



# EDUCATING THE WORKING COMPUTER SCIENTIST

## A Survey and Analysis

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### ABSTRACT

Due to the strong job market for recipients of Bachelor of Computer Science degrees, fewer graduates are immediately continuing with post-graduate education. These individuals will experience a need for graduate education later, at a time when they are less able to attend school on a full-time basis. This will lead to an increasing demand for part-time graduate programs, especially near centers of computer technology. This paper reports the results of an informal survey of existing part-time degree-granting graduate programs in computer science. Topics discussed include program format, student enrollment, source of faculty, and characteristics of students.

**KEYWORDS:** computer science education, part-time education, graduate programs, continuing education.

### 1. INTRODUCTION

There has been concern recently about an impending crisis in computer science education [1,2] brought about by a decrease in the number of computer science Ph.D.'s produced [3]. Fewer and fewer Ph.D.'s go into teaching, and an exodus of current faculty to industry in favor of better experimental equipment and higher salaries is occurring. There is a similar trend among recipients of undergraduate computer science (and related technical) degrees toward immediate acceptance of industrial positions, instead of going on to graduate school [4].

As industrial applications become increasingly complex, and require broader and/or deeper knowledge of computer science, these students will find their undergraduate education increasingly inadequate. They will see a need for further education in the discipline. The same need will be experienced by individuals with skills in related areas (e.g., engineering and mathematics) who have been employed

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in computer scientist positions due to the shortage of more qualified people. How is this demand for education to be satisfied?

Corporate internal training programs, and most continuing education courses, tend to cover isolated topics. These working computer scientists will need a more balanced, integrated coverage of the field. The subject content of traditional Master degree programs would better meet their needs, and the degree would enhance career development. Unfortunately, many of the prospective students will have acquired significant family responsibilities, which will prevent them from full-time study unless they are lucky enough to be granted full salary and educational support by their companies.

A likely result is that there will be increasing demand for part-time, degree-granting graduate programs, particularly at schools located near centers of computer technology. Note that this educational format would permit tapping the pool of Ph.D.-level talent in industry to provide a substantial portion of the teaching effort.

The remainder of this paper briefly describes such a program conducted at the author's institution, and then summarizes the results of an informal survey of graduate degree-granting programs for working computer scientists conducted during the summer of 1980.

### 2. THE SANTA CLARA EARLY-BIRD PROGRAM

The University of Santa Clara is a small, private university located about 45 miles south of San Francisco in the Santa Clara ("Silicon") Valley. There is an undergraduate student body of about 3500, and a similar sized graduate population divided primarily among a (substantially full-time) law program, and (mostly part-time) programs in business and engineering.

The engineering program (known as the "Early-Bird" program) has offered Master degree level education, directed primarily at people working in the surrounding high technology industry, since 1959. Classes are taught from 7:00 to 9:00 a.m., a format which allows students to attend classes while rested, yet minimizes time lost from work. Current enrollment in the program is about 850 students, of whom 95% are part-time. The typical student course load is four units per quarter, and students complete a

degree (45 units) in four to five years. Courses are taught primarily by adjunct professors from industry, of whom roughly 75% have the Ph.D.

A Master degree in computer science was first offered in 1971, with an initial population of 85 students. There are currently about 320 students in the computer science program, and some 45 degrees are awarded annually.

### 3. SURVEY

A survey was conducted via questionnaire distributed to various computer science departments located in the United States. The departments to be queried were selected on the basis of geographic location and degree offerings. The author conjectured that departments located near current high technology centers, or in areas experiencing rapid growth of computer-related industry, would be those most likely to have graduate programs for working computer scientists, or to be planning such programs.

Growing centers of technology were identified from a forecast of technology growth prepared by Chase Econometrics [5]. Departments located in those geographic areas, and offering M.S. or Ph.D. degrees in computer science, were chosen from the ACM Directory [6]. To this list were added five additional schools which the author knew were conducting programs of the type under consideration.

A total of 74 departments were thus selected and sent copies of a questionnaire (Appendix). The questions were all relatively open-ended in an attempt to elicit as broad a response as possible. Thus, the ensuing discussion of results will be more qualitative than quantitative.

Finally, it must be emphasized that no claim can be made for the completeness of the survey, nor for any conclusions drawn from it. The answers, however, do present an interesting cross-section of approaches and viewpoints.

### 4. THE RESULTS

A total of 23 out of the 74 questionnaires were returned (31%). Of those returned, four were from schools whose programs made no accommodation for working students, nor were such students a significant part of their current graduate program. However, one of the four responses indicated a feeling there would be a local demand for a program for working students, that a program was in the planning stage (although no detailed plans had been established), and that it would hopefully be initiated in the Fall of 1981.

Three more departments indicated that they admitted working students to their full-time program, but made no efforts (such as convenient class scheduling) to attract such students. Those admitted either took relatively light loads (one class per term) or were granted significant amounts of release time by their companies. One of these departments stated that working students, under these conditions, comprised about 50% of the department's graduate student body.

Two other departments indicated they had programs specifically designed for students who were working, centered primarily around television or videotape classes which students took at their company sites. Students taking such classes accounted for 20 and 50% of the total graduate student enrollment, respectively.

The final group, consisting of 14 departments, indicated they had a program which in some way had been arranged for the convenience of students who were working full-time. The discussion in the next two sections is based on the 16 responses from the latter two groups.

#### 4.1 The Programs

##### 4.1.1 Formats and Degrees

Fourteen of the responses (all except those based primarily on television) said that they offered graduate courses in the evening hours as a convenience to working students. Two of the fourteen also scheduled some classes during early morning, or noon hours, as well. For these fourteen, most graduate courses were offered at times working students could attend, and full-time students who were in the program also took all their classes at those times. The exceptions were separate sections of certain required courses which were offered during the day for full-time students, and during the evening for part-time students.

Six departments offered traditional classes (with the professor physically present) at off-campus sites. Three said they made some use of closed-circuit television, and two more made use of videotapes for students at sites some distance from campus.

Three programs allowed working students to earn Bachelor, Master and Ph.D. degrees through the special program. Six offered only the Master degree, and the remainder (seven) offered both the Master and Ph.D. degrees.

##### 4.1.2 Impact of Part-time Students and Faculty

Student enrollments in the programs varied widely. Table I summarizes the number of part-time students enrolled in the various programs. The size varied from 18 to slightly more than 400 students. Table II presents the distribution of part-time students as a percentage of the total graduate enrollment, based on number of students.

TABLE I

Enrollment Distribution  
Number of Part-time Students

NUMBER OF STUDENTS	PROGRAMS
0 - 25	3
26 - 50	1
51 - 75	2
76 - 100	2
101 - 150	4
151 - 200	0
201 - 250	1
251 - 300	0
301 - 350	2
351 - 400	1

TABLE II  
Part-time Students as  
Percent of Total Enrollment

PERCENT PART-TIME STUDENTS	PROGRAMS
< 10	1
11 - 20	1
21 - 30	0
31 - 40	0
41 - 50	2
51 - 60	0
61 - 70	3
71 - 80	5
81 - 90	2
91 - 100	2

As Table II indicates, working students represent a significant proportion of the graduate program in most of the responding departments. This impact decreases, but does not disappear, if the figures are based on full-time equivalents (FTE's).

Consider, for example, a program with 75% part-time students. Average working student course loads were reported as three to six hours. Using 4.5 hours as a typical part-time student load, and 15 hours as an FTE, working students still represent 47% of the total program.

All responses indicated that enrollments in the graduate program were increasing at rates between 25% and 50% per year.

Table III lists the percent of the faculty in the respective graduate programs which are full-time teachers. The remainder of the staff are adjunct faculty selected from industry. Again, there is no uniformity among the programs.

TABLE III  
Distribution of Faculty

PERCENT FULL-TIME FACULTY	PROGRAMS
100	5
75	2
67	2
50	4
33	0
25	2
0	1

Several of the departments offering courses at remote sites indicated the proportion of courses taught by full-time faculty was higher for on-campus classes. They were placed in Table III at the ratio appropriate for the part of their program with greatest enrollment.

Those schools with television or videotape-based programs indicated that all their courses were taught by full-time faculty. This makes sense, since teaching a television class simultaneously with a live class doesn't add much to faculty workload. There would, of course, be a greater burden for TA's and graders.

Typical teaching loads reported were two or three

courses per term for full-time faculty, and one or two courses per term for adjunct faculty.

Tables II and III indicate that while part-time students constitute the majority of the program for most schools, full-time faculty handle most of the teaching load. Several respondents commented on the fact that increasing enrollments would dictate an increase in the percentage of part-time faculty in the program, a tacit admission of the difficulty of hiring full-time computer science faculty even when student enrollments justify it.

One school mentioned that the "core" courses were taught by full-time faculty only, and the remaining courses were divided evenly between full- and part-time faculty. This might be taken as an implication that the important courses were taught by full-time faculty to be sure they were done right.

In Santa Clara's experience, this concern over the quality of part-time faculty is not justified. There are, of course, occasionally questionable adjunct professors, but these are relatively quickly weeded out. For the most part, their teaching performance is at least average, and many exceed that level, based on student evaluations.

It seems that most part-time faculty are not teaching to earn extra income, but because they enjoy both the subject matter and the act of teaching. This holds true especially when they only teach one or two courses a year, and those courses are rotated often enough to keep teaching a new and exciting experience.

#### 4.1.3 Equipment and Administrative Support

A final area on which input was solicited was part-time students' access to facilities (e.g., computer time, labs) and advising. Computer facilities were provided in a number of different ways: students used their companies' computers, RJE facilities were provided (particularly for classes offered at remote sites), dial-up terminal access to the school's computer facilities was available, or computer centers were open long hours (16-24 hours, in most cases). The logistics involved in this support can be staggering. Consider the problems of providing enough dial-up ports to allow 400 part-time students relatively convenient access to computer time.

Several responses indicated that part-time students did not participate in laboratories. Presumably, this refers to courses such as microprocessor or digital logic labs, since the same schools indicated a means for student access to computer time.

The question of advising students is of considerable interest to the author, since he spends from four to 10 hours per week advising part-time students and otherwise administering just the software course offerings in the Early-Bird program.

Most responses indicated that advising was performed on campus during normal business hours only. Students either arranged to get to campus, or called and were advised over the phone. Some respondents said full-time faculty arranged periodic office hours after evening classes just for such purposes.

One department indicated that a thesis was a requirement for the Master degree, and that many of the part-time students had difficulty satisfying the requirement. No particular reasons for the difficulty were given. Possible factors might be the inaccessibility of thesis advisors and, of course, the effect of a full-time job. One wonders if there is a similar difference between the performance of full-time and part-time Ph.D. students on their theses.

#### 4.2 The Students

In response to a question about differences in characteristics between working and full-time students, all schools indicated (not surprisingly) that part-time students tended to be older and were more likely to be US citizens. Only one response (from the School of Advanced Technology, SUNY/Binghamton) provided detailed statistics on the characteristics of part-time and full-time students. These are reported in Table IV.

TABLE IV  
Student Characteristics  
SUNY/Binghamton

PERCENT OF STUDENTS	
	PART-TIME
Age	25 - 40
Sex	50% Female
Nationality	95% U.S.
Undergrad Major	80% Technical
	FULL-TIME
Age	21 - 35
Sex	30% Female
Nationality	60% U.S.
Undergrad Major	30% Technical

Of interest are the larger percentage of female students among the part-time ranks and the large difference in students with a Bachelor degree in a technical field.

Only the one response indicated a difference in female enrollment between full- and part-time students. It is not known whether these women were already working in industry, or were seeking education to prepare them to find a first position.

The large number of students with non-technical degrees indicates the expected movement of students into the computer science field in response to good job opportunities. Whether to educate students with severely deficient backgrounds at the graduate level, with remedial work, or at the undergraduate level, is open to question. Two schools reported significant numbers of students returning for second Bachelor degrees in computer science.

Santa Clara has experienced a marked increase in the last two years of students in the Early-Bird program with undergraduate computer science degrees. Previously, most of the students in the program had

been trained as EE's, but had been working in a computer science area. This, of course, places a demand on the program to provide more advanced courses and course sequences, which did not previously exist.

Santa Clara has received a relatively high percentage of applications (20%) from students with non-technical backgrounds, but have been unable to accept them due to already heavy enrollments.

With respect to quality differences between working and full-time students, there was general agreement that the full-time students performed a little better in the classroom. It was felt that this was primarily due to the conflict between working full-time and going to school part-time, rather than an actual quality difference.

There were, however, differences of opinion. Several respondents reported that the working students were more practical, and two schools (both with significant proportions of students with non-technical undergraduate degrees) reported that working in computer-related jobs provided a distinct classroom advantage for the part-time students.

A somewhat alarming comment was that "part-time students are more interested in the degree, whereas full-time students want a more thorough learning experience." The author has observed similar feelings ("I'll take anything, just give me the degree.") in some, but not most, of the part-time students in the Early-Bird program. Part-time students do tend to be more concerned about the practical applications of topics. Perhaps the most realistic comments on quality were that members of both groups (full-time and working students) ran the spectrum from good to bad.

#### 4.3 Continuing Education

The departments which responded to the questionnaire were evenly split over whether they were involved with continuing education (non-degree-granting). Of those that said yes, two indicated that continuing education involved non-degree students attending classes in the degree-granting program, but that all students were "strongly encouraged" to pursue a degree. Most respondents said that the continuing education programs were run by a separate organization of the university, and that the individual departments cooperated when asked.

Two respondents, however, indicated that the departments were involved in continuing education in a significant way. These efforts included on-campus seminars and intensive short courses, involving relatively large numbers of students (250 and 1000) per year.

#### 5. UNANSWERED QUESTIONS

While the survey has given some insight into the current status of degree-granting education for working students, the responses have also raised some questions.

Given that the demand from working Bachelor degree

holders for further education exists, one question is what motivates a department to attempt to satisfy that demand? The author proposes three possibilities:

- 1) Departments which had large full-time graduate programs, and developed correspondingly large faculties to support them, can use part-time students to bolster lagging full-time enrollments and justify their present faculty size.
- 2) Part-time enrollments can be used to justify the existence of a graduate program in a small department, and provide the critical mass necessary to offer a reasonably broad selection of courses. This would help attract new faculty and allow a small full-time enrollment for use as TA's in the undergraduate program.
- 3) Simply to provide a service in response to demand from the community. This same service would also help promote closer ties to industry.

A second question is what is the effect on industry of a program educating working computer scientists? The probable benefits of more knowledgeable employees can be estimated, but there are other less obvious effects.

For example, the author has noticed that students sometimes change companies shortly after receiving their Master degree, despite the fact that the degree was paid for by their old employer through an educational assistance program. The reason seems to be that graduation is a major event for the student, and the student feels it should be rewarded with a raise or promotion. This doesn't happen, however, since the company has been gradually gaining the benefits of the advanced education (and rewarding the student for it) over the time the degree was earned. The extent of this phenomenon, and the existence of similar problems, should be investigated.

The possible existence of part-time computer science programs, in geographic areas without concentrations of high technology computer industry, should be determined, along with differences in emphasis with the programs described here (data processing vs. computer science?).

Finally, a similar survey and analysis of existing part-time programs aimed primarily at offering computer science Bachelor degrees, and the need for such programs, should be made.

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## Appendix

Answer the following questions if your school has a special degree-granting program for working students.

Describe the program and any special arrangements made to accommodate working students (night or morning classes, closed circuit TV, coop program, classes at off-campus sites, etc.).

How does the program relate to your programs for full-time students? Do students from both programs take the same classes from the same professors?

Who teaches classes for working students: full-time faculty, adjunct faculty, combination (what proportion)? What is the course load of a typical professor in the program?

Are there different admission standards for working students? Different degree requirements?

What degrees are available in the program? How long does it take a typical student to complete the requirements for each degree?

How many students are enrolled in the program? What is the average course load per term?

What percentage of your total graduate student enrollment is working students (in terms of number of students and full-time equivalents)?

How do working students gain access to computer time, other labs, advising, etc.?

Have there been any noticeable trends in enrollment in the last five years?

Are there significant differences in characteristics between full-time and part-time graduate students (age, sex, nationality, etc.)?

Do you feel there is a difference in "quality" between full-time and part-time students (e.g., part-time are much better, better, the same, worse, much worse students)?