Implementation Report of the Subcommittee on Educational Computing

Outline

I. SUMMARY AND RECOMMENDATIONS

A. Introduction

In its goals report of May 1989, the Subcommittee on Educational Computing concluded (1) that faculty, staff and students should have access to the computational resources necessary for their work, (2) that computing resources should be familiar tools for every student, and computing should be systematically integrated into the curriculum, and (3) that modern administrative computing must be coordinated to increase productivity for educational support functions, such as advising, course registration, and course evaluations.

Rice University is dedicated to the mission of providing unequaled undergraduate education to highly talented students. To fulfill this commitment and seize the opportunities that computing offers, Rice has developed a powerful concept, the electronic studio, for enhancing its educational program. Rice's claim to continued national leadership in undergraduate education will depend on quick action in implementing this vision.

Rice University's primary concept for educational computing, the electronic studio, represents an electronic analogy to the architect's or artist's studio. The electronic studio is a workplace existing on a network of workstations or personal computers and serving multiple functions. It includes a set of tools for course work, for storing and retrieving files, and for communicating with other people, including instructors, and other computing networks. The electronic studio provides the student with a home for creating, completing, and storing work, a place where the tools of one's intellectual endeavors are close at hand. The studio is linked to many other resources, including other people (both at Rice and around the world via electronic mail), bibliographic databases, library materials, and powerful computing facilities via access to remote mainframes or supercomputers.

Each of the seven schools that make up Rice University's educational community has now developed an electronic studio specification that best fits its particular curricular goals. Plans for each of the seven divisions are incorporated within this report. These plans are rich with details on how the vision of educational computing should be integrated into the curriculum of each division.

B. Summary of key recommendations

1. All students at Rice University should have individual electronic studios, accessible by way of microcomputers or workstations in public facilities, through which they can access, work with, and store their own data and programs essential to their education. Although these studios are intended mainly for use by undergraduates, they will serve many of those needs of graduate students not met by the recommendations of the Research Subcommittee.

2. All faculty should have personal, private access to computing facilities compatible with and ideally networked to these electronic studios, so they can prepare courseware and assignments for their students. Thus, the Educational Subcommittee concurs with the corresponding recommendation of the Research Subcommittee that "Every faculty member and student should have access to a microcomputer/ workstation environment meeting at least minimum specified standards."

3. With respect to mid-level computing, the Educational Subcommittee supports the recommendation of the Research Subcommittee that Rice needs to maintain and upgrade mid-level computing, including mainframe computers that are essential to the instructional goals of many Rice departments. The committee fully supports the goal of combining educational needs with those of research and administrative computing to contain the high costs of mid-level computing.

4. The Educational Subcommittee recommends substantial expansion of networking within the university, not merely within individual public facilities but also into departments and faculty offices, into administrative computing to the extent that security safeguards will permit, and into the University Library. Networking is essential to the fundamental principle that students be able to access their individual electronic studio from any public facility on campus. Linking to faculty offices is central to faculty members' ability to communicate with their students electronically. Thus, the Educational Subcommittee fully supports the recommendation of the Research Subcommittee on networking. This network should be as seamless as current technology allows, and it should permit users to move data between different types of computers with ease. The Educational

Subcommittee at this time does not place a high priority on extension of the network to the colleges.

5. Additional investments must be made in support staff to make the electronic studio concept viable. These staff would include technicians to maintain the public facilities and network, to advise on mainframe computer usage, and to assist faculty in incorporating computing into the curriculum. Some of these staff should be assigned directly to divisions, although in some cases centralizing staff will be more efficient.

6. Moderate amounts of new space must be identified at a number of campus sites to accommodate expansion of existing public facilities and creation of new electronic studios. In addition, the university should outfit a number of classrooms of varying sizes with equipment for overhead projection of screen images from the types of computers used in public facilities.

7. Faculty should be encouraged to incorporate state of the art developments in computing into their course curricula. Wherever possible, they should receive assistance from the university in these efforts. Innovations and improvements in the curriculum are the most important goals of educational computing. In the spirit of containing costs, parallel efforts should be made to identify possible savings that such computerization could produce (for example, through substituting computerized teaching for some more expensive and less effective teaching technology).

8. Wherever it is possible, the Educational Subcommittee supports the sharing of resources, not only between various educational efforts (e.g., combining resources of two or more electronic studios) but also with research and administrative computing efforts. For example, the staff maintaining networks in public educational facilities could meet the needs of researchers in many cases. Similarly, the Educational Subcommittee supports the establishment of hardware and software standards to reduce purchase and maintenance costs.

9. The progress of educational computing at Rice should be monitored continually by the Deans and Provost, by the Vice President for Graduate Studies, Research, and Information Systems, and by the Computer Planning Board. The Educational Subcommittee also recommends that we consider identifying a leadership position

within the university focused specifically on the development of Educational Computing.

C. <u>Summary of Proposed Budget</u>

The overall budget for educational computing at Rice over the five year period (1989-90 through 1993-94) is summarized in the attached spreadsheet. Initial figures were provided by the seven divisions, and in many cases adjustments were then made by the Educational Subcommittee. In some cases the figures are firm, save for uncertainties in pricing of hardware and software in future years. In other cases the dollar amounts are less firm, reflecting the earlier stage of maturation of these divisions' plans.

The totals do not take into account any overlap between educational computing on the one hand, and research and administrative computing on the other. From preliminary discussions, however, it is apparent that there will be significant overlap between educational and research computing, in at least the areas of computers for faculty offices, networking, and support staff.

Budgets from the various divisions differ with respect to the rate of acquisition of new equipment and the method of amortizing existing and new equipment purchases. This reflects the fact that some divisions have a large existing base on which to build, whereas others are starting from scratch. With additional work, these figures could be refined, but in all likelihood the final totals would not be significantly different. The total, steady-state, annual increment above current base budgets that are needed to achieve these electronic studio plans within five years amounts to approximately $2.5 million, excluding costs for a new mainframe computer. After taking into account overlap with the Research plans, this figure might drop to $2.0 million per year.

<u>Space</u>. On the matter of space, some divisional plans require little or no space beyond what is already allocated to educational computing, whereas other plans call for significant additional space. The most significant needs for new space are for 60 additional seats each for OWLnet and the Natural Sciences studio (which may be available in the Biosciences and Bioengineering building); and around 2100 square feet of additional electronic classroom space for Humanities (which might be available in a proposed addition to Fondren Library or Rayzor Hall).

II. IMPLEMENTATION PLAN

The implementation plan for educational computing calls for adequate instructional facilities, revisions in the curriculum, a coherent system of instruction to support the use of computing throughout the curriculum, and ongoing planning and evaluation. The implementation plan is divided into six sections: strategic issues; the facilities plan, including detailed plans for electronic studios in Rice's seven divisions; the organizational plan for computing support; the curriculum development program; the faculty development program; and the general approach.

A. Strategic issues

Four strategic issues have dominated planning for the implementation of the electronic studio concept:

1. Providing access to appropriate computing power within all academic disciplines
2. Ensuring adequate speeds and capacities for campus computer networks
3. Guaranteeing the security and integrity of networks and facilities
4. Achieving a seamless computing environment without having to make unacceptable sacrifices in software or hardware choices.

We now elaborate on each of these four issues.

1. *Providing appropriate computing power.* The needs for computation in educational environments vary from projection of computer screens to high performance computing for advanced modeling, database manipulation, and advanced graphics and visualization. Midway between these extremes are mid-level workstations such as the SUN 3/50, the IBM RT and the Mac II, as well as entry level computers such as the Mac SE and the IBM PS/2 50, which support word processing, spreadsheets, remote log-on to other systems, and electronic mail. There is at present significant support for the notion that the university should support the growth of OWLnet while at the same time increasing the level of support for users elsewhere in the university who do not require hardware as powerful as OWLnet workstations. It is the sentiment of the Educational Subcommittee that all these efforts are important and worthy of university support. It may be possible in the future to formulate useful priority schemes based on the

number of students needing simpler equipment (PCs and Macs) compared with those requiring more sophisticated and expensive workstations.

2. *Quality of campus computer networks.* Different users require different capacities for transmitting data and accessing computing resources at a satisfactory rate of speed. For transmission of short texts, a 2400 baud rate (which can be achieved via a modem over telephone lines) is minimally satisfactory. Appletalk and modem or terminal facilities will accommodate traditional 9600 baud rates (a quality of service acceptable for most text transmission) and will provide acceptable service for full screen editors. For high quality graphics, 1M to 1.2M rates are necessary, and these rates require ethernet or T1, which are significantly more expensive. For heavy use and high-speed transmission, 10M to 80M fiber-optic links are necessary. The high cost of this quality of network connection to each work station precludes its use for educational computing (beyond the backbone network), except where research functions bear the cost of the network and educational users can obtain service at essentially Appletalk rates.

   The Educational Subcommittee strongly supports the extension of high speed networking across the campus and endorses the related proposals contained in the Implementation Plan of the Research Subcommittee. To a great extent, the educational benefits and the research benefits of networking overlap. We urge that all faculty members at Rice be interconnected via a network operating at a minimum of 9600 baud by the end of the five year planning period. If funds are available, we believe that this connectivity should be extended to the colleges for access by undergraduates, and to graduate students wherever they may be housed. The ROLM switch system is serviceable for the moment in some settings. It has worked acceptably as a bridging technology, but it is now dated and any further investments in it should be avoided.

3. *Security and integrity of networks and facilities.* Plans for developing and managing both the networks and the facilities must take into account threats to the security of equipment, programs, and data as well as the integrity of the computing systems. Viruses and unethical use can sabotage intellectual property, research in progress, course materials, and students' course work. Plans should take into account the

possible necessity of operating facilities without the network in the event of security threats from deliberate misuse. Policies for preventing and dealing with computer-related crime should be developed and enforced.

4. *Development of a seamless computing environment.* The extent to which Rice University can achieve a seamless educational computing environment must be studied further. (A seamless network is one in which boundaries between different sections of the network are transparent to users, so that they may access or communicate easily with any node on the network irrespective of its location or the type of hardware existing at that node.)

   Although computing needs vary widely over the campus, some degree of uniformity must be maintained so that computers can communicate. Standards must be created and enforced so that files can be transferred, information can be shared, and networks can be effective. At the same time, diversity must be allowed so that students who need differing categories of computing can all be served without the university's providing the most expensive equipment to all students. Although it would be ideal if any student could access all the tools in his or her electronic studio from any Rice public facility (or even from an off-campus terminal), this may be prohibitively expensive given the difficulties in reconciling the wide range of hardware and software selected by the different studios. The extent to which differences in operating systems can be concealed will continue to be a challenge for some years to come.

B. Facilities Plan

1. *Facilities Plan Overview: Divisional Studio Plans.* The needs of students in the various disciplines differ. Some require powerful numeric workstations, whereas others need systems with less raw computing power that can still run specialized educational software. All electronic studios, however, will share some basic capabilities, including access to the Fondren Library and to a campus-wide communication system. Certain educational tools, such as those for writing perhaps, may be common to all disciplines, although many tools will be specific to the disciplines involved. These studios must be connected to the campus network, and

the public computing facilities must have sufficient staff to ensure the full use of equipment.

An ultimate goal of the overall facilities plan is to enable students to enter any public computing facility and access their individual programs and files stored in their electronic studios. This goal of the electronic studio concept can be achieved only when a seamless environment can be created. Current technology does not yet permit a fully seamless environment without unacceptable limitations in hardware and software choices. Although all studios include file server access and a link to the network, some programs may not be portable over the network, and some students may have to go to a particular facility in order to work on particular types of tasks. The network, the facilities, the software selected for the seven studios, and the necessary staff, therefore, constitute the core of the electronic studio implementation plan.

The university should provide three basic types of computing support for education: (a) support for intensive numerical computing through OWLnet and the Mudd Center for Computing; (b) support for various types of computing in the Center for Scholarship and Information, the Social Sciences Computing Laboratory, the Jones School Executive Computing Center, the Rice Architecture Computer Laboratory and Rice Advanced Visualization Laboratory, and the Shepherd School Computing Studio; and (c) computer-projection in selected classrooms. Successful operation of the educational computing facilities will require appropriate staffing. Faculty, computing liaison staff, graduate students who have been hired as teaching assistants, and undergraduate assistants are needed.

We now present a brief description of the seven divisional plans. The complete plan for each division, including specific, quantitative recommendations for both equipment and staffing, may be found the in the Appendix.

2. *Descriptions of electronic studios.* Here is a brief overview of the electronic studio plans for each of the seven divisions at Rice. A complete set of the full divisional plans may be found in the Appendix.

   a. ARCHITECTURE

Vision for electronic studio. The goal of educational computing in Architecture is to incorporate state-of-the-art visualization into their existing architectural studios. Both the hardware and the software supporting architectural design are advancing rapidly, so efforts must be made to keep Rice students abreast. The plan calls for phasing computers into existing architectural studios on a gradual basis. This would enable our Architecture students to be at the forefront of computer assisted design.

Existing base. Both RAVL (Rice Advanced Visualization Lab) and RACL (Rice Architectural Computing Lab) exist as prototypes for an electronic studio. However, none of the existing architectural studios contain any significant computing equipment; they still exist as conventional architectural studios. Aside from three staff members, none of whom is full-time, there are no resources for computing built into the base budget in Architecture. Much of the existing equipment has come from outside donors, with the balance coming from Rice.

Proposed enhancements. The plan calls for infusion of a large amount of highly specialized computer equipment into the studios, and additional computers for faculty members. The plan calls for one new staff member, in addition to upgrading a part-timer to full-time status. Architecture supports Rice's retaining mid-level computing capabilities of the sort that would be met by an IBM 3081 or 3090. Extension of high speed networking to faculty offices is a high priority. Much of the new equipment will come from external sponsors. Perhaps for that reason, no amortization is built into the Architecture's base budget at this time.

Space. RAVL and RACL already are in operation and have adequate space. Future plans call for placing computers into the existing architectural studios. Although this might create some crowding, there appears to be enough space in those studios to accommodate this growth.

b. ENGINEERING

Vision for electronic studio. The vision for educational computing in Engineering already exists in OWLnet. Although much work remains to be done, OWLnet has had a dramatic, positive impact on the curriculum. Engineering is further advanced than the other divisions in their planning process. So far, OWLnet is regarded as an educational success and a strong base upon which to build. The goal is to ensure access by all students and all faculty and the thorough integration of computing into the curriculum.

Existing base. OWLnet currently consists of 60 workstations, plus the additional equipment (including file servers, printers, networking, etc.) needed to keep the system operational. Currently four FTE staff are assigned to OWLnet. Most faculty have a personal computer or workstation (often bought with grant or contract money), and many have high speed networking in their offices.

Proposed enhancements. The basic proposal from Engineering is to double the number of workstations from 60 to about 120, to include color stations among these 60, and to make concomitant enhancements to support equipment. About 40 workstations are proposed for faculty offices, which would fulfill the goal of every faculty member's having access to a workstation. Staff size would be doubled. Engineering is among those divisions expressing strong support for classrooms equipped for overhead projection of computer images. Only a few Engineering faculty have a continuing need for mid-level computing, but the needs of those faculty are significant.

Space. The OWLnet plan, which encompasses both Engineering and Natural Sciences, calls ultimately for a tripling of the number of seats from the current 60 to 180. In addition, space must be found for new staff. Currently OWLnet facilities have little extra space, so a significant amount of new space must be found. The new Biosciences and Bioengineering building would appear to be an ideal candidate for finding this space.

c. HUMANITIES

Vision for electronic studio. A number of members of the Humanities division are enthusiastic about incorporating computing into the curriculum. The basic plan would put writing and research tools into the hands of both the faculty and students. A new course on computing in the humanities is planned.

Existing base. Although there are certain faculty members in the division who are heavily computerized, probably fewer than half the Humanities faculty have a personal computer, and most have no access to the campus-wide network from their offices. Currently, Humanities students use facilities in Mudd and in the Center for Scholarship and Information (CSI) to meet their needs. There are no staff members specifically assigned to computing in this division.

Proposed enhancements. The proposal calls for an electronic classroom that would include 30 personal computers, plus almost 60 more for faculty offices, so that virtually every faculty member who needs and wants a computer will have ready access to one. There is also a need for networking into each faculty office. The Andrews software package from Carnegie Mellon University has generated considerable support in the division and thus is the software of choice at present. The proposal calls for three full-time staff, including one network administrator. Significant sharing of facilities and staff with Social Sciences appears possible. Humanities is among those divisions expressing support for classrooms equipped for overhead projection of computer images. The needs for mid-level computing are modest, but there are a few faculty members for whom this is important.

Space. Humanities students currently make use of the CSI and of the public facilities in Mudd, in addition to the 2000 square foot Language Lab. Humanities' plan projects a need for 2100 additional net square feet, 1500 of which would be used for an electronic classroom to be filled with PCs. No space has been identified as yet for this classroom, but it could be included in a proposed addition to the Fondren Library or to Rayzor Hall.

d. JONES SCHOOL

Vision for electronic studio. The Jones School is already 75% of the way toward finishing an electronic studio for their graduate students that will prepare them with the necessary computing skills tools their future employers expect them to have mastered. These include word processing, spreadsheets, business graphics, presentation software, and data analysis techniques. At this stage, 90% of all Jones School courses have a central computing component that goes beyond basic word processing.

Existing base. The existing base includes 92 personal computers, 41 of which are state-of-the-art; the rest are obsolete. This equipment has been given to the Jones School by external sponsors, including Apple Computer, as a result of faculty proposals. All faculty who want personal computers have them, although many are in need of upgrading. No networking exists at the moment, save for a few DTIs. The Jones School has one staff member assigned to computing, but they have had difficulties keeping this position filled at its current salary level. Aside from this staff member, however, there is no base budget for computing in the Jones School and no specific plan for replacing the obsolete equipment.

Proposed enhancements. These include adding more computers and building a network to tie them all together within Herring Hall and to the campus backbone. Additional personal computers for staff are needed. Plans are underway to put overhead projection of computer images into classrooms in the upcoming academic year. Regarding mid-level computing, the demand is declining but is expected to remain strong among a handful of faculty for several more years.

Space. The Jones School's electronic studio is already 75% complete, as noted above. Sufficient space currently exists to complete their plan.

e. MUSIC

Vision for electronic studio. Computing will have an enormous impact on the curriculum in music. Compared with other areas where computerization mainly accelerates the pace of conventional activities, computers in music make possible whole new realms of creative activities and interaction between faculty and students. Where once a composer might never be able to hear his or her composition, now it can be synthesized in sound the instant it is created, altered in response to the listeners' reactions, recorded, and printed in musical notation. The Shepherd School's plan calls for involvement of all students in educational computing.

Existing base. The existing base in the Shepherd School is minimal; essentially it is a single personal computer (Mac II cx) connected to a MIDI keyboard and sequencer and a sound system. This system, which is fully operational and includes a laser printer, runs a comprehensive software package called *Finale*. A few of the faculty have personal computers at home; almost none have them in their offices. There are presently no staff members and no base budget for computing.

Proposed enhancements. These call for three more Mac IIs for the publishing studio, 16 Mac SEs for the Aural Skills lab, and 14 Mac IIs for faculty. A full-time manager is also proposed, along with some form of connectivity to faculty offices. Because of the highly specialized hardware that goes into these computers for music, sharing of facilities with other divisions will be limited.

Space. Music is preparing to move into their new building beginning as early as August, 1990. Sufficient space for the division's plan, which includes computerizing the Aural Skills Lab, the Publishing Studio, and some classrooms, apparently will be available in the new building.

f. NATURAL SCIENCES

Vision for electronic studio. Natural Sciences has adopted OWLnet as the basic model for its electronic studio concept, custom tailored to meet the particular curricular needs of their division. This is another indication of the success of OWLnet, and Natural Sciences' adoption of a facility similar to OWLnet should yield some cost-saving efficiencies. OWLnet will provide students with essential tools for numerical analysis, statistics analysis, color graphics, data analysis, simulation, and word processing. Although some of these tools may overlap with those used in Engineering, others are certain to be designed specifically for the Natural Sciences.

Existing base. Although many students in Natural Sciences use Rice's public facilities (including OWLnet), there are no public facilities yet devoted to this division. Many if not most faculty have some personal computer, in many cases purchased from research grants. Some networking (including LANs) already exist. There appear to be no staff permanently assigned to computing in Natural Sciences.

Proposed enhancements. The Natural Sciences plan calls for an additional 60 workstations for OWLnet, in addition to about 60 personal computers (20 of which would go into a classroom that could be shared). About 25 PCs are required for faculty offices, so every faculty member who wants and needs one will have access to one. The plan calls for four staff members, including one who would assist faculty in incorporating computing into the Natural Sciences' curriculum. Mid-level computing continues to be important to a few faculty members in this division.

Space. Because Natural Science's electronic studio plan is basically an extension to OWLnet, the space implications are covered by the remarks presented above for Engineering.

g. SOCIAL SCIENCES

Vision for electronic studio. Educational computing in the Social Sciences is based in the SSCL (Social Science Computing Lab), which presently is modest but sufficient to give students the basics in computing. In particular these basics include: statistical analysis (often of large databases such as census or poll data sets) with powerful statistical software packages; simulation; real-time experimental control; graphics; and word processing.

Existing base. The SSCL contains only 13 PCs now (9 Mac SEs and 4 IBM clones), connected with a small network and a DTI for mainframe access. Many faculty have personal computers in their offices. No networking exists in the division, although some faculty have DTI connections to the AS9000 mainframe. There presently is no staff member assigned to computing, although two teaching assistants work in the SSCL.

Proposed enhancements. Although the SSCL contains only 13 PCs now, an upgrade to 25 Mac II cxs and 10 IBM PS/2 Model 70s is projected for the near future. Short-term plans include networking the SSCL and connecting it to the campus backbone. Later plans extend that network to departmental and faculty offices. At least one staff member is needed to administer the network. The need for mid-level computing in Social Sciences is strong and is projected to remain so for several more years. In particular, several key researchers in Political Science and Economics have computing projects that are intensive with respect to computation, input, and output, and it is not clear how this work would be done if there were no mainframe computer on campus. Social Sciences is among those divisions expressing strong support for classrooms equipped for overhead projection of computer images.

Space. Some modest additions to SSCL's space have been planned for FY91. The space has been identified adjacent to the existing SSCL and can be accommodated within the division's overall space plan.

3. *Classroom facilities for computer projection*

In addition to the public facilities supporting electronic studies, several campus classrooms should be equipped for computer projection so that faculty members can demonstrate processes and systems that are difficult or impossible to describe with blackboards or conventional overheads. In addition, these projection devices can be used to illustrate problem solving techniques and simulations in accounting, engineering, mathematical sciences, social sciences, and a wide range of other disciplines. Programs such as Hypercard can allow the instructor to demonstrate static or moving images from compact disks. As noted above, many divisions have called for these projection facilities. The Educational Subcommittee puts a high priority on them and believes they should be provided centrally rather than by divisions.

The most efficient way to provide these capabilities is to equip these classrooms with overhead projectors (which they should have anyway!). Several companies offer devices that can be used in conjunction with overhead projectors that are both less expensive and more portable than traditional computer projection devices. Portable computers and these projection devices should be provided to OWLnet (for use in Natural Sciences and Engineering classes), the Center for Scholarship and Information (for use in Humanities and Statistics classes), and the Social Sciences Computing Laboratory (for use in Social Sciences classes). Teaching assistants assigned to these facilities should be responsible for coordinating the use of these projection systems. Equipment should be provided to departments not served by these facilities through the Computing Resource Center.

C. <u>Organizational Plan for Computing Support</u>

1. *Computing Resources Center.* A central recommendation of this implementation plan is that staff support is essential for the electronic studio concept to succeed, and that at least some of this staff should be decentralized (i.e., should report to the divisions for whom they work). However, much of the support services for educational computing during the years of this planning process should be centralized in the Computing Resources Center, which should provide a variety of services. This organization should have sufficient staff to:

    a. Provide expert advice on the availability, quality, and capabilities of educational software packages. By having a place where faculty could seek assistance, try out new products, and learn to use new resources, the Center will provide a centralized and highly visible support service.

    b. Obtain and maintain software and equipment used in teaching. This includes negotiating site licenses and volume discounts for use in labs. The campus bookstore should not be involved in purchases for laboratories but only for software sold to individuals. A regular planning process, similar to the budget process, carried out by the Vice President for Graduate Studies, Research, and Information Systems, can also be used to identify what equipment and software are needed for various courses for the next year to two years, and to review for duplication and efficient purchasing.

    c. Sponsor summer sessions and programs to help faculty become aware of how computing could be helpful in their teaching and to help faculty develop educational software.

d. Oversee the work of professional staff and student programmers who would develop or adapt existing programs for use in courses and assist in the preparation of copyright and license agreements. This service should be tested with specific courses in several divisions in the next two years. Because the development of software can be a lengthy and expensive undertaking, every attempt should be made to obtain existing software instead. As a rule, software developed under the auspices of the resource center should be limited in scope. Programs that take no more than 20 hours to develop and that help clarify one specific concept would be ideal. Also valuable would be larger projects that consist of numerous modules, each of which is useful in its own right. The choice of projects to be funded should be made in conjunction with a committee of faculty. The Computing Resources Center should also oversee preparation of patent and copyright applications and license agreements and copyright agreements among developers that would comply with any policies the university adopted on software development.

2. *Continuous Evaluation of Facility Use.* The Vice President for Graduate Studies, Research, and Information Systems should develop a management information system to monitor courseware development, integration of computing into the curriculum, and use of facilities. By initiating a system for surveying faculty members by way of department chairs approximately three months before the beginning of each semester, the Vice President could anticipate levels of equipment use and then warn faculty when facilities were likely to be overloaded. By using software such as "lab controller" in the low-end facilities, use of individual machines and laboratories could be monitored and periods of heaviest use could be charted. If facilities began to be used very heavily before the end of Phase I, consideration could be given to further expansion of educational facilities in Phase II, along with encouraging individuals to purchase their own machines.

   In addition, colleges should require students to register and mark their personal machines, partly for security purposes and partly to maintain reasonable estimates of computing availability outside of educational facilities. The Computing Resources Center could also report the number of faculty involved in workshops and courseware development programs so that any courseware likely to have a major impact (such as foreign language study programs where none existed before) would have adequate facilities support when the programs were finished.

3. *The Importance of Staffing.* Successful operation of educational computing facilities will require appropriate staffing: faculty, additional computing liaison staff, professionals, graduate students who have been hired as teaching assistants, and undergraduate assistants. Regular faculty members' participation as part-time directors will ensure that equipment and software in the facilities are appropriate for the curriculum. Computing liaison faculty would be faculty with reduced teaching loads whose service obligations to the university consisted of: (1) keeping up with new hardware and software developed for the disciplines of their school or departments; and (2) working with regular faculty to integrate computing into the curriculum. Each school is expected to need at least one computing liaison faculty member. The subject area knowledge of graduate students holding teaching assistantships and their experience with computers will enable them to help students run educational programs and use courseware designed for specific courses. The teaching assistants who staff these educational facilities should be able to assist faculty by preparing and distributing diskettes and documentation.

   These recommendations are based on the surveys of faculty in the first cycle of the planning process, published reports on the experience of other universities, and recommendations from consultants who assisted the Planning Board and its subcommittees. Brian Hawkins, Vice President for Computing and Information Services at Brown University, emphasized that too often universities have assumed that computing required equipment rather than people. Instead, he said, computing in a university is "people intensive." Without support people, equipment will go unused and total productivity will decrease. For the next five years, in his judgment, computing will require additional, not fewer, staff. At the same time, experience with other technologies has shown that there is always a period at the beginning of the learning curve in which effort devoted to mastering skills is proportionally greater than at later periods, when productivity and efficiency increase. To the extent that universities seek to keep up-to-date and introduce students to a variety of equipment, programs, and techniques, educational computing will always be more labor-intensive and less efficient than computing in industry, where standardization throughout a system can be achieved.

D. Curriculum Development

Rice's Departments and Divisions should consider changes to the curriculum to integrate computing systematically into the curriculum. Where appropriate, they should also consider changes to their graduation requirements to ensure that their graduates have necessary experience with the computing methods vital to their fields of study. The Educational Subcommittee should work with representatives from the various divisions to encourage the development and teaching of courses that will instruct students and faculty in the use of computing facilities and software that will be employed in courses throughout the university.

The Vice President for Graduate Studies, Research, and Information Systems, together with the Curriculum Committee, should review courses offered in the various departments to ensure that the first two educational computing goals are met. These goals, expressed in the Goals Report of the Subcommittee on Educational Computing (May 1989), are:

1. All faculty, students, and staff should have access to the computational resources necessary for their work; and

2. Computing resources should be familiar tools for every student, and computing should be systematically integrated into the curriculum.

Computing should be integrated into the curriculum to take advantage of the ability of computers to enhance the learning experience. In addition, the university should offer high quality courses in disciplines that use computing as a principal method (for example, computational chemistry, physics, linguistics, or theoretical physics), as well as courses in the discipline of computer science itself (a field that builds theories of possible architectures and their uses). The Provost should request that the appropriate bodies review and, where appropriate, modify graduation requirements to ensure that candidates in the various disciplines have the necessary course work or other credentials in computing for their majors and minors.

E. Faculty and Staff Development

Workshops should be offered to help faculty learn to use equipment, try out programs, write grant proposals, and develop courseware. Some of these workshops should be very short, one- or two-day programs. In addition, a more elaborate Faculty Computing Project could organize longer programs, which could include both basic software instruction, programming, and courseware development projects. The Office of Continuing Studies and Special Programs could administer this project. The Office of Sponsored Research could oversee the proposal writing project. The third goal of educational computing requires that staff as well as faculty have training in computing. This goal states that "modern administrative computing must be coordinated to provide efficient information management and productivity for educational functions, such as advising, course registration, and course evaluation." Because staff frequently assist in the preparation of materials, record keeping, and other processes, they must have opportunities to learn necessary skills.

F. General Approach

1. *Phase I* (1988-1991). In the initial deliberations, the Educational Subcommittee identified a set of goals to be achieved during Phase I, which covers the period 1988 to 1991. At this time, we are more than half way through Phase I, and some of these goals are being achieved. The goals state that the university should:

   a. Ensure the availability of appropriate high quality courses in important disciplines, including new and expanding subdisciplines, that use computing as a principal method as well as sufficient courses in computer science as a discipline.

   b. Provide each student access to an electronic studio by developing facilities and providing support for this type of educational computing.

   c. Extend the campus "backbone" network to link all major educational computing facilities, and appropriate administrative and research computing facilities.

   d. Set sufficient standards to ensure, as far as current technology permits, that computers in different facilities can communicate with one another and share appropriate programs and data.

e. Expand facilities by building upon the existing foundation for educational computing available in the facilities of OWLnet, the Mudd Center for Computing, the Fondren Library, and the Social Sciences Computing Laboratory, as well as by starting a small number of new, special-use facilities such as the Center for Scholarship and Information, the Anderson Graphics Laboratory, and the Shepherd School Computing Studio.

f. Provide appropriate training and support for faculty to use the electronic studio effectively in their courses.

g. Review and modify graduation requirements as necessary to ensure that a degree candidate has had experience with and is competent in computational methods essential for the disciplines (major and minor) in which the degree is granted. Departments would specify the types (if any) of computation essential to their fields, as they now specify course requirements.

The Educational Subcommittee continues its commitment to these initial goals and is pleased with the progress made to date in expanding the backbone, in developing electronic studios, and in integrating OWLnet into the Engineering curriculum.

b. *Phase II* (1991-92). During Phase II (1991 and 1992), Rice University should evaluate the rate at which computing has been integrated into the curriculum, project continuing changes, and consider including residential colleges in the campus network. During this phase the continuing need for the AS 9000 or a super mini-computer in educational support of advanced modeling courses and graphics should also be assessed, in the event that this matter has not been resolved during Phase I.

A cluster strategy underlies the facilities plans for educational computing. Students often prefer working in groups to working alone, even if they own personal computers. Association allows for the rapid exchange of ideas in a relaxed, friendly atmosphere. For this reason, we discourage an implementation plan in the first three years that would require students to compute at home or in their residential college rooms. Nevertheless, students should be encouraged to own computers if they choose, and the university should negotiate discounts and other arrangements that make the selection, purchase, maintenance, security, and repair of student and faculty-owned computers easy. Students should be able to access campus computers from their own machines for educational purposes.

APPENDIX

Divisional plans for electronic studios

NOTE: Many of these plans are still undergoing development and thus are not final.

1. School of Architecture
2. Brown School of Engineering
3. School of Humanities
4. Jones School of Administration
5. Shepherd School of Music
6. Wiess School of Natural Sciences
7. School of Social Sciences