COMPUTER LITERACY: AN INTERDISCIPLINARY, HANDS ON APPROACH AT THE EVERGREEN STATE COLLEGE, OLYMPIA WASHINGTON

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Introduction

The Evergreen State College is a fully accredited four year undergraduate liberal arts college of the State of Washington. Evergreen was founded in the late sixties as an alternative to the prevailing pedagogical model of undergraduate specialization. Evergreen instead favors integrated, thematic academic programs which typically involve faculty from several disciplines. From its inception the College has had a strong commitment to familiarizing its students with the computer as a tool. This paper outlines some of the methods used at Evergreen and indicates some of the lessons we have learned which may be useful to other liberal arts colleges.

Computer Literacy and Liberal Arts

A liberal arts education is usually intended to be broad and to develop fundamental intellectual abilities and problem solving techniques rather than merely knowledge of a particular body of "facts." There can be little doubt that in the last ten years the computer has emerged as a significant analytic tool. When mastered it enhances the user's ability to tackle a variety of advanced subjects in the arts and sciences. Computers are fast becoming commonplace not just in the obvious studies like physics, but even in aesthetic subjects such as music. Moreover, the computer is effecting an increasingly widespread transformation of our world with profound social implications. A liberal arts education today must therefore involve a more complex kind of "literacy" than just reading, writing, and mathematics.

As a consequence of this view of a liberal education, we have endeavored to make it possible for even the most non-mathematically inclined student to be exposed to the use of computers and to the fundamental concepts of programming. Before explaining some of the techniques we have used, it is necessary to outline the kind of academic program followed by a typical student at Evergreen.

An Interdisciplinary Approach to Learning

Traditional undergraduate education (even at most liberal arts institutions) is based on a fragmentation of knowledge into disciplines. One studies physics, say, rather than natural science. It is our premise that while specialization may be appropriate at the time (if) a student goes on to advanced work, a strong undergraduate education should serve a different purpose than the amassing of facts in some narrow specialty. Consider the case of Computer Science itself. Computer Science is a discipline which did not exist until the late fifties. Indeed it is still true that many faculty in departments of Computer Science do not have terminal degrees in that specialization. Might not the future hold other such emergent fields for which our students would be best prepared by developing critical intellectual faculties rather than narrow ensembles of facts?

Further, the rapidly changing world in which we live suggests that the typical 21st century man or woman will not work in one occupation for a lifetime, especially if s/he leaves the halls of academe. The facts that such an individual might have learned in an undergraduate course twenty years ago will probably be useless or obsolete. The basic skill of learning to learn and an attitude of being unafraid of new knowledge will, however, serve a lifetime. There is also the obvious fact that many students simply do not have even immediate career goals until part way through their undergraduate career. This is probably an appropriate response to the obvious acceleration of change which they see about them, but even if this were not so, most have been poorly prepared by regimented high schools to make wise long term commitments to careers.

Many of the greatest intellectual achievements of the past have involved the synthesis of knowledge from different fields, rather than digging more deeply into the same mine. Indeed, Computer Science may be said to have evolved in precisely this way. Consider these words of Norbert Wiener, certainly one of the seminal figures in Computer Science:

> "For many years Dr. Rosenblueth and I had shared the conviction that the most fruitful areas for the growth of the sciences were those which had

> been neglected as a no-man's land between the various established fields. Since Leibniz there has perhaps been no man who has had a full command of all the intellectual activity of his day...It is the boundary regions of science which offer the richest opportunities to the qualified investigator. If the difficulty of a physiological problem is mathematical in essence, ten physiologists ignorant of mathematics will get precisely as far as one physiologist ignorant of mathematics and no farther." (From Cybernetics, 1948)

Evergreen's objective then is to produce physiologists who can interrelate physiology and mathematics...and literature...and history...

To accomplish this, the College deliberately set out to change the usual format of instruction. Consider the way in which classes are typically taught: a student enrolls in four or five different courses pursuing unrelated topics on a part-time basis. Not only are the subjects fragmented, but so is the student: s/he must satisfy not one, but several professors simultaneously and if s/he becomes deeply interested in one class, that interest must be postponed lest failure occur in the others.

At Evergreen, the principal vehicle is rather different. A student, particularly an entering student, is encouraged to enroll in a "Coordinated Studies Program" which is an integrated, full-time thematic study lasting from one quarter up to an entire academic year. That such a program is integrated implies that it will involve more than a single specialization or discipline and that these will be studied in an interrelated fashion. That it is full-time implies that the student's interest and time will not be fragmented. That a program is thematic implies that it will be centered around an issue or a general question about the world in which we live. A Coordinated Studies Program will have between forty and eighty students working with two to four faculty drawn from different fields and united by their interest in the issue. An important implication is that such group study emphasizes cooperative rather than competitive learning. Some examples which unify diverse fields are "The Nuclear Power Issue" (social science, ecology, physics and economics); "Dynamical Systems" (control theory, physics, linear algebra); and "Sociobiology and Human Values" (biology, history, political philosophy). Programs are also used to teach fundamentals. For example, "Foundations of Natural Science "(FONS) integrates mathematics, physics, chemistry, and biology into a year-long full-time study of the scientific mode of thought.

The Coordinated Studies approach obviously has limitations too. For the student who needs to concentrate on a single topic or who wishes to pursue a unique interest, it is inefficient and even inadequate. To address these requirements, the College utilizes a second major mode of instruction called the "Individual Contract." A contract is a negotiated agreement between a student and one or more faculty which specifies the responsibilities of each. The student outlines what s/he wishes to learn, the faculty member indicates what support s/he can provide, and after discussion and (often extensive) modifications they agree on mutual performance expectations. Individual Contracts are full time like Coordinated Studies, vary in length from one quarter up to a year, and are most commonly used by advanced students.

The combination of Coordinated Studies and Individual Contracts began at Evergreen as a direct response to what the planning faculty saw as a conceptual defect in traditional undergraduate education. That combination also bears on a motivational defect, however: traditional education does not effectively reinforce curiosity. A student is wondering about why there are so many wars so we tell him to take History 101. Why not organize an academic inquiry like "The Causes of War" aimed directly at the student's interest and teach some history in the process? That turns out to be much more motivating. Thus, by using integrated, full-time, thematic studies, the College not only offers a more useful education, but also makes academic work more interesting.

It would be wrong to fail to acknowledge that Evergreen's approach has drawbacks too. The combination of no courses, no grades, no requirements (other than earning enough credits to graduate), and heavy reliance on the student to plan his/her own educational program places a heavy demand on all parties. Students not infrequently require a year to be deprogrammed from structured secondary schooling, and many who lack mature, responsible, and assertive personalities do not make it. Faculty must constantly guard against erosion of academic content and standards and they must anticipate the big questions about which students as a group are curious in order to devise successful new academic programs. Evergreen deliberately chose to abandon tenure. As a consequence there is much pressure, and "faculty burnout" is not uncommon. But in a stumbling way, drawing equally on the ideas of students and faculty, Evergreen has grown into an immensely exciting place for both.

Computers in an Interdisciplinary Environment

Having drifted rather far into educational philosophy, it is now appropriate to return to how the College attempts to expose its students to computers and programming in the context of the educational structure just outlined. The first problem is that of access. At Evergreen's inception it was decided to treat computing resources in the same fashion as its library--that is to say that there would be free access to all students, faculty and staff. The College acquired an interactive, timesharing computer and passed out free sign-on numbers. Now as the experience of Dartmouth has shown, this in itself will result in widespread exposure of

students to the use of computers. Freed of the limitations of accounting, the computer becomes accessible and can be explored in a reactive and leisurely fashion. It is important to note that free access does not mean unlimited access; the College is obviously unable to provide super-computers in quantity to any student who requests one. What is meant, rather, is access without charge to an extent compatible with the needs of other users. The community of users by and large is self-regulating, with peer pressure serving as a primary counter to overuse. As with curricular planning and completion of academic work, the emphasis is on placing responsibility on individuals for their own actions.

The policy of free access is supported by a determined effort to make terminal facilities and staff support widely available. This has taken several forms: clusters of terminals in various campus buildings close to focal points of academic programs, portable terminals available for checkout in the library, and long term loans of terminals to students engaged in projects. A computing laboratory which is open to everyone from early in the morning until late at night consolidates terminals on the College's academic timesharing system, stand alone microprocessor systems, and support staff in one place.

Since students are typically enrolled in year-long programs, the number of opportunities to catch students in a traditional "Introduction to Computers and Programming" course is much reduced. Such a course (called a "Module" at Evergreen) has been offered and students may and do sometimes incorporate it as part of an Individual Contract, but this is not how the majority of students learn to use the computer. In fact, experience has shown that the tendency to develop modules to meet perceived disciplinary needs of full-time students* is an insidious reversion to specialization. It has been periodically necessary to remind ourselves of the overall goals of the College and stamp out such creeping departmentalism. Rather than courses, three primary approaches are used:

First: Workshops are conducted by Computer Services staff, faculty and advanced students on an informal basis for those in any academic program who are individually interested in computers.

Second: Many Coordinated Studies programs include a specific computer component. For example, FONS devotes about the first two weeks* to developing familiarity with the College's timesharing system, program libraries, and to learning the BASIC language. This skill is then exercised throughout the year in solving problems.

For the 1979-80 academic year a Coordinated Studies program has been planned which will utilize the computer as the unifying theme. Five faculty from physics/chemistry, mathematics, music, computer science, and history/economics will join forces to explore the range of applications of computers, teach the technical skills required to understand and use computers effectively, and examine the social impact of computers and the economics of the computer industry. This full-time, year-long program is expected to involve 100 students.

Third: Perhaps the largest number of students actually teach themselves, however. This requires a bit of explanation: With a free access policy, any student can get at the computer simply by picking up a free access code and signing on at a terminal. A number of attractive and attracting computer games (almost all written by students) are deliberately maintained on the system. Many students first use the computer because they have heard that it can play games with them. Through a not-so-subtle process, these students are drawn into interactions with the other students who inevitably collect in college computer centers and led to question <u>how</u> the computer can play games. This in turn often leads game players into programming either on their own or under the direction of a CAI tutorial which teaches how to program the computer for more than just games. This sort of approach is not without side effects: from time to time hordes of high school students descend and must be reminded that there are limits to community service.

<u>Beyond Literacy</u>

So much for the promotion of computer literacy. The availability of the computer and the combination of incorporating computer programming into academic programs and informal instruction

* Meeting the needs of part-time students within Evergreen's format poses special problems which cannot be adequately addressed here. Suffice it to say that the College is struggling to respond to the continuing education requirements of the large data processing community associated with the state capitol where Evergreen is located.

* It should be remembered that two or three weeks of full-time study in a Coordinated Studies program is roughly the equivalent of a traditional 4 quarter hour course.

results in about 40% of all students using the computer in any given academic year. But what of the student who becomes more deeply interested in computers? For the student who continues to see the computer as a tool--for instance the student doing research in an environmental issue such as heavy metal pollution in Tacoma--Individual Contracts are available with faculty and Computer Services staff to develop competency in languages other than BASIC, improve programming techniques, gain knowledge of statistical packages such as SPSS, or study other computer related topics. From time to time when there are a sufficient number of interested students, a module may be organized in one of these areas; for example, this year a module was offered on APL. Students from a wide variety of Individual Contracts and Coordinated Studies programs included participation in the module as a part of that quarter's academic work.

Another group of students is more difficult to serve. These are the ones who become primarily interested in the computer as an object of study; in what we would call Computer Science. Evergreen is a small school--current enrollment is about 2,500. As has been indicated, there are no majors and the emphasis is on interdisciplinary studies. How then does one accommodate the needs of the few students who are developing a professional or academic interest in computers? From time to time we have fallen back into the trap of trying to offer specialized programs of advanced modules, group contracts, and other euphemisms for courses in order to "prepare students for graduate school." It has always proven to be a mistake because such a path leads back to just those educational failings we sought to escape. The real answer hinges on the view which one takes of requiring an undergraduate to have specialized knowledge of a discipline in which s/he intends to do postgraduate work. We believe that most undergraduates are better prepared for work/graduate school/life if they concentrate their undergraduate years on developing the ability for continuing individual scholarship rather than an unnecessarily detailed study of the field which they will later study in detail.

Thus, we encourage the student whose interest in computers extends beyond toolsmanship to an advanced degree to seek out the College's strongest faculty and programs in any related area. The objectives are to develop abilities to learn independently and cooperatively, to develop critical analytic and quantitative skills, and to develop the expressive skills of articulate writing. Almost incidentally, we also encourage such students to deepen their knowledge of computers by applying the computer to other disciplines and by working with those faculty who can nurture their interest in Computer Science. Thus from time to time students have written Individual Contracts to study artificial intelligence, computability, operating systems design, computer graphics, and other advanced topics, but this is not seen as a necessary prerequisite to graduate studies.

A case history may best serve to illustrate the ideal to which we aspire. X transferred to Evergreen in 1971, the College's second year. He spent his first two quarters here in a Coordinated Studies program called "Individual in America," which drew together the social sciences, humanities, and outdoor education in an examination of the identity crisis of post-adolescent American youth. In the spring quarter he enrolled in a Group Contract called "Games, Puzzles and Problem Solving," in which he learned about computers and applied the College's computer to an enormous number of problems and games. He spent the summer studying basic design and behavior principles of systems (thermodynamic, information, cybernetic, etc.) under an Individual Contract which also involved the use of the computer to compose music. The entire next academic year was spent in a Coordinated Studies program titled "Natural and Social Science" in which he studied the interrelationships of science and culture, creativity, the search for truth, futures and utopias; took modules on gravity, energy, genetics, waves and particles; and conducted an individual project in artificial intelligence. In his third year he worked with other advanced students in a Group Contract in physics--"Architecture of Matter." Along with immersion in thermodynamics, quantum mechanics, and electromagnetic theory, this work involved extensive use of the computer in projects such as an FFT spectrophotometer and a LISP theorem prover. X spent his last summer studying abstract algebra under an Individual Contract, then went to work for a custom computer system house. Subsequently he entered graduate school in Computer Science at Stanford University. His academic path may be considered prototypical for the Evergreen student headed for graduate school.

For the student whose interest in Computer Science derives from an intention to pursue a career in programming or a related area after graduation, Evergreen's philosophy of hands on experience extends to the design of the College's academic computing system itself. Thus the College's timesharing system now uses an operating system conceived and developed by students under academic contract as a design project. The implementation of BASIC presently provided on this system contains major enhancements including structured constructs such as IF THEN ELSE, WHILE, UNTIL, DO blocks, etc. These not only encourage other students to develop good programming practices, but also offered a significant learning opportunity to the students who implemented them. Currently a group of ten advanced students is engaged in a year-long academic program to design another new operating system which will expand the range of languages and capabilities available. We anticipate repeating this development cycle again and again not because it will improve the quality of academic computing (though it does), but rather as a learning experience for the developers. Other students with career interests in programming make use of extensive

microprocessor laboratory facilities including hardware interfacing resources and systems such as IMSAI, a SOL-20, and an Intecolor. Real-time laboratory data collection minicomputer systems, computer graphics facilities, access to large scale off-campus systems, and a hybrid analog/digital system provide further opportunities for advanced students. Through cooperative arrangements with businesses and others in the Puget Sound area, students may take internships which offer an opportunity to develop applied knowledge and to interrelate theory and practice.

At the risk of seeming to focus on successes, a second case history exemplifies preparation for a career in computing which does not contemplate graduate school. Y entered Evergreen directly from high school in 1972. She first enrolled in the year-long program "Natural and Social Science," previously described. Unlike X, however, she concentrated on biological topics such as photosynthesis and botany rather than physics. Both X and Y, of course, were involved in the interdisciplinary part of the program centered around the relationship of science and culture. In Y's second year she took a group research contract in ecology and natural history. It was here that, in addition to chemistry and physics, she discovered the computer. She learned BASIC and began to use the machine to model ecosystems and energy flows. In the fall quarter of her third year, she was a participant in a group research project which emphasized field work at a local ecological reserve. During the remainder of her third year, she concentrated on computing, working at various times to master assembly languages, LISP, APL, system architectures and hardware, minicomputer systems and systems design methods, research on the College's academic timesharing system, and programming style. These activities were carried out under Individual Contracts, many with computer center staff. In her last year she carried Individual Contracts to study linear algebra, integral and differential calculus, formal language theory, system intercommunications, and large scale virtual operating systems. During these contracts she did extensive programming on a variety of systems and in several languages. On graduation she went to work for a large systems company in Los Angeles.

Does it Work?

The ultimate test of any educational approach is whether it produces a satisfactory graduate. There is a rarely discussed problem in evaluation which revolves around what one means by "satisfactory." Should one focus on vocational measures such as student placements in graduate schools and jobs, earning power five years after graduation, etc.? Or should one seek to determine the graduate's "happiness" some time after s/he has graduated? These are not easy questions.

To our knowledge no student who could in any sense be said to have concentrated in computing at Evergreen has failed to find a related job on seeking one after graduation, but it seems to us that this kind of narrow vocational approach by itself is sterile and even questionable given the unpredictability of long term careers in a constantly changing world. Rather, we would hope that when Evergreen's graduates have been out of college for five, ten, or even twenty years they will report back to us that their exposure to the computer broadened the range of tools they have available to deal with a complex and changing environment. This is a question which much be left to the future.

In the meantime, however, what has happened to the several hundred graduates of the College? Well, of course the vast majority did not go on to careers revolving around Computer Science. A sizeable minority has gone into programming or other computer related positions in businesses, industries, government and education up and down the West Coast. Several have distinguished themselves already by their application of computers in the arts, particularly in computer animation. A smaller number of students have gone to graduate schools in Computer Science. A few have even made it to such prestigious places as Stanford University and The University of Edinburgh, Scotland.

It is, of course, too early to judge the long term results of Evergreen's interdisciplinary approach in any area of scholarship including Computer Science. Too few graduates have been gone for too few years. In 1977, however, Evergreen was selected by the NSF-sponsored HumRRO study of instructional computing as one of the 10 exemplary four-year institutions in the nation. We think that selection is in part a result of the College's approach to computer science education and computer literacy. That approach has grown out of a radically different view of education thanks to the contributions of many people: students, faculty, and staff. Much of what we do today was not anticipated when the College was formed in the minds of the planning faculty. The interdisciplinary approach requires constant nurturing, for it grows in a more hostile climate in 1978 than in 1968. Yet it has withstood that climate well and we feel there are already some lessons here for other liberal arts schools and that some of our approaches will prove useful to others who question the narrow specialization typical of most undergraduate curricula.