program in Linguistics and Cognitive Science, the Medical School, and Thayer School of Engineering. At the same time, computational approaches are emerging as dominant research directions in many other disciplines, suggesting areas that Dartmouth could develop. Some examples of possible areas of development are: computational biology (bio-informatics), computational neuroscience, computational approaches in the physical and engineering sciences, computational linguistics, image processing, geographical information systems, and new computational applications in the arts, languages, and other humanities.

Promoting interdisciplinary computational research and teaching will require deliberate institutional strategies to promote coordinated recruiting, collaboration, and communication. A computational biologist whose research content is biological but whose approach is computational needs both biologists and computer scientists as colleagues in order to succeed. Undergraduates, graduate students, and postdocs who wish to work with these faculty members will need programs and spaces designed to address their interdisciplinary interests.

B. Recommendations

We propose a substantial initiative in computational science, focusing on emerging interdisciplinary areas. The term “computational science” is used here to refer to research in any area in which computational approaches are central to the research and thus includes – but is broader than – computer science. This initiative should be a coordinated effort that builds on existing strength in the Computer Science Department, the Mathematics Department, and the Thayer School of Engineering. It should dovetail with the other initiatives under way at Dartmouth, particularly in the life sciences and physical sciences, thereby yielding the maximum benefit. If done properly, this initiative could launch Dartmouth into a position of prominence in the computational sciences. Enrollment pressures and rapidly advancing developments in information science and its application to a broad range of disciplines require that we expand our academic base in the computational sciences and that we do so in a way that crosses disciplinary boundaries.

In order to focus the effort, spark collaboration, and yield the maximum benefit for students and faculty, we propose the creation of a Center for Computational Science. We recommend that a task force be established to undertake the planning for such a Center. Existing faculty members in Computer Science, Mathematics, and Engineering would form the base on which to build, and the center would foster closer ties between these entities with natural affinities. This initiative would require six to eight faculty positions (including at least one senior appointment as director of the Center). At least three new positions – at least some of which would be in Computational Science – would be created in Computer Science because of enrollments (taking it from 12 to 15 or more), and the others should be in other departments that form the expanding core of the Center. Some of the positions would be created by urging departments and professional schools with computational interests to coordinate some of their own future hiring with this initiative in mind. The core would be computational applications in the life and physical sciences, but the center would attempt to bring together faculty and students throughout campus (including the arts) who have computational interests.

In addition to new positions, there would need to be investments in equipment, support personnel, and space. These investments would spur grant activity, which would bring post-docs, graduate students, equipment, and indirect costs to the institution, and would also provide new opportunities for faculty and students. Equipment could be funded from corporate grants.

The initiative would require at least 11,000 net assignable square feet added to the Kemeny project, excluding classrooms. This includes offices and research labs for the faculty, common rooms to house equipment, offices for postdocs, graduate students, and visitors, and an administrative office. While this estimate is rough and preliminary, it is not inflated. It is imperative that the Kemeny building project be reconceived if we are to build for the future and if we are to do justice to the Kemeny vision. If recent successes in grantsmanship are any indication, we can expect to increase our grant intake significantly by investing in computational research and education.

While there eventually could be formal curricular programs associated with the center, it would begin as a research center, with students getting involved in projects. Initially, coursework, independent research, honors theses, and degree programs would be coordinated through participating departments, programs, and schools.

IV. Academic Computing Support and Services

A. Description

Dartmouth's academic computing services and general computing services are overseen by an area called *Computing Services* that reports to the Provost. The divisions of computing services include: academic computing, administrative computing, administrative information systems support, technical services, information systems, instructional services, user communications, and fiscal and auxiliary services. (The Appendix includes descriptions of these areas.) A strong degree of centralization is appropriate in the delivery of many IT services, particularly because Dartmouth is a comparatively small institution. This provides efficiency and strength when delivering a full range of services, and ensures that the broad, institutional view is always considered. The general philosophy is to centralize costs whenever possible.

Within computing services, there has been limited growth in the academic computing area. In contrast, administrative computing areas have seen rapid and steady growth. We believe that there has been a lack of focus in planning and budgeting for the computing opportunities and challenges that are most directly related to the academic mission of research and teaching. It is indeed important to upgrade and support administrative systems, creating greater efficiencies which in turn help the academic enterprise. However, it is now time for Dartmouth to focus on its academic computing needs.

This is true at least in part because Dartmouth's educational niche among the Ivy Leagues schools has been the active engagement and interest of faculty in the learning experiences of their undergraduates. Dartmouth is thus uniquely placed to become the kind of institution envisioned in the Boyer Commission report of 1998 – a research university where inquiry-based learning – learning by discovery – is the norm. Dartmouth already more closely resembles this model than do either its university or college peers. This educational niche converges with Dartmouth's niche in instructional computing. The Boyer Commission report explicitly cites IT as a tool in enriching the learning process. The convergence of these two niches – educational and computing – is the leadership space Dartmouth must seek to retain in the instructional area.

Beyond the findings of the Boyer Commission, the growing role of IT in higher education is attested to by the Campus Computing Project³, which annually surveys colleges and universities about their IT challenges. In 1998, as in the previous year's survey, the IT challenge identified most frequently (33%) as the most important was that of providing assistance to faculty in integrating technology into their instruction. The next most commonly cited challenge was user support (27%), followed by financial planning for IT (17%). The survey also reported increasing use of information technology. From 1996 to 1998, the percentage of classes using the Internet rose dramatically: from 25% to 44% using email; from 15% to 33% using the Internet as required by the course; and from 8% to 23% using web pages for class materials and resources. The report also notes that 91% of private universities have their course catalogs on-line (as does Dartmouth), and 61% have instructional software available on their institutional web sites.

The increasing use of the Internet for schoolwork is documented in a national survey conducted by the Cooperative Institutional Research Project (coordinated by the Higher Education Research Institute). This survey of first-year students before they matriculate indicates that 83% of college-bound students have used the Internet for research or homework in high school. Dartmouth's Office of Evaluation and Research reports that this figure is slightly but significantly higher (86%) for entering Dartmouth students, and concludes that the "Internet has become an important academic tool for the majority of students nationwide, but particularly for those attending Dartmouth." Fortunately, a comparison of this national survey with Dartmouth's own survey also shows that incoming Dartmouth students are significantly less likely than their counterparts nationally to use the Internet for computer games (64% Dartmouth, 80% nationally) or to participate in chat rooms (40% Dartmouth, 54% nationally).

Our feedback from the faculty suggests that Dartmouth needs to pay more attention to IT support for research and teaching in the Arts and Sciences, particularly in the area of support personnel who can help faculty and students bridge the gap between academic content and information technology. Colleges and universities are hiring increasing numbers of IT support personnel with academic training in specific disciplines to enable faculty to take advantage of rapidly emerging information technology that can advance their research and teaching goals.⁴ Faculty and students need to focus on academic substance, making the IT transparent even as they use it. This requires support staff who are fluent in the technology but understand the academic issues and also have a service orientation suited to helping people who differ greatly in their level of comfort with computers. In today's market, these support personnel are expensive and difficult to find – a situation that requires particular attention.

In the Arts and Sciences, this need is currently addressed to some extent by the divisional and departmental computing services, which are funded from a combination of sources, including the Dean of the Faculty, the departments, and Computing Services. For example, Humanities Resources has for years provided specialized research and curricular support, headed by a staff member who is a doctoral level academician. Computing Services, like the library, employs a number of individuals who hold doctoral degrees in areas other than computer science, who support faculty research and teaching in discipline specific ways. Computing Services also provides statistical computing support campus-wide, with a staff member who functions as research faculty, working and publishing with faculty from various disciplines. Tuck Computing has a research computing staff of five FTE to support the research need of some 30 faculty. Of these five, four have advanced academic degrees. The Dartmouth Medical School employs many

³ The 1998 National Survey of Information Technology in Higher Education (Nov 1998).

⁴ Lisa Guernsey (1998, December). A New Career Track Combines Teaching and Academic Computing. *The Chronicle of Higher Education*.

professionals who have expertise not only as researchers in a particular discipline but also computational expertise.

There is, however, a widespread sense in the Arts and Sciences that our support system has not kept pace with the requirements and expectations created by the rapidly changing technology. There is a need for more support professionals who would be housed in or near the departments to provide local or “on-site” support for research and curricular applications. It is reasonable to expect investigators to raise some of the funds for such personnel from grants. However, granting agencies are increasingly looking for institutional commitments to share these costs. The Dean of the Faculty Office currently deals with these cost-sharing issues on an *ad hoc* basis. As Dartmouth scales up its research expectations of faculty, and seeks to provide students with more research experience, this issue has become more pressing. A strategic financial plan is needed specifically for the IT requirements on the academic side of the institution.

At various points in its computing history, Dartmouth has obtained grants (e.g., from the W.M. Keck and Alfred P. Sloan Foundations) to enable faculty and staff to develop innovative teaching tools using IT. Many of these programs have been distributed nationally and internationally. The Computing Technology Venture Fund is the current incarnation of these efforts. The goal of the Venture Fund is to explore and develop ways of applying computer technology in direct support of Dartmouth's curriculum. It encourages curricular projects based on their original and innovative concepts or on the breadth of their applicability. Venture Fund projects serve as explorations as well as foundations for future directions in academic computing at Dartmouth. The types of projects funded during past years have included: software development (to provide both network-based and stand-alone tools); database acquisition or digital resource development (to build scholarly information resources); classroom or public cluster equipment (to enhance technology-based teaching); and programmatic efforts (to support activities such as workshops, lectures, and seminars relevant to the use of technology in education). Venture Fund awards are made to a maximum of \$10,000. Proposals are selected by the Venture Fund Advisory Committee. The Committee consists of four faculty representatives, the Director of Computing Services, and two staff members from Academic Computing.

These projects stem from Dartmouth's greatest strength – a faculty of active researchers who are also dedicated to teaching. At a research university, faculty members aren't as likely to invest time in curricular projects, and most teaching colleges do not have the resources and the infrastructure to compete with Dartmouth in IT. We believe that these curricular efforts form the basis for defining Dartmouth's continuing leadership role.

In addition, faculty members who create web sites for their courses cite the efficiency gained from streamlining the mechanics of running the course. This is particularly the case in large courses requiring the management of lots of information, including the distribution of software, problem sets and their solutions, laboratory instructions, lecture notes, and announcements. Web sites are also used as discussion forums for students in the class.

In order to assess the range of curricular applications for computing and to get feedback about these efforts, comments were solicited from faculty members who had recently received Venture Fund grants or who were known to be interested in integrating information technology into their teaching. The responses reveal a wide range of applications. Some of the most notable IT innovations are in language instruction and the study of other regions of the world. Several professors require students to access foreign web sites for a “culturally and linguistically authentic context” they would never get from reading either textbooks or American newspapers. Some even encourage students to strike up email correspondences in foreign languages with interesting individuals they find on the web. The multimedia capabilities of the web are being exploited as well, with applications involving artwork, images of cultural artifacts, scenes from films, poetry reading, virtual reality simulations, maps, satellite image data, and images from brain scans.

As expected, there are a number of faculty members who are almost evangelical about computing. Interestingly, most are from the humanities. According to one such testimonial, “computing resources have become inseparably interwoven with our traditional classroom curriculum... This is the more interactive, creative side of information technology which now attracts the most student interest and faculty energy.” One humanist, who had been part of a discussion on ubiquitous and seamless computing of the future, remarked: “I also want that ubiquitous computing that was bandied about. When will we have ‘computers on our feet’? I want to be there in line.” Some faculty members cite the curricular enhancements they have been able to achieve by using smart classrooms or facilities like CBBC or the facility at Tuck. A few respondents were more cynical about information technology. One faculty member (a scientist) described the Internet as “a vast waste of bandwidth” and suggested that we include his comments in an appendix entitled “The Old Fogey Mindset.”

Excerpts from faculty Venture Fund proposals give one some sense, then, of what faculty mean by successfully integrating computing into their teaching. In its 1998 Venture Fund proposal, the Department of Studio Art notes:

It is easy to envision the spread of this technology to our all of our classes, especially to show works of art related to the work being done in class. It is also a way to break down traditional boundaries between media. An image, for example, no longer has to be an object hung on a wall - it could actually be a quick-time movie on the World Wide Web. Sculptors could create virtual models of their work, and explore its interaction with a site. Installation artists can quickly and accurately sketch ideas and get a sense of how things will appear in three dimensional space.

A 1998 proposal by Professor Jeremy Rutter of the Classics Department illustrates vividly the possibilities afforded by virtual reality simulations. He writes:

The Classics Department proposes to take advantage of Quicktime VR [virtual reality] as a mode of graphic presentation, and of its uniquely designed Foreign Study Program [FSP] to Greece ... as an existing curricular venue, to design and produce a series of 360-degree panoramas of ancient Greek archaeological sites and the contemporary landscapes in which these sites are located. Dartmouth undergraduates will participate in all aspects of the production and use of these visual teaching aids, from (1) the selection of the locales to be illustrated and the specifics of each individual panorama's design, including the actual photography on the Greek FSP this coming spring, to (2) the scanning and stitching together of the slide images employing existing facilities in Academic Computing at Dartmouth (by way of paid student labor rather than in coursework) to (3) the viewing of the panoramas in ancient history and Classical archaeology courses (both in class lectures and through research assignments pursued outside of class, themselves predicated on and specifically designed for the existence of this novel form of visual resource).

A recent example from the sciences is Chemistry Professor Sally Hair's proposal:

This proposal describes multimedia additions to a website being developed for the General Chemistry Laboratory at Dartmouth, called ChemLab (<http://www.dartmouth.edu/~chemlab/>). This website will be used three terms per academic year by a total of approximately 660 undergraduates enrolled in Chem 3, 5, and 6. ChemLab will provide still photos, audio, and interactive web-based applications for student use before and after lab. These additions will enable students to prepare for experiments more thoroughly and with greater understanding than our current, text-only lab manual. A multimedia website provides a novel way of improving student learning before, during, and after a lab experiment.... [One] way of improving student learning and understanding in the lab is to include interactive applications which make a connection between the experiment and

higher level thinking.... An example would be a simulation of the experiment, to enable students to practice the reasoning used in the lab.... The analysis of this type of experiment turns into a logical puzzle, with the laboratory observations as the clues. Giving students the opportunity to practice this analysis *before* lab, will improve their ability to do it *in* the lab.

Some of the comments remind us that the explosion of information is as much a challenge as an opportunity. The noise and clutter on the Web can be overwhelming. Students need to learn that sheer gigabytes of information are no substitute for careful analysis – that just because they find something on a website doesn't make it true. It is tempting simply to download facts, figures, and text and slap a project together. This makes the close student-faculty relationship at Dartmouth all the more relevant today, in spite of the Internet. IT is not a substitute for close faculty supervision.

Another concern is the uncertainty about whether IT can fulfill its promise even if fully utilized and supported. Many IT educational innovations fail to live up to their billing. Over and above universal access, we need a better understanding of how IT can enhance learning and the appreciation of it. This requires careful evaluation and study of the innovations that have been developed. Though many institutions tout the use of IT in higher education, especially when applied to distance learning, few institutions make it a priority to assess how IT does or does not inform teaching and learning beyond just productivity enhancements, conveniences, and novelties. Here we make this goal explicit, and recommend that Dartmouth seize upon this as the area in which to provide future leadership in the use of IT in higher education.

B. Recommendations

The comments of Dartmouth faculty suggest considerable enthusiasm for incorporating IT into teaching. While large numbers of faculty members have already been involved in these initiatives, it is by no means a majority. Although basic computing use and universal access – a dream only 15 years ago - is now pervasive at Dartmouth, computing is not as fully integrated into the institution's academic goals as it might be. Most faculty, students, and staff do not participate in computing beyond the basics. Yet, information technology can put tools and curricular resources in the hands of learners in ways that were unthinkable just a few years ago. IT potentially offers an array of collaborative and pedagogical opportunities that were not envisioned when most courses in the current curriculum were designed, or when most current faculty members received their graduate training and acquired their early teaching experience.

To pursue the second principle, we propose that the senior officers commission Computing Services to work with the faculty and others to submit a plan of action to the Provost.

The action plan should fully consider how to make best use of the Faculty Development Center (FDC), a space within the new Berry Library that will feature computing resources tailored to the faculty's needs, with advanced equipment and support staff. The FDC, which will be operated by the Academic Computing division of Computing Services, will be jointly led by the faculty and Academic Computing. Computing Services will provide the technical support needed and will work closely with the faculty. We suggest that this relatively modest FDC be strongly encouraged to sponsor seminars and speakers on the topic of educational applications of IT. It should coordinate its efforts with existing departments and programs in order to anchor its work in the substance of academic disciplines. The FDC could provide undergraduate internships that provide the glue that brings diverse faculty together. The focus on faculty and academic content is important; the FDC should not become simply an IT "shop" where jargon inhibits the broad participation of faculty who have ideas but aren't technically sophisticated. In other words, the focus should be on the use of IT in teaching and learning rather than on information technology *per se*.

An evaluative component of the FDC is also important to separate educational value from hype. Which aspects of IT, or which features of a piece of software, truly enhance the learning process? Which aspects or features are interesting but don't contribute to learning? (In this respect, we have taken our cue from Stanford, which has already made a substantial investment in the evaluation of IT resources for the curriculum.)

The committee makes several specific recommendations.

Faculty-Focused Recommendations:

1. Build upon the model of the Faculty Development Center planned for Baker-Berry Library.

2. Increase professional staff support for faculty. As indicated in some of the faculty reports, one impediment stems from the scarcity of on-going professional support. Faculty need incentives to continuously retrain and innovate, even as they do their teaching and writing. If an IT project proves successful, the initial investment in a faculty member's time should be followed up by continuing technical support in the face of rapidly changing operating systems and hardware. A faculty member should be able to focus on disciplinary content and pedagogical innovation while professional IT staff keep the system current and bug-free. As things stand, a curricular application developed with the Venture Fund rarely survives more than a few years, even though the underlying design may continue to be useful. We believe that present levels of professional IT support are inadequate even to sustain current curricular initiatives. If we are to implement a bold vision that builds on these curricular efforts, significantly more professional support will be necessary.

We recommend setting up a network of support professionals for the academic departments to remove barriers and greatly expedite use. They would be housed in or near the departments to provide local or on-site support for curricular and research applications. These professionals would be recruited for their academic backgrounds as well as their computing consulting skills. While serving separate departments, they would function organizationally as a team.

3. Provide decentralized or "local" academic project centers. There are academic departments that share specialized curricular and research needs. In general, Dartmouth should encourage academic use of IT by establishing local academic computing clusters and providing the support personnel needed. One example is the "southern" (i.e., those located on campus south of the Green) humanities departments (Drama, Film Studies, Studio Art) who, given their work with film, video, and three dimensional materials, have unique curricular needs that entail specialized resources. All three would benefit from a cluster of computers equipped to meet those needs. Another case stems from the increasing importance of geographic information systems in the sciences and social sciences.

4. Provide faculty members with computers that are at least on par with those of the undergraduates. With each in-coming first year class, the technology possessed by the undergraduates becomes more advanced. If one wishes to be able to handle the escalating requirements of the Internet and commonly used productivity software, the obsolescence cycle is two or three years. The life cycle for much discipline specific software is even shorter. The Carson fund (which enabled faculty to upgrade their desktop computers) had a dramatic impact on baseline faculty computing, but expires soon. The institution quickly will need to address this situation before the upgrades that are now being offered to the faculty become obsolete. This problem was recognized in 1984 when personal computers at Dartmouth became prevalent, but it has never been addressed with a solution lasting more than a few years.

5. Provide extensive media preparation services. One barrier to faculty use of computing is the time and specialized knowledge required to produce digital content, such as images, and audio and video sequences. For example, for some years Academic Computing has provided faculty free scanning of 35 mm slides. This has proved to be a popular and useful program, essentially “jump starting” some faculty in the use of information technology in the curriculum. We propose to expand this model to provide a wider range of preparation services, such scanning, full text, video and audio digitizing.

6. Expedite introducing technology in the classrooms. The Classroom Subcommittee has been at work renovating classrooms for a number of years. Given the resources the Subcommittee has been given and the complexities of classroom renovation work, the Subcommittee has only been able to renovate classes at the rate of one or two per year. The Subcommittee recently articulated a vision for our classrooms: that all auditoriums should be equipped as SMART classrooms, all lecture halls as having basic computer projection capability, and that half of all smaller classrooms and seminar rooms have basic computer projection capability. Following Kemeny’s vision, Dartmouth should work to make sure that technology-equipped classrooms, like network ports, should be the norm. Faculty should be able to rely on the availability of such classrooms.

7. Begin a high-level discussion on opportunities for distance learning, particularly for alumni.

Undergraduate-Focused Recommendations:

1. Create more computer clusters throughout the campus for students.

Undergraduates on the Council on Computing argue that clusters are attractive because they provide the latest machines and cross-platform alternatives, as well as an atmosphere conducive to work (their rooms afford too many distractions). In addition, upperclass students whose computers have become obsolete rely on clusters to be able to run current software. Finally, students turn to clusters when they need to use a platform other than the one they own.

Dartmouth currently has too few clusters to accommodate demand. After the completion of the Baker/Berry project, the number of computers available in public clusters is estimated to rise from the current 70 to about 120. While this will be an improvement, it may not be sufficient. Taking note of this situation, the Computing Council on May 13, 1999, adopted the following resolution:

In light of the fact that (a) Dartmouth College is increasingly becoming a multi-platform computing environment, (b) student use of computing clusters is increasing, and (c) computers purchased by first year students increasingly do not meet changing student needs across their four years at Dartmouth, the Council on Computing urges that Dartmouth College provide a significant increase in: (a) the number of computer clusters, especially 7x24 clusters, (b) the numbers of both windows and Mac OS computers in those clusters, (c) the breadth of distribution of those clusters around the campus, and (d) the numbers of stations (desk or table space, power outlet, and network connection) in those clusters for student owned computers.

A related issue is the students’ need for assistance for particularly ambitious projects, to exploit fully the academic project centers in Berry/Baker. In addition to the help desk consultants, there is a need for consultants who can assist students in advanced tasks necessary for their academic work. Such tasks might include constructing databases linked to web pages, linking video and audio, and “stitching” together images to form a single panorama. At the moment, students have no source of assistance even to learn these skills, except from willing friends.

2. Re-evaluate policy on acquiring and upgrading student equipment. Upon matriculation, students receive the latest technology, but by the time they are juniors and seniors their equipment is not equal to the challenging (and sometimes even more routine) academic tasks they face. Seniors with computers that are four years old are forced to run word processors, spreadsheets and other academic software that is equally old. For example, senior students in Studio Art cannot run PhotoShop, an image editing program, on their computers, even though their senior year projects require them to do so. To address this, we might enable students to upgrade their computer once during their Dartmouth careers, so that they have the capacity to tackle major and innovative curricular projects.

Students need access to equipment that was not foreseen when the ownership requirement was established. This includes equipment such as flat-bed and 35 mm slide scanners, color printers, and video and audio editing stations. In Berry we have planned a small room to house specialized equipment for students to use for academic projects. This room is small, and will be able to accommodate only 3 to 4 students at a time. We should take the Berry idea of the student academic projects center and expand it so that more students have access to these resources. This entails setting up clusters not just of desktop computers, but also peripheral devices such as scanners, video and sound editors, equipment to make QuickTime VR movies, and so forth. These resources should be distributed throughout Berry and be available to dozens of students at a time. This will transform Berry into one large academic project center, offering content and the means to work creatively with that content.

4. Increase professional assistance for student work. While students are often comfortable using information technology, they do need assistance for particularly ambitious projects. To exploit fully the academic project centers in Berry/Baker, we should establish a team of professionals and student assistants to offer help to students in the use of information technology for their academic projects. These consultants would constitute a kind of academic “help desk” for students, assisting with tasks such as constructing databases linked to web pages, linking video and audio, and “stitching” together images to form a single panorama.

Graduate Student-Focused Recommendations:

1. Expand computing facilities for graduate students. The Northstar initiative, initially fueled by a grant of IBM UNIX workstations, was targeted to support the graduate students and their computing requirements. We propose a fresh Northstar-like initiative, one that would offer a robust mix of desktop computers (Mac and Windows) and UNIX workstations. We propose establishing these new “Northstar” clusters in each of the major academic departments that have graduate programs, as well as at the Dartmouth Medical School.

General Recommendations:

1. Upgrade networking in all locations, including implementing wireless networking. Dartmouth was innovative in 1984 by wiring all its dormitories. There is now a transition from desktop computing to web-based or browser-based computing, which represents a shift back to centralized computing. Data and software increasingly will be stored remotely, but the user will be able to access it from anywhere. Dartmouth should ensure that the network keeps pace with newer software and newer standards. Universal switched Fast Ethernet (100 Mbits per second, or ten times faster than today’s 10 Mbits Ethernet ports) will be accomplished within the next one to two years. We need to plan for gigabit speeds to the desktop. We also need to establish wireless networking so that those with laptops or with some hand-held computing device, can access networked resources from any point on campus, indoors or outside.

2. Develop an IT financial strategic plan. “Investing in information technology no longer is an option; it is a necessity.”⁵ Many institutions nationwide are developing financial strategic plans for IT. Dartmouth needs one if it is to stay abreast, let alone be a leader. We strongly urge the institution to move from its current distributed and somewhat *ad hoc* planning for IT and its funding to a more pro-active, coordinated and continuous process of financial strategic planning for academic needs. This process should involve Computing Services, the budget officers of the various schools, and the Vice President for Finance, in consultation with departments and programs and the Development Office.

⁵ Carol A. Twigg, “Getting Results from Investments in Technology”, *Priorities*. Washington, DC: The Association of Governing Boards on Universities and Colleges.

Appendix

Organization of Academic Computing Within Computing Services

Dartmouth's academic and administrative computing services are coordinated by an area called *Computing Services* that reports to the Provost. A strong degree of centralization is appropriate in the delivery of many IT services, and because Dartmouth is a comparatively small institution this is especially true. This provides efficiency and strength when delivering a full range of services, and ensures that the broad, institutional view is always considered. A concrete example is the data network and its management. The general philosophy is to centralize costs whenever possible.

The major divisions of Computing Services, comprising about 140 FTE, are:

Technical Services. Develops and maintains communications network services that are accessible to all, with an emphasis on reliability and ease of use.

Academic Computing. Supports computing in research and the curriculum, and provides general consulting to the entire community.

Information Systems. Provides access to scholarly and other databases, and supports library automation.

Instructional Services. Supports the use of technology in the classroom, and, in collaboration with faculty, helps develop content-specific IT tools for use in the curriculum.

Administrative Computing. Creates and maintains administrative systems.

Administrative Information Systems Support. Provides training and support in the use of administrative systems and works with departments to improve efficiency and effectiveness by analyzing business practices and workflow.

Fiscal and Auxiliary Services. Provides fiscal management for Computing Services, including management of sales and human resources, and Telephone Services.

User Communications. Provides communications, publishing and editorial services to clients and IT projects.

Within Academic Computing, the Consulting and User Education group provides general computing assistance and user education to all members of the Dartmouth community. Its academic support groups, Curricular Computing and Research Computing, assist faculty and students in the use of information technology for the creation, organization, analysis, and presentation of scholarly and scientific resources, for research as well as for the curriculum. The Curricular and Research Computing groups focus more narrowly on the academic mission of Dartmouth, offering assistance and services in support of the curriculum and research. Both groups provide specialists to assist faculty and students in areas such as statistics, curricular resources and web site design, media databases, programming, and data visualization, and data mining. Research Computing maintains a central research cluster for computationally intensive tasks and analyses; a distributed fleet of UNIX workstations for use by students in engineering, the sciences, and social sciences; and a central host for general UNIX services. The Curricular Computing group maintains a faculty technology center in Kiewit, housing specialized equipment (such as digitization equipment) for faculty projects.

Instructional Services provides and maintains audio and video technology services for Dartmouth's courses and classrooms, and AV services for various academic and institutional events. This division assists faculty directly with the use of AV technology. Instructional Services also maintains a campus-wide CATV network, satellite facilities, and a large media collection.

The director of the Information Systems division reports jointly to the Dartmouth College Library and Computing Services. Its mission has two primary aspects. The first is to help make information resources available in an organized and consistent manner and to develop and maintain the underlying computing mechanisms that deliver them. This group began with the creation of the Dartmouth College Information System (DCIS). DCIS, a joint project of the Library and Computing Services, originally provided access to Dartmouth's campus-wide scholarly information resources, and now provides access to all manner of content. Utilizing a variety of administrative and academic networked computer systems, Information Systems creates access to the online catalog, to bibliographic and full text sources, as well as to administrative sources. The second aspect of its mission is to provide technology support for the Library and maintain the computer systems that are used for the Library's internal operations.

Divisional and Departmental Computing Services

Though Dartmouth's computing services are more centralized than is the case at most universities, special needs are served by satellite facilities devoted to academic divisions or departments. The professional schools (especially the Tuck School) have their own extensive computing facilities and support staff. The main satellite facilities are described in this section, and the professional school facilities in the next.

Humanities Resources offers assistance and facilities to members of the humanities division. It consists of two endeavors: Humanities Computing, offering a computing lab, proactive consultation, and computer services and the Language Lab. Humanities Resources consists of 3 FTE and its manager reports to the Dean for Humanities.

Social Science Computing offers assistance and facilities to members of the social science division. It is also a facility with a variety of computing workstations, printers, database archives, and a lending library of periodicals and documentation. SSC has one FTE, a manager, who co-reports to the Associate Dean for the Social Sciences and to the Associate Director of Consulting and User Education.

The Center for Biological and Biomedical Computing (CBBC) is a resource for the life sciences community, providing assistance in the rapidly expanding use of computing technology. The Computer Science Department maintains facilities to support its curriculum. These include three instructional labs that contain a variety of computers, including UNIX workstations, PCs running Windows and Windows NT, as well as Macintoshes. Research laboratories contain both general purpose and specialized equipment, including robots and parallel computers. Computer Science has 1 FTE devoted to the maintenance of its computer systems. The Mathematics Department funds a half-time consultant to provide basic computer support to its faculty and staff.

A number of other centers and labs exist as well, including the Rahr Lab in Geography, the Remote Sensing Lab in Earth Sciences, the Electro-Acoustic Lab in Music, the Visualization Lab in Psychological and Brain Sciences, and several computational labs in Physics and Chemistry. There are also many individual researchers who have a single desktop UNIX system for their own research needs.

The Professional Schools

The Tuck School considers information technology nothing less than the principal tool for the fulfillment of its mission. The School makes heavy use of information technology both in its curriculum as well as a means of involving alumni, executives and other professionals in its programs. The Tuck School has directed a great deal of resource to promote the use of information technology, both in terms of support staff and its infrastructure. *Tuck Computing* provides a broad range of assistance with the use of technology and a variety of facilities and services. The group consists of 16 FTE and its Director of Information Technology reports to the Dean of the Tuck School.

Thayer School Computing provides basic computing assistance to faculty and staff at the Thayer School of Engineering. It also provides support for faculty research by assisting in computing purchasing, installation, and maintenance. The Thayer School Computing consists of 4 FTE, currently one software engineer, a senior technician, a UNIX system administrator, and a director.

The mission of Dartmouth Medical School Office of Information Technology (OIT) is to enhance the application and use of information technology for teaching, research, scholarship and learning. OIT provides assistance to the faculty, physicians, scientists, students and staff in their use of information technology and supports administrative business applications and processes by designing, developing, and helping to select and implement information systems for the Medical School. OIT actively assists all members of the Medical School and the Dartmouth community in the use of information technology and maintains collaborations with other institutional organizations (Dartmouth College, Clinic, Hospital, VA). OIT has 6 FTE.

Berry/Baker Library

A large addition to the existing Baker Library, the Berry Library, is currently being constructed. The architects created space based on the notion of physically uniting two strongly service oriented and centralized organizations. The new library pushes the continuum of library-computing integration with space that preserves each organization's unique identity but brings the services of the two organizations together.

Single-platform versus Multi-platform Environment

Dartmouth's requirement that incoming undergraduates purchase a computer has served the institution and the students well. This policy has recently been debated vigorously in the Council on Computing, because of two issues it brings into focus: the institution's recommendation of a particular platform, and the obsolescence of computers by the senior year.

The class of 2003 has been offered a range of desktop and laptop computers to purchase. At the basic end of the spectrum are the Apple iMac 333 MHz at \$1,196 and the Dell OptiPlex G1 433 MHz at \$1,261. Students were required to make their selection by July 15 before arriving on campus, and the cost is added to their tuition bill. Students on financial aid may request a loan to cover the cost of a basic package, and their financial aid packages are revised accordingly.

The letter from the Director of Computing that accompanies this summer mailing to incoming students reflects the gradual transition from a single-platform Macintosh campus to a multiplatform campus. Each year the letter is reviewed by the Council on Computing, and present policy on this issue is best articulated by reprinting the letter in its entirety:

Dartmouth supports both Apple Macintosh and Windows 95/98 personal computers. Which computer you choose is your decision. Dartmouth has been a predominately

Macintosh campus since 1984. While the Macintosh is still the most commonly used personal computer at Dartmouth, Windows is increasingly preferred in engineering courses, in some courses in the sciences, and in some statistics courses. Macintosh computers are the machines more often used in the humanities and languages and in Computer Science. However, many departments don't rely exclusively on the Macintosh or Windows; either machine is fine.

Your interests and needs are likely to change during your career at Dartmouth. Many students choose to upgrade or buy new computers after a couple of years, when their needs become clearer. If you need access to different kinds of computers, Dartmouth has computing clusters available with a variety of computers in each cluster.

If you are not sure what kind of computer to buy, we suggest you select the basic desktop Apple Macintosh. The vast majority of undergraduates (more than 90 percent) and faculty use the Macintosh.

Common use of Apple systems over the years has helped create robust, pervasive, and easy-to-use computing services. Because most students, faculty, and staff have a Macintosh, Dartmouth is able to deliver a high level of technical support for the Macintosh. We also deliver a high level of technical support for Windows machines, but Windows users are still in the minority at Dartmouth.

As is apparent from the letter, Dartmouth's current policy is to transition to a multiplatform environment rather than switch from the Macintosh to the PC. This policy is supported by the widely held view that the choice of platform will become less important as routine computing becomes increasingly browser based.⁶ In this scenario, the distinction between local and distant computing will be blurred, and the desktop, laptop or hand held units will be devices that link people to the Internet.

At the moment, the preference for one platform over the other varies by discipline and often by individual faculty member. The Macintosh is favored in the arts, humanities, and biology. The PC is favored in engineering and fields that use statistics (e.g. economics and psychology). The PC is clearly the dominant platform in the world at large. It is argued that the Macintosh can emulate the PC and run much of the standard PC software (albeit more slowly) while the reverse is not true. While some would argue for a wholesale switch to the PC, this would severely disrupt the introductory computer programming course (which is Macintosh based) as well as many other courses for which faculty have developed Macintosh software over the years. Furthermore, upperclass students would be stuck with a sunk investment. A sudden switch would require substantial resources to equip, train and support students, faculty and staff. The Council on Computing, in wrestling with this issue, has determined that preferred course of action is to allow the number of Windows machines to grow naturally, and with it the support requirements, and to acknowledge the reality of a multi-platform environment. We also acknowledge that a multiplatform trend will surely increase support costs. About a third of the class of '03 has selected a Windows platform. About 25% of all computers at Dartmouth, including the three professional schools, are Windows machines.

In addition, about a third of this class, regardless of choice of platform, has selected a laptop. In previous years, only about 10% of any class selected a laptop. A trend toward more laptops among students is interesting, especially as wireless is now becoming a reality on the Dartmouth campus and as laptop battery life slowly but surely continues to improve. A few schools have already instituted a computer requirement that specifies a laptop, as is the case with Dartmouth's Tuck School of Business.

⁶ Technology Review, vol 102 (3), 1999, pp. 74-80.

