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Guzo, Andrew Joseph, Ed.D.

Columbia University Teachers College, 1989

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AN INVESTIGATION OF TEACHER CHARACTERISTICS THAT CONTRIBUTE TO STUDENT PERFORMANCE ON THE ADVANCED PLACEMENT COMPUTER SCIENCE EXAMINATION

by

Andrew Joseph Guzo

Dissertation Committee:
Professor Bruce R. Vogeli, Sponsor
Professor J. Phillip Smith

Approved by the committee on the Degree of Doctor of Education

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1989

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ABSTRACT

AN INVESTIGATION OF TEACHER CHARACTERISTICS THAT CONTRIBUTE TO STUDENT SUCCESS ON THE ADVANCED PLACEMENT COMPUTER SCIENCE EXAMINATION

Andrew Joseph Guzo

The purpose of the study is to identify those teacher components which correlate with student performance on the Advanced Placement Computer Science Examination. These components include teacher experience, student textbooks, teacher participation at summer workshops for Advanced Placement Computer Science and teacher perception of his/her ability in computing.

A questionnaire of 29 items was constructed, then sent to 203 schools administering the Advanced Placement Computer Science Examination in 1986. Questionnaires were returned by 149 schools, and 120 were usable for the study.

Several factors proved to be related to student performance on the Advanced Placement Computer Science Examination. These factors include the type of computer system used by the students, amount of computer-access time for students, prior programming experience of the students, the number of students per computer, adherence to the Advanced Placement Computer Science syllabus, teacher's level of education, the degree of comfort the teacher feels teaching the course, the number of computer languages

understood by the teacher, the teacher's proficiency in Pascal, the teacher's self-rating of 14 topics from the Advanced Placement Computer Science syllabus and the teacher's judgment of how difficult students would find questions from the Advanced Placement Computer Science Examination.

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Chapter I

INTRODUCTION

Need for the study

In the fall of 1983, the College Entrance Examination Board sponsored an advanced placement program in computer science. By May, 1984, the first advanced placement computer science course was offered by 915 schools; 4262 students participated in the program. In the 1984-85 school year those numbers increased to 1200 participating schools and an expected 6000 students will take the examination. With most schools needing only one advanced placement instructor, an approximate 1200 teachers are involved in the program.

To date no research has focused upon the correlation between teacher background and student success on the examination. A survey conducted by the College Entrance Examination Board found that most high school teachers taught BASIC and had little experience in a structured language such as Pascal. They were unfamiliar also with algorithms and data structures, essential elements in a computer science program.

The professionals who seem most qualified to teach this course would be recent graduates of computer science programs. Very few, however, enter secondary education. To implement the advanced placement computer science curriculum successfully, teachers must be trained to teach the course.

During the summer of 1983, 41 universities and colleges hosted intensive summer workshops to train high school teachers to handle the advanced placement computer science program (33 taught courses covering the full advanced placement computer science curriculum; 8 offered an introduction to Pascal). During the 1984 summer, 41 schools offered workshops (36 in the advanced placement computer science curriculum; 5 in Pascal). The number for 1985 was 25 (20 in the advanced placement computer science curriculum; 5 in Pascal). While these workshops were reported to be "successful," the colleges have received little feedback concerning the effects of their programs.

Both the colleges and the College Entrance Examination Board would benefit from information concerning the effectiveness of teacher training programs in the advanced placement computer science curriculum. Research is needed to identify those resources which teachers possess, beyond the information in the computer science curriculum, that contribute to student success on the Advanced Placement Computer Science Examination. Is exposing a secondary teacher to six credits of Pascal, data structures and algorithms adequate for mastering the content? Do workshops offer the instructor an expertise so that he/she can teach the material effectively? Is an extensive training program, rather than an intensive one, more effective? How much time during a training program should be devoted to Pascal, data structures and computing algorithms? If significant factors can be identified, the level of secondary instruction can be improved, and teacher training programs can be planned more effectively.

Purpose

The purpose of this study is to identify those teacher components and characteristics that have a high positive correlation with student success on the Advanced Placement Computer Science Examination.

The questions to be considered are

1) what is the relationship between the number of years experience a) teaching, b) teaching mathematics and c) teaching programming or computer science and student success on the Advanced Placement Computer Science Examination?
2) what is the relationship between teachers who do and teachers who do not attend Advanced Placement Computer Science workshops and student success on the Advanced Placement Computer Science Examination?
3) what is the relationship between the textbooks used in the course and student success on the Advanced Placement Computer Science Examination?
4) what is the relationship between teacher training in a) Pascal syntax, b) data structures and c)

algorithms and student success on the Advanced Placement Computer Science Examination?

5) what is the relationship between a teacher's perception of his/her proficiency in syntax, data structures and algorithms and his/her actual training?

Procedures of the study

The study was carried out by designing a questionnaire and administering it to a small sample of high school Advanced Placement Computer Science teachers for pre-testing. The final revised questionniere was sent to a sample of those who taught the Advanced Placement Computer Science course in 1985-86. The scores of the students taking the Advanced Placement Examination in 1986 were obtained with the cooperation of the College Board. These scores were used as the measure of student success on the Advanced Placement Examination.

Teacher proficiency was measured by asking the teachers to rate six multiple choice questions from the 1984 Advanced Placement Computer Science Examination for level of difficulty. All of the variables were statistically analyzed to determine relationships between factors. These included correlations and analysis of variance between student success and a) years teaching, b) years teaching mathematics, c) years teaching computing, d) textbooks used, e) teacher training in Pascal syntax, f) teacher training in data structures and g) teacher training in algorithms. A factor analysis was also performed to find contributors to the variance in student success on the Advanced Placement Examination.

Plan of this report

This report describes the background of the Advanced Placement Computer Science Examination and reviews the revelant literature. The rationale for the limitations of the study, the sampling procedure and the construction of the sampling instrument are described. The results of the study are then discussed giving appropriate statistical evaluation. Based on the analysis of the data several conclusions and recommendations for future study are discussed.

Chapter II

BACKGROUND AND RELATED MATERIAL

The first Advanced Placement examinations were administered in May, 1954 and were one of the first attempts to bridge the educational gap between high school and college for high aptitude students (Chamberlain, et al., 1978). Currently, 24 Advanced Placement examinations are offered by the College Board for advanced placement in college.

The College Board was organized in 1900 by several college presidents and secondary school headmasters. The purposes in forming the College Board were to establish a single college entrance examination, to adopt a more uniform and demanding academic curriculum for secondary schools and to create lines of communication between secondary schools and colleges. The College Board introduced the Scholastic Aptitude Test (SAT) in 1926 and objective achievement tests in 1936. In 1947 the College Board along with the American Council on Education and the Carnegie Foundation for the Adancement of Teaching founded the Educational Testing Service (ETS).

The popularity of these examinations is reflected in the surge of participants. In 1961 the number of schools giving Advanced Placement examinations in all subjects was

1126, an average of 16 examinations per school. By 1976 the number of schools had risen to 3939, approximately 25 students per school. Ten years later in 1986, 7201 schools participated, 44 students per school. This represents a 540% increase in the number of schools giving Advanced Placement examinations, and a 1660% increase in the number of students taking them (Watt, 1983).

Like the other examinations, the number of participants in the Advanced Placement Computer Science Examination, first administered in May, 1984, has risen. In an article in Popular Computing (Watt, 1983), Haag, then director of Advanced Placment programs for the Educational Testing Service, estimated that between one and two thousand students would take the Advanced Placement Computer Science Examination in 1984. Miller of Carnegie-Mellon, on the other hand, estimated the number would reach ten to twenty thousand. Miller further thought the number of students taking the Advanced Placement Computer Science Examination would eventually rival the 52,706 participants who took the English Advanced Placement examination in 1986.

Participation in the Advanced Placement Computer Science Examination has exceeded the estimate of Haag, but has fallen short of Miller's. In the three years since its introduction the number of students taking the examination has almost doubled: 4262 in 1984 to 8207 in 1986, a 93% increase.

In 1986 the computer science examination was already the ninth most popular Advanced Placement examination. More computer science examinations were given than both art and music, all language examinations except Spanish, and all science except biology and chemistry.

Despite the widespread popularity of the Advanced Placement Computer Science Examination, the introduction of the computer science course was not without its problems. Teachers were not prepared in the traditional sense. Few had taken graduate or undergraduate computer science courses. Fewer still held a degree in computer science. Most had majored in mathematics.

The Computer Science Advisory Task Force, established by the College Board, suggested that summer institutes, modeled after National Science Foundation institutes, be established to train prospective Advanced Placement teachers (Braswell, 1984). For teachers without computer science backgrounds these institutes would provide minimum course preparation. Countrywide, universities and colleges like Teachers College, Columbia University, Carnegie-Mellon and others took leadership roles in designing summer workshops. The Task Force believed this recommendation essential to the proposed Computer Science course's being well received by colleges and secondary schools.

The Computer Science Development Committee (Braswell, 1984) addressed student backgrounds. It noted that students be familiar with the symbolism taught in a second year algebra course and have a firm foundation in mathematical reasoning. Although the research on the Advanced Placement Computer Science programs and examinations is virtually nonexistent, studies by Petersen and Howe (1979) and Konvalina, Stephens and Wileman (1983) support the fact that success in high school mathematics is an important factor in influencing success in college computer science courses. No recommendations suggesting prior programming experience were made by the committee. The Advanced Placement course, reasoned the committee, was viewed as a first year college course, designed to serve students majoring in all disciplines including computer science.

Critical questions are posed as a result of the rapid increase in the number of schools giving the Advanced Placement Computer Science Examination and in the number of students taking the examination: Do schools have adequately trained teachers to staff the rapidly increasing number of sections in computer science? Do teachers possess a level of expertise that would insure proficient teaching and subsequent successful student performance on the examination? Precisely what impact, if any, do summer institutes have?

Relevant literature

The body of literature dealing with the Advanced Placement Computer Science course is limited. The College Board has published two works dealing with the Advanced Placement Computer Science Course and Examination. One, Advanced Placement Course Description Computer Science, is a booklet distributed to all teachers of

Advanced Placement Computer Science. It contains the course outline, sample questions for both the multiple choice and free response parts of the examination, a commentary on the course description and a list of references. The references include lists of introductory texts, texts on Pascal and general reference works. The other, The Entire 1984 AP Computer Science Examination and Key, is a reprint of the 1984 examination and a summary of the results.

Only two other articles deal with the Advanced Placement Computer Science Examination. One (Watt, 1983) deals briefly with the development of the Advanced Placement Computer Science Examination and some of the shortcomings of the test. One problem centers on the ability of the test to measure whether a student can write a coherent program in response to a problem. The other deals with a potential conflict between what the developers intend and what the teachers and students do. The intent of the course is to develop broad programming and problem solving skills. The author wonders whether the students will only concentrate on developing solutions to the short programming problems included in the test booklet. The author also feels that the subject of computer science might be too young for the kind of standardization that this course will probably lead to. He fears being locked into a set of rigid standards in a field that is rapidly expanding.

The other work (Braswell, 1984) gives a history of the development of the Advanced Placement Computer Science Examination. This includes the establishment of a task force to examine the feasibility of an examination in computer science and its recommendations about the examination. He also discusses the goals of the program and the selection of the programming language and includes a course outline. He briefly treats teacher preparation but only to say that teachers should take a course in Pascal that stresses top-down design and modular construction and a course on data structures. Braswell does say that he feels most teachers will find that pointers, linked data structures and tree structures will require more time to master than can be afforded in a summer workshop.

Chamberlain, Pugh and Schellhammer (1978) show that students who took advanced placement courses in high school performed better than students who did not take advanced placement courses. The measures used were hours completed per semester, the proportion of junior and above level course hours, and grade point average. Jones (1975) discusses the reluctance some colleges have in accepting advanced placement scores. He also enumerates ten advantages of the Advanced Placement Program and seven problems in starting an Advancced Placement Program in a school.

In another article Jones and Valentine (1984) gives a history of the College Board and the Advanced Placement Mathematics Examination. He indicates that the program has had a stimulating effect on the teaching of mathematics and has facilitated communication between secondary school and college teachers. He hopes that the same effects will occur for the Advanced Placement Computer Science Program.

Research has been conducted about the relationship between teacher characteristics or teacher experience and student performance. Fagan and Ponder (1981) found that in low achieving schools teacher qualifications are related to student performance. There is no relationship, however, in high achieving schools. Brophy (1986) concludes that teachers make a difference in student performance. Enhanced performance comes about through classroom management, articulation of achievement expectations and the selection and design of academic tasks. The background of the teacher is not a factor.

In two reviews of the relevant literature Ornstein (1983, 1984) discusses the hereditarian's thesis that teachers and schools contribute little to student outcomes and cites several experiments designed to support this idea. He also looks at the viewpoint that teachers do make a difference in student outcomes and cites several correlational studies to support this view. He concludes that the research is unclear about the teacher's role in studnt performance. The role of teacher background is also unclear. Variables and interactions make it virtually possible to isolate factors. Rosenbloom (1966) reported on two studies conducted in Minnesota mathematics classes. He found that mathematics teaching experience and mathematics courses and course grades do not differentiate between the most and least effective mathematics teachers. He also found the length of time teachers consciously spend preparing lessons does not differentiate between the most and least effective teachers.

Chapter III

SURVEYING SCHOOLS OFFERING ADVANCED PLACEMENT COMPUTING

In 1986 almost 1,600 schools administered the Advanced Placement Computer Science Examination. Of these, 203 schools were chosen as the sample population for this study. Three limitations were placed on the sample:

(1) that schools be located in the United States,

(2) that schools have four or more students taking the 1986 examination, and

(3) that one instructor teach the Advanced Placement section(s) within the school.

Rationale for limitations

Choosing schools in the United States was merely a practical consideration, one which focused on expediency in contacting the schools by mail or phone. Of the 1575 schools administering the examination, only 34 were located outside the United States.

Schools having three or fewer students taking the examination were eliminated from the study. With fiscal considerations a priority in many districts, a strong possibility existed that schools with relatively few examination participants could not offer an Advanced Placement Computer Science class. This proved correct. The

Advanced Placement Program School List, compiled by The College Board, registered approximately 900 schools with four or fewer examinees. Twenty-four schools, randomly selected, were contacted by phone. The six schools having four examinees offered a class, but as the number of examinees declined, the number of schools offering Advanced Placement Computer Science proportionally declined.

The focus of this study is to compare teacher background with student performance. Since The College Board, which provided the data, maintains student scores by school, not by individual teacher, the population was restricted to schools in which one instructor taught all course sections.

How was it determined that one instructor taught the course? Twenty schools, where 11 or more students took the exam, were randomly selected. In the telephone survey that followed, no reliable information could be obtained from three schools. One school with 43 examinees reported two instructors. The remaining 16 schools reported one instructor. It was reasonable to conclude that few, if any, of the 203 sample schools would have more than one instructor.

The sampling procedure

Using the Advanced Placement Program School List, this sample was stratified -- with some modification -- by the number of examinees in each school. Very few schools, 21 in all, had 21 to 45 students taking the examination. So that a disproportionate number of schools were not clustered in the highest ranges, these were regrouped: 45-40, 39-35, 34-30, 29-25 and 24-21. With this modification, the 203 sample schools closely reflect the distribution of the schools in the United States and the number of schools with four or more examinees. (See Appendix A.)

The schools were selected using a table of random digits from The Standard Mathematics Tables (Selby, 1975). The College Board codes each school by a six digit number. The last three digits in the table of random numbers were compared with the last three digits of the school code. When a match appeared, the school was selected for the study.

The only exception to the selection process occurred in the 45-40 range. The randomly matched school with its 43 examinees was eliminated. It was the same school, previously mentioned in the limitations section, reporting two instructors. In its place the remaining school in the 45-40 range was chosen. This school was also contacted in the preliminary survey. Despite its 45 examinees, it had one instructor.

The survey instruments: preliminary draft

Initially 33 questions were developed (see Appendix B). Several readers, including Braswell of The Educational Testing Service, reviewed the questionnaire.

Braswell suggested some changes:

(1) that as many multiple choice responses as possible replace free responses,

(2) that questions 11 and 15 be eliminated because accurate information would be difficult to estimate; that questions 27, 28 and 31 be eliminated because of irrelevancy and redundancy,

(3) that questions better representing algorithms, data structures and Pascal programming syntax be selected for question 16. Two problems for each topic were chosen from The Entire 1984 Advanced Placement Computer Science Examination and Key (1986). Algorithm questions 16b and e in the questionnaire are numbers 13 and 40 on the 1984 examination. Data structures questions 16a and d are numbers 3 and 36. Pascal syntax questions 16c and f are numbers 2 and 41.

A revised questionnaire was sent to three members of the Advanced Placement Computer Science Committee and fourteen readers of the Advanced Placement Computer Science Examination. They were asked to fill in the questionnaire, to estimate the completion time and to offer comments and suggestions.

Fourteen responded. As a result four significant changes were made.

(1) Question 1, originally "Are you currently teaching the Advanced Placement Computer Science course?", was revised to read "Did anyone, beside yousel f, teach the Advanced Placement Computer Science course at your school in

1985-86?". In response to the original question one reader wrote that he was currently teaching the course, but that another teacher had taught it the previous year. The original question had not accounted for this possibility and was revised to keep the sample as uncontaminated as possible.

(2) Question 8 was reworked to read "How closely do you cover the Advanced Placement Computer Science Syllabus?". The original question did not account for a teacher's covering the entire syllabus, but not following its sequencing.

(3) Three readers mentioned they taught in private schools. This option was added to the school descriptors in question 4.

(4) Some readers found question 7, "How much time do you spend preparing for the course?", confusing. Did the question refer to the '86-'87 school year? Did it refer to the previous year, the apparent focus of the study? To clarify "during 1985-86" was added.

A final question was added after serendipidously coming across a study done by Johns Hopkins University ("Instructional Uses," 1986). It found that 47% of the instructors teaching high ability students own their own computers. Would the Johns Hopkins finding be corroborated in this study?

The survey instruments: final version

The 29 questions in the questionnaire were designed to elicit information about the teachers, the students and the computer science courses. Question 1, "Did anyone, besides yourself, teach the Advanced Placement Computer Science course at your school?", served as a check to preserve the integrity of the study. Should a respondent answer yes, the questionnaire would be discarded. A copy of the questionnaire is included in Appendix C.

Teacher-related questions

Questions 25, 6, 26, and 28 focus on the teacher's experience: how long the teacher has taught, how long s/he has taught in the current school, how long has the teacher taught computing, how long has the teacher taught Advanced Placement Computer Science.

Questions 23 and 24 probe the teacher's computer-related business experience, if any.

Questions 18, 19, 20 and 21 elicit traditional information about the teacher's degree(s), undergraduate major and minor(s), and formal graduate work.

Question 27 asks for a listing of computer science courses taken by non-majors. Question 22 asks all teachers, majors or not, how recent the last formal computing course was taken. Question 14 probes summer workshop study.

Question 15 elicits detailed information about the teacher's accessment of his/her proficiency in at least seven computer languages and fourteen topics in computing. The teacher was also asked to indicate whether these topics were learned through summer workshops, self study, or a formal course.

Question 17 focuses on the affective domain: How comfortable is the instructor teaching the advanced placement course? Question 7, on the other hand, focuses on effort and planning: How much time is spent preparing for class? Question 29 asks if the teacher owns a computer.

Question 16 with subparts a through e presents six multiple choice questions. These questions involve algorithms, data structures and the Pascal programming syntax. The teacher is asked to estimate how easy or how difficult the students would find the problem.

Student-related questions

Question 4 focuses on students from a sociological perspective: are the students from a rural, urban, suburban environment? Do they attend private or public school?

Question 10 asks class size. Question 11 inquires about prerequisites for the Advanced Placement students.

Questions 3 and 5 concentrate on computer accessibility: What is the ratio of computer to student? Approximately what percentage of students had access to a computer outside class?

Course-related questions

Question 9 asks the number of semesters the course runs. Question 13 asks for a listing of primary texts. Question 2 inquires about the kind(s) of computer used to teach the course.

Question 12 asks whether the "Karel the Robot" program is used as a teaching aid.

Question 8 focuses upon how closely the instructor follows the Advanced Placement Computer syllabus.

Conducting the survey

The final revision of the questionnaire (see Appendix C) was mailed March 15, 1987 to the 203 schools. The mailing included a cover letter explaining the purpose of the study. It was not indicated that the study was part of a doctoral dissertation (Berdie and Anderson, 1974).

The questionnaires and their corresponding return envelopes were labeled with the school's code, a number designated by The Educational Testing Service. Also included was the number of students participating in the 1986 examination from that school. The coding would facilitate recording the returns and preparing a second mailing, if necessary.

Special directions were included for cases in which the person teaching the '85-'86 course were no longer employed by the school.

March 25, 1987 was the target date for returning questionnaires. As of April 11, 109 schools had responded. Immediately a second questionnaire was sent to schools that had not responded. A new cover letter was included with a suggested return date of April 21. (See Appendix D.) An additional 34 questionnaires were received, bringing the total to 149 or 73.4% of the original mailing.

Of the 149 returned questionnaires 29 were un-usable: 16 were discarded because the teacher who taught the '85-'86 course was no longed employed by the school; the other 13 were eliminated because more students took the examination than those who took the course.

This left 120 schools in the study, 59.1% of the original mailing.

Further follow-up

A letter and a return postcard, Appendix E, were sent to the fourteen schools which reported using textbooks not found in Books in Print. The schools were asked to supply full title, author(s), copyright and publisher. Eleven schools answered, leaving one of the original five books unaccounted for: A.P. Review by Schulman, et al. Two schools used this title.

Student scores

Student scores from the 1986 Advanced Placement Computer Science Examination were obtained from The College Board. The College Board reports student scores from each school by distribution and mean. For this study mean scores were used. It was felt that the mean score for each school would be a better indicator of teacher impact on student performance than individual scores would be. The means would tend to smooth out any extreme scores in the class. Of special concern were the "computer hackers" in the class whose scores might not reflect as much teacher influence as theose of other students.

Chapter IV

RESULTS OF THE STUDY AND INTERPRETATION

Pearson correlation coefficients were computed that compared the mean scores of the students with other variables. Oneway analyses of variance, using the Tukey-b multiple comparison test, were also performed. A factor analysis was performed using the varimax rotation and Kaiser normalization methods.

The results in this section have not been not grouped in the order the questions appear in the questionnaire. They have been organized according to the information they offer: teacher-related, student-related and course-related questions.

Teacher-related questions

Question 25: How many years have you been teaching (not including 1986-87? Although the teachers were seasoned-- 45% taught twenty or more years and 76.6% ten or more-- classroom experience showed no relation to student scores (r = .0565, p = .5240, F(5,114) = 0.5084, p = .7694).

Table 1

Teacher Experience

Years teaching	Respondents Number	Respondents Percent	Student Scores Mean	Student Scores Variance
26-37	8	6.6	2.87	0.321
21-22	10	8.3	2.86	0.833
16-20	36	30.0	3.11	0.979
11-15	38	31.7	3.14	0.636
6-10	16	13.3	2.91	1.375
1- 5	12	10.0	2.78	0.818
Total	120			
M 14.78				
SD 6.692				

Question 26: *How many years have you been teaching computing (not including 1986-87?* Experience teaching computing had a marginal effect on student scores. The correlation was positive, though not significant (r = .1677, p = .0670). The analysis of variance showed significant differences, $F(3,116) = 3.2602$, p = .0241, though no two groups showed significant differences at the .05 level. See Table 2.

Question 28: *How many years have you taught the* Advanced Placement Computer Science course (not including

1986-87? The relationship between experience teaching the Advanced Placement Computer Science course and student scores also was not significant (r = .0807, p = .3810, $F(2,117)$ = 0.9603, p = .3858). See Table 3.

Table 2

Experience Teaching Computing

Years teaching computing	Respondents Number	Respondents Percent	Student Scores Mean	Student Scores Variance
16-20	5	4.1	2.44	2.220
11-15	20	16.7	3.36	0.430
6-10	36	30.0	3.23	0.679
1- 5	59	49.2	2.83	0.875
Total	120			
M 7.10				
SD 4.603				

Question 6: *How many years have you been in the school where you are teaching the Advanced Placement Computer Science course?* Of those teaching the Advanced Placement Computer Science course 45% have been teaching in their current schools for 10 years or more. Others, 72.5%, had been employed for six or more years. Again, however, the correlation was not significant (r = .0949, p = .3030). The mean was 4.00, the standard deviation 1.145.

Table 3

Experience Teaching APCS

Years teaching APCS	Respondents Number	Respondents Percent	Student Scores Mean	Student Scores Variance
1	32	26.7	2.84	1.144
2	42	35.0	3.13	0.652
3	46	38.3	3.05	0.789
Total	120			
M 2.12				
SD 0.801				

Question 23: Have you had any business related computer experience (programmer, systems analyst, etc.)? Business-related experience was reported by 44, or 36.7%, respondents with a mean of 4.18 years, a standard deviation of 3.532. Experience ranged from one half year to 20 years. No significant correlation was found between business-related experience and student scores (r = .1384, p = .1320, $F(10,109)$ = 0.8056, p = .6237).

Question 24: If you answered yes to Question 23, how much has this helped you in teaching the Advanced Placement Computer Science course? Subjects with computer-related business experience were asked to judge how helpful that experience was in teaching the Advacned Placement course. Although 42.2% felt their experience "somewhat" helpful, and 18.2% "very" helpful, no significant correlation was found between the response to this question and student scores (r = .1755, p = .255, $F(3,33)$ = 1.1967, p = .3150).

Question 18: Highest degree you attained. A significant correlation, r = .2696, p = .003, was found to exist between the teacher's highest degree and student scores. Analysis of variance showed differences between the groups, $F(3,40)$ = 3.3469, p = .0284. Student scores of teachers who had a masters degree plus 15 graduate credits (M = 3.42) differed (p < .05) from those whose teachers had a bachelors degree plus 15 graduate credits (M = 2.12) and those with a bachelors degree plus 30 credits (M = 2.22). See Table 4.

Question 19: What was your major field in college (if 'education', list the area of education in which you specialized, if any)? Majors are listed for 120 respondents, four of whom hold double majors. See Table 5.

College major, or the area of masters work for that matter, did not prove to be related to student performance on the Advanced Placement Examination. Analysis of variance showed no significant differences between groups, $F(4,115)$ = 0.3217, p = .8630. For those with a masters degree, analysis showed no significant differences between groups, $F(5,93)$ = 0.5017, p = .7345.

Table 4

Distribution of Degrees

Highest degree	Respondents Number	Percent	Student Scores Mean	Variance
BA	7	5.8	2.57	0.994
BA+ 15	6	5.0	2.12	0.798
BA+ 30	9	7.5	2.22	0.682
Masters	22	18.3	3.16	0.955
Masters+ 15	20	16.7	3.42	0.411
Masters+ 30	52	43.3	3.11	0.755
Doctorate	4	3.3	3.13	0.449

Table 5

Distribution of Bachelors Degrees

Major area	Respondents Number	Percent	Student Scores Mean	Variance
Mathematics	81	65.3	3.01	0.850
Science	23	18.6	2.79	0.794
English/ foreign lang.	6	4.8	2.88	1.324
Social studies	2	1.6	2.56	1.728
Other	12	9.7	3.08	1.120
Total	124			

Question 20: What was your minor field in college (if 'education', list the area of education in which you specialized , if any)? College minors, reported by 98 respondents, represented almost every discipline offered by traditional colleges. There turned out to be a problem as to what constitutes a minor. Several schools offer no minor and in the colleges that do the number of credits required in a field to be called a minor differ widely. Because of this and the diversity of responses no statistical analysis was performed on these data.

Question 21: If you have a masters degree (or higher) what was your major field (if 'education', list the area in which you specialized, if any)? A total of 99 respondents had masters degrees. Of these, four have two masters degrees each. Four respondents held doctorates, one each, in philosophy, mathematics, mathematics education and computer science. See Table 6 for a list of concentrations at the masters level.

Table 6

Distribution of Masters Degrees

Major area	Respondents		Student Scores	
	Number	Percent	Mean	Variance
Computer	11	11.1	3.20	0.714
Mathematics	57	57.6	3.27	0.411
Science	11	11.1	2.77	0.587
English/ foreign lang.	2	2.0	2.56	2.820
Social studies	1	1.0	3.88	0
Other	17	17.2	3.13	1.111
Total	99			

Question 27: *If you do not have a degree in computer science, how many computer programming or computer science courses have you taken? List them.* The ninety-three teachers who responded, all computer science non-majors, took as few as one computer science course or as many as 14 with a mode of 2. (M = 4.804, SD = 2.786).

The correlation between the number of computer courses taken by non-majors and student scores was not significant, r = .0405, p = .689. Even when the number of courses was regrouped into 1-4 courses and 5 or more, analysis of variance showed no significant differences between groups, $F(1,94)$ = 0.1252, p = .7243.

Question 22: How long ago was the last computer programming or computer science course? The results show that 70 respondents, approximately 58%, have taken a computer science course within two years of the 1984-85 Advanced Placement Examination. See Table 7.

Table 7

Years Since Last Computer Course

Time since	Respondents		Student Scores	
last course	Number	Percent	Mean	Variance
None taken	3	2.5	3.35	0.597
Within 0.5 yr.	20	16.7	2.76	0.661
Within 1 yr.	15	12.5	3.21	0.763
Within 1.5 yrs.	15	12.5	3.17	0.621
Within 2 yrs.	20	16.7	2.92	1.176
2 years+	46	38.3	3.09	0.847
No reply	1	0.8		
Total	120			

The 3 respondents who have not taken any computer science courses have a bachelors degree in mathematics. They also hold advanced degrees: one a masters in mathematics, one a doctorate in mathematics education, and one a doctorate in philosophy. Analysis of variance showed no significant differences between any groups, $F(5,113) = 0.7026$, $p = .6226$.

Question 14: How many summer workshops dealing with the Advanced Placement Computer Science course have you attended? List where and when you attended. There was a wide range in the number of workshops teachers attended. See Table 8. Almost 60% reported attending no workshop, and 33% attended one. Less than 10% attended more than one summer workshop. See Appendix F for a complete listing of the summer workshops.

For the analysis three categories were used: no workshops, one workshop and two or more workshops. There was no significant relationship between the number of summer workshops teachers attended and student scores, $r = -.0691$, $p = .455$). An analysis of variance was performed and showed no differences between groups, $F(3,117) = 0.5937$, $p = .6202$.

Table 8

Background in Summer Workshops

Number of workshops	Respondents Number	Percent	Student Scores Mean	Variance
None	71	59.2	-	-
1	38	31.7	2.95	0.768
2	9	7.5	2.94	0.592
3	1	0.8	3.67	0
4	0	0	-	-
5	1	0.8	2.25	0
Total	120			
M 0.54				
SD 0.790				

Question 15: Rate your proficiency in the following languages and topics and indicate how you learned each. This question focused upon the respondent's subjective evaluation of his/her expertise in computer languages and in selected computer topics, such as local and global identifiers, parameters, recursion and others. Each respondent rated his/her level of proficiency on a scale from 1 to 4, with 1 indicating no proficiency. See Table 9.

Although teachers evaluated their expertise in many computer languages, the teacher's self-rating of Pascal alone correlated significantly with student performance,

r = .2638, p = .004. Analysis of variance showed a difference between groups, $F(2,115) = 4.7498$, p = .0105). Student scores of teachers who rated themselves 3 (M = 2.79) and 4 (M = 3.19) in Pascal differed significantly ($p < .05$). Each respondent also rated what they perceived as their proficiency in BASIC. See Table 10.

Table 9

Teacher's Self-Rating in Pascal

Proficiency	Respondents		Student Scores	
in Pascal	Number	Percent	Mean	Variance
No reply	2	1.7	-	-
1-none	0	0	-	-
2-fair	5	4.2	2.23	0.560
3-good	41	34.2	2.79	0.902
4-excellent	72	60.0	3.19	0.733
Total	120			
M 3.58				
SD 0.565				

The average rating for BASIC was slightly higher than for the Pascal, though one person considered himself to have no proficiency in BASIC. The self-rating in BASIC, however, showed no relation to student scores, r = -.0141, p =.8790. Analysis of variance also showed no significant differences, $F(3,114)$ = 0.2962, p = .8281).

Table 10

Teacher's Self-Rating in BASIC

Proficiency	Respondents		Student Scores	
in BASIC	Number	Percent	Mean	Variance
No reply	2	1.7	-	-
1-none	1	0.8	3.71	0
2-fair	6	5.0	2.82	0.783
3-good	29	24.2	3.05	0.892
4-excellent	82	68.3	3.01	0.841
Total	120			
M 3.63				
SD 0.624				

Responses to a working knowledge of the other languages were so varied that no statistical analysis was performed; however, the number of languages teachers understood correlated significantly with the performance of the students on the Advanced Placement Examination, r = .2650, p = .004. Analysis of variance showed a difference, $F(8,110)$ = 2.3013, p = .0255, though no two groups were different at the .05 level. See Table 11.

Table 11

Number of Languages Understood by Teachers

Number of languages	Respondents Number	Respondents Percent	Student Scores Mean	Student Scores Variance
no reply	1	0.8	-	-
1	1	0.8	4.25	0
2	10	8.8	2.38	0.760
3	38	31.7	2.80	0.841
4	21	17.5	3.29	0.629
5	28	23.3	2.98	0.921
6	10	8.8	3.38	0.927
7	3	2.5	3.78	0.001
8	7	5.8	3.42	0.221
9	1	0.8	4.00	0
Total	120			
M 4.24				
SD 0.790				

How did teachers learn computer languages? Most teachers reported their learning was a result of college coursework, summer workshops, self study or classroom teaching. See Table 12.

Table 12

How Teachers Learned Pascal and BASIC

	Pascal		BASIC	
	No. of subjects	% of subjects	No. of subjects	% of subjects
No reply	2	1.7	4	3.3
a	38	31.7	27	22.5
b	3	2.5	1	0.8
c	28	23.3	70	58.3
d	2	1.7	-	-
ab	6	5.0	-	-
ac	7	5.8	13	10.8
ad	4	3.3	-	-
bc	4	3.3	-	-
bd	1	0.8	-	-
cd	5	4.2	-	-

Note: a=College course b=Summer AP workshop
c=Self taught d=Teaching AP course

Approximately 17% of those who learned Pascal and 3% of those who learned BASIC reported learning from the three or four sources mentioned above; some indicated other sources, such as tutoring by a colleague or having learned in high school. Because of these variations, statistical data focused upon those responses which indicated primary and secondary sources only. See Table 12.

The results showed that 45.8% learned Pascal primarily from college courses, 36.7% considered themselves self-taught and 10% learned through their own teaching. This compares with results found by the National Assessment of Educational Progress study (Martinez and Mead, 1988): 45% of eleventh grade coordinators indicated they received most of their computer science training from college courses; 31% were self taught and 1.8% learned by teaching. In contrast, however, were the BASIC respondents, 33.3% who learned from college courses and 69.2% who were self-taught.

The respondents also rated themselves on their proficiency in 14 topics taken from the Advanced Placement Computer Science syllabus. Each topic was rated from 1 (no proficiency) to 4 (excellent) by the respondents, then summed to produce a total score. The highest possible score was 56. See Table 13. There was a significant positive correlation between this score and student scores, r = .2590, p = .004. For the analysis of variance teacher ratings were grouped: 1= less than 30, 2= 31-40, 3= 41-45, 4= 46-50, 5= 51-56. Analysis of variance showed a difference between groups, $F(5,113)$ = 2.5013, p = .0346. The groups whose teachers rated themselves 31-40 (M = 2.56) and 51-56 (M = 3.35) were significantly different ($p < .05$).

Table 13

<u>Teacher's Self-Rating in 14 Computer Science Topics</u>

Rating in Pascal topics	Respondents Number	Percent	Student Scores Mean	Variance
No reply	1	0.8	-	-
Less than 30	2	1.7	2.40	0.650
31-40	22	18.3	2.56	0.928
41-45	20	16.7	3.05	0.773
46-50	31	25.8	3.09	0.978
51-55	34	28.3	3.35	0.633
56	10	8.3	3.79	0.586
Total	120			
M 47.04				
SD 6.711				

Question 17: How comfortable are you teaching the Advanced Placement Computer Science course? The teachers were asked to give a subjective rating of how comfortable they felt teaching the Advanced Placement Course. See Table 14.

There was a significant correlation between this rating and student scores, $r = .2667$, $p = .003$. Analysis of variance showed a difference between groups, $F(2,117) = 4.8449$, $p = .0095$. The scores of the students whose teachers felt "only a little comfortable", *M* = 2.34, and those whose teachers felt "very comfortable", *M* = 3.20, differed significantly ($p < .05$).

Table 14

Comfort Level Teaching APCS

Comfort	Respondents		Student Scores	
level	Number	Percent	Mean	Variance
a	0	0	-	-
b	11	9.2	2.34	0.845
c	44	36.7	2.93	0.841
d	65	54.2	3.20	0.736

Note a Not at all b Only a little comfortable
c Only a little uncomfortable
d Very comfortable

Significant correlations existed between the teacher's comfort level and

--the number of years teaching the Advanced Placement course, $r = .3613$, $p = 0$,

--the teacher's rating of his/her proficiency in Pascal, $r = .5345$, $p = 0$,

--the teacher's rating of his/her proficiency in the 14 topics, $r = .5022$, $p = 0$,

--the number of programming languages known,

r = .4169, p = 0.

Question 7: How much preparation time did you spend (per week) during 1985-86 on the Advanced Placement Computer Science course? Preparation time spent on the Advanced Placement Course each did not correlate with student scores (r = .0409, p= .6580). Analysis of variance showed no significant differences between the scores of students grouped by the amount of preparation time spent by the teachers, $F(3,116)$ = 0.0641, p = .9787. See Table 15.

Table 15

Teacher Preparation Time Per Week

Hours	Respondents		Student Scores	
	Number	Percent	Mean	Variance
Less than 5	27	22.5	2.96	0.938
6-10	65	54.2	3.03	0.721
11-15	15	12.5	3.05	0.747
More than 16	13	10.8	3.08	1.513
Total	120			

Question 29: Do you own your own computer? Did the teacher's owning a computer affect student scores? In this study it was found that 88 of the respondents, or 73%, owned their own computer. There was, however, no relation between

the teacher's owning a computer and student scores, r = .0064, p = .9440, $F(1,118)$ = 0.0049, p = .9443.

A Johns Hopkins University study ("Instructional Uses...", 1986) showed that 47% of people teaching high ability classes own their own computers. The NAEP study (Martinez and Mead, 1988) found that 73.5% of eleventh grade computer coordinators owned a computer or had access to one outside the classroom.

Question 16: Six questions from the multiple choice portion of the 1984 Examination were presented. The teachers were asked to rate the level of difficulty of each question as it would be perceived by their students. The rating scale ranged from 1 (very easy) to 4 (very difficult). See Table 16.

Table 16

Teacher Rating of Question Difficulty

Question	Teacher rating/difficulty level							
	1	%	2	%	3	%	4	%
a	51	42.5	50	41.7	16	13.3	3	2.5
b	17	14.2	45	37.5	49	40.8	9	7.5
c	50	41.7	53	44.2	15	12.5	2	1.7
d	4	3.3	38	31.7	42	35.0	36	30.0
e	9	7.5	43	35.8	50	41.7	18	15.0
f	34	28.3	34	28.3	35	29.2	17	14.2

These ratings were used to determine the level of difficulty for each question, from the easiest to most difficult. Each level of difficulty was multiplied by the number of teachers who gave it that evaluation. These products were added, and the sum divided by the number of respondents.

The following is the result of that computation, presented in increasing level of difficulty:

Question c, 1.74 weighted average

Question a, 1.76 weighted average

Question f, 2.29 weighted average

Question b, 2.32 weighted average

Question e, 2.65 weighted average

Question d, 2.93 weighted average.

The level of difficulty as perceived by students was determined by the percentage of correct responses by all students participating in the 1984 Advanced Placement Computer Science Examination.

The following is the result, presented in increasing level of difficulty:

Question c, 93% correct response

Question a, 56% correct response

Question b, 50% correct response

Question e, 38% correct response

Question d, 30% correct response

Question f, 14% correct response.

Based on teacher perception and student performance, it was concluded that teachers could judge, with a fair degree of accuracy, the difficulty level of questions on the Advanced Placement Examination. It was hypothesized that a teacher's ability and understanding of the complexities of the computer science field would correlate with student performance. To test this hypothesis a correlation was made between the teacher's estimate of the degree of difficulty of the six 1984 Advanced Placement Computer Science Examination questions and the average score of the teacher's class on the 1986 Advanced Placement Computer Science Examination. Significant correlations were found, except for question e. A more detailed analysis follows.

In question a (data structures) the correlation between teacher rating and student scores was significant ($\underline{r}$ =

$-.3129$, $p = .001$). Analysis of variance showed a significant difference between groups, $F(3,116) = 5.8676$), $p = .0009$. The student scores of teachers who rated the question as 3 (difficult) ($M = 2.29$) and those who rated it as 1 (very easy) ($M = 3.31$) or 2 (easy) ($M = 2.96$) differed significantly ($p < .05$).

Question b (algorithms) showed a significant correlation, $r = -.1792$ $p = .050$, with student scores. Analysis of variance showed no significant differences between the groups.

Question c (Pascal) showed a significant correlation between teacher rating and student scores ($r = -.2117$, $p = .020$). Analysis of variance showed differences between the groups, $F(3,116) = 3.2578$, $p = .0242$. The student scores of teachers who rated the question 4 (very difficult) ($M = 1.27$) differed significantly ($p < .05$) from the other three groups: 3 (difficult) ($M = 2.84$), 2 (easy) ($M = 3.00$) and 1 (very easy) ($M = 3.17$).

Question d (data structures) showed a significant a correlation of between-teacher rating and student scores ($r = -.2296$, $p = .012$). Analysis of variance showed differences between the groups, $F(3,116) = 3.1356$, $p = .0282$. The student scores of teachers who rated the question 4 (very difficult) ($M = 2.67$) differed from those rating it 3 (difficult) ($M = 3.17$) at the .05 level.

Question e (algorithms) did not correlate significantly with student scores (r = .0084, p = .927).

Question f (Pascal) revealed a significant correlation between teacher rating and student scores (r = .2705, p = .003). Analysis of variance revealed significant differences between the groups, $F(3,116) = 3.3013$, $p = .0229$. The student scores of teachers who rated the question 1 (very easy) (M = 2.76) differed ($p < .05$) from those rating it 4 (very difficult) (M = 3.55).

Student-related questions.

Question 4: In what type of school do you teach? This question attempted to focus upon the kind of school best representing the sample. Five choices were offered: urban, suburban, rural, private and public. This question would have been better posed in two items: one which asked respondents to indicate urban, suburban or rural, the other to indicate public or private. Most respondents checked two categories, a few one.

Table 17 lists the results of the respondents who checked the type of school and its sector. Table 18 represents data from those respondents who checked a single category.

Ignoring the public/private classification of schools produced the results in Table 19. What was significant, despite the flaw in this question, was that the analysis of variance showed no differences between scores when schools were grouped as rural, urban and suburban, $F(2,82)$ =

2.5972, p = .0806.

Table 17

Type of School: Both Options Checked

School type	Respondents		Student Scores	
	Number	Percent	Mean	Variance
Rural private	3	2.5	3.36	1.830
Rural public	4	3.3	3.13	1.188
Suburban/ private	3	2.5	4.33	0.583
Suburban/ public	33	27.5	3.19	0.709
Urban private	7	5.8	2.93	0.674
Urban public	7	5.8	2.56	1.091

Table 18

Type of School: One Option Checked

School type	Respondents		Student Scores	
	Number	Percent	Mean	Variance
Rural	4	3.3	2.00	1.301
Suburban	19	15.8	3.12	0.762
Urban	5	4.2	2.70	0.235
Private	16	13.3	2.93	1.041
Public	19	15.8	2.99	0.739

Table 19

Type of School: Rural, Suburban or Urban

School type	Respondents		Student Scores	
	Number	Percent	Mean	Variance
All rural	11	9.2	2.78	1.504
All suburban	55	45.8	3.21	0.721
All urban	19	15.8	2.78	0.667
No response	35	29.2	-	-

Ignoring the rural/urban/suburban classification produced the results in Table 20.

Table 20

Type of School: Public or Private

School type	Respondents		Student Scores	
	Number	Percent	Mean	Variance
All private	29	24.2	3.09	0.969
All public	63	52.5	3.06	0.784
No response	28	23.3	-	-

Analysis of var‹ ‹nce also showed no difference between the scores when the schools were grouped as public or private, $F(1,90) = 0.0202$, $p = .8874$.

Question 10: What was your total number of students in Advanced Placement Computer Science during 1985-86? No significant correlation existed between the number of students enrolled in the Advanced Placement Computer Science course and student scores, $r = -.0833$, $p = .3770$. (It is not known whether schools with higher enrollments had more than one section.) Students in schools with a large course enrollment performed as well as those with smaller enrollments. Analysis of variance showed no differences between groups, $F(26,93) = 1.5995$, $p = .0525$.

When the schools were regrouped according to the number of students per school (31-35, 26-30, 21-25, 16-20, 11-15, 6-10, and 4-5), another analysis of variance was completed. No significant differences were found between the student scores using this grouping, $F(6,113) = 0.5932$, $p = .7352$. See Table 21.

Table 21

APCS Enrollment

Students per school	Respondents Number	Respondents Percent	Student Scores Mean	Student Scores Variance
31-35	2	1.7	3.20	0.756
26-30	8	6.7	2.57	0.700
21-25	10	8.3	3.08	1.021
16-20	21	17.5	3.05	0.917
11-15	31	25.8	3.11	0.736
6-10	38	31.7	2.94	0.841
4-5	10	8.3	3.31	1.091
Total	120			
M 14.12				
SD 7.122.				

Question 11: What are your math prerequisites for students entering your Advanced Placement Computer Science course? Although 6 schools, or 5%, listed programming as

their only prerequisite, 18 schools, or 15%, indicated that they used programming as one of the prerequisites for the course. Seven schools, 5.83%, indicated special requirements, such as department permission, and one of these indicated three years of regents mathematics. Table 22 lists the frequencies of the prerequisites reported.

When all 17 of these combinations of prerequisites were subjected to an analysis of variance, a significant difference, $F(16,103) = 2.5145$, $p = .0027$, was found between those for whom programming only ($M = 3.9847$) was used as a prerequisite and those for whom Algebra II and geometry ($M = 1.81$) were used as a prerequisite. These two groups differed at the .05 level.

Several prerequisites were combined, based on the assumption that the more common sequence of mathematics courses was Algebra I, geometry, and Algebra II. A new grouping was made using the most advanced course as the criterion for classification. If programming were indicated with other prerequisites, it was disregarded. If it were the only prerequisite, it was placed in a category. This, then, produced five groups: Algebra I, geometry, Algebra II, pre-calculus, programming. Another two groups were added: a group for no prerequisites and a general "other" category. This was done so that all student scores were included in the statistical analysis. Analysis of variance showed no differences between these categories, $F(6,113) = 0.1821$, $p = .9812$.

Table 22

Prerequisites for the Advanced Placement Course

Prerequisites	Number of respondents	Percent of respondents
None	14	11.7
Algebra I	11	9.2
Algebra II	26	21.7
Geometry	3	2.5
Pre-Calculus	7	5.8
Programming	6	5.0
Algebra I/II/Geometry	20	16.7
Algebra I/II/ Geometry/Pre-Calculus	4	3.3
Pre-Calculus/Calculus/ Programming	1	0.8
Algebra I/II/Geometry/ Programming	2	1.7
Algebra II/Programming	3	2.5
Algebra I/II	5	4.2
Geometry/Programming	5	4.2
Algebra II/Geometry	4	3.3
Algebra I/Geometry	1	0.8
Algebra I/Programming	1	0.8
Others	7	5.8
Total	120	

Question 3: During your Advanced Placement Computer Science class how many of your students are there per computer? Table 23 shows the ratio of student to computer. In 80% of the schools each student had his/her own computer to use during class.

Table 23

Student-Computer Ratio

Students per computer	Respondents Number	Respondents Percent	Student Scores Mean	Student Scores Variance
1	97	80.8	3.15	0.721
1.5	5	4.2	2.62	0.800
2	16	13.3	2.48	1.178
3	1	0.8	3.18	-
4	1	0.8	1.55	-
Total	120			

M 1.2 students per computer

SD 0.464

There was a significant negative correlation between mean score and number of students per computer, r = -.2756, p = 0.002. Analysis of variance, $F(3,116)$ = 3.3594, p = .0212, showed the number of students per computer affected student scores. A significant difference

($p < .05$) existed between scores when two students shared a computer ($M = 2.48$) and when one student alone used a computer ($M = 3.12$).

Question 5: What fraction of the advanced placement class had access to computers outside your class time? Almost half, or 47.5%, of the schools reported that more than three quarters of the students had access to computers outside of class time, whether students used their own computers or the school's. See Table 24.

Table 24

Student Access to Computers Outside of Class

Percent of access	Respondents Number	Percent	Student Scores Mean	Variance
Less than 10%	6	5.0	2.30	0.960
10%-25%	21	17.5	2.45	0.929
26%-50%	20	16.7	3.00	1.244
51%-75%	15	12.5	3.08	0.798
More than 75%	57	47.5	3.31	0.394
No response	1	0.8		
Total	120			

A significant positive correlation existed between student scores and the percent of the class having access to computers outside of the class time, r = .3621, p = 0. Analysis of variance, $F(4,114)$ = 4.7090, p = .0015, showed significant differences between the groups. The greatest difference (p < .05) was between classes in which less than 10% of the class had access to computers outside of class (M = 2.46) and classes in which more than 75% of the class had access outside of class (M = 3.31).

Course-related questions.

Table 25

Duration AP Course

Course length	Respondents		Student Scores	
	Number	Percent	Mean	Variance
1 semester	2	1.7	3.51	0.212
2 semesters	110	91.7	2.98	0.818
3 semesters	6	5.0	3.64	0.691
4 semesters	2	1.7	2.88	3.540
Total	120			
M 2.08				
SD 0.361				

Question 9: How long is your Advanced Placement

Computer Science course during 1985-86? Most schools offer the Advanced Placement Computer Science course two semesters. The duration of the course did not correlate significantly with student scores, r = .0543, p = .556, $F(3,115)$ = 1.7840, p = .1726. See Table 25.

Question 13: What are your primary textbooks? Of the 120 schools surveyed, 11, or 9.2%, reported using no textbook. The remaining 109 used a total of 40 different titles. Some schools used several texts, a mean of 1.85 for those 109 schools using a text. One of the 40 titles, A.P. Review by Schulman, could not be identified in Books in Print (1987), nor was any response received when a second inquiry was sent to the schools. This book was used by two schools, or 1.7%, with a total of 16 students, 9 of whom took the Advanced Placement Computer Science Examination.

The two most frequently used books were

(a) Pascal Plus Data Structures, Algorithms and Advanced Programming, by Dale and Lilly, used by 53 schools (44.2%) and

(b) Introduction to Pascal and Structured Design, by Dale and Orshalick, used by 52 schools (43.3%).

Next in popularity were

(a) Oh! Pascal by Cooper and Clancy, 18 schools (15.0%),

(b) Karel the Robot: A Gentle Introduction to the Art of Programming, by Pattis, 13 schools (10.8%),

(c) Computer Science with Pascal for Advanced

Placement, by Mandell and Mandell, 10 schools (8.3%) and

(d) Data Structures Using Pascal, by Tenenbaum and Augenstein, 6 schools (5.0%).

For a complete list of text titles see Appendix G.

In order to analyze the textbook information the types of textbooks used were grouped into eight categories. A grouping of the textbooks was necessary because the 112 schools that used textbooks used 61 different combinations. No attempt was made to group the books according to content or structure. This was beyond the scope of this paper. The groupings were based on how frequently that book or combination of books was used. The eight categories (the numbers in parentheses are the number in each category) are:

Category	Text
1 (8)	No textbook used
2 (5)	Oh! Pascal
3 (14)	Pascal Plus Data Structures or Introduction to Pascal
4 (27)	Pascal Plus Data Structures and Introduction to Pascal
5 (31)	any text except those already noted
6 (4)	Oh! Pascal and Pascal Plus Data Structures and/or Introduction to Pascal
7 (22)	Pascal Plus Data Structures or Introduction to Pascal and any book(s) other than

Oh! Pascal

8 (9) Oh! Pascal and any book except Pascal Plus Data Structures and Introduction to Pascal

Analysis of variance showed no significant difference, $F(7,112) = 0.9526$, $p = .4695$, between the text used and student scores. The last three categories were combined and another analysis of variance was performed. These also showed no significant differences, $F(5,114) = 0.5366$, $p = .7482$.

Table 26

Type of Computer Used for AP Instruction

Computer	Respondents		Student Scores	
	Number	Percent	Mean	Variance
Apple II	55	45.8	2.81	0.795
MacIntosh	1	0.8	3.60	-
IBM PC	16	13.3	3.36	0.983
TRS-80	10	8.3	3.01	1.168
Commodore	5	4.2	2.53	0.502
Other	22	18.3	3.43	0.444
No Reply	11	9.2	-	-

Question 2: What computer(s) do you use to teach Advanced Placement Computer Science? Analysis of variance showed that the type of computer used for instruction and student scores was significant, $F(5,103) = 2.5047$, $p = .0350$. A significant difference existed ($p = .05$) between the scores of students using Apple computers ($M = 2.81$) and those in the "other" category ($M = 3.43$). See Table 26.

Eleven of the twenty-three schools in the "other" category reported using more than one system. Of those eleven, five reported using Apple/IBM combinations. Three schools used three or more systems.

One school reported using overhead monitors for instruction with no indication as to the computer system, nor any indication as to the type of computer used by the students.

Question 12: Do you use "Karel the Robot" program in your course? Only 13 schools, or 10.8%, reported using Karel the Robot. Two other schools (1.7%) reported using it in an introductory Pascal course. The schools that used Karel the Robot reported using it for a mean of 9.86 periods ($SD = 4.50$). Of those schools, 7, or 50%, used it for two or three weeks. One school reported making it available as a resource in the library, but did not use it as part of the course.

No significant correlation existed between the use of Karel the Robot and student scores, $r = .1203$, p

= .1910. Analysis of variance showed no significant difference, $F(1,118) = 1.7331$, $p = .1906$.

Table 27

Adherence to AP Syllabus

Degree of adherence	Respondents Number	Respondents Percent	Student Scores Mean	Student Scores Variance
Not at all	0	0	-	-
Somewhat	39	32.5	2.60	0.714
Very closely	71	59.2	3.23	0.748
Exactly	9	7.5	3.44	0.716
No response	1	0.8	-	
Total	120			

Question 8: How closely do you cover the Advanced Placement Computer Science syllabus? See Table 27. The word cover was used instead of follow to avoid the problem that someone might think we were referring to the scope and sequence rather than just the scope of the syllabus. A significant correlation existed between student scores and how closely the syllabus was covered ($r = .3291$, $p = 0$). Analysis of variance showed significant differences between groups, $F(2,116) = 7.7174$, $p = .0007$. The differences between student scores in the courses where the syllabus was covered "somewhat" ($M = 2.60$) and those in

which it was covered "very closely" (*M* = 3.23) or "exactly" (*M* = 3.44) were significant at the .05 level.

Factor analysis

A factor analysis was performed on all variables except the teacher's minor and the way in which Pascal and BASIC were learned. The resulting factors were rotated using the varimax method producing 13 factors explaining 84.6% of the total variance. For each factor variables were selected that had a correlation of .35 or higher with the factor (Nunnelly, 1967).

The following is a list of factors with their correlated variables.

Factor 1: rating of language proficiency, Pascal self-rating, BASIC self-rating, proficiency on 14 selected topics, years teaching, years teaching computing, years teaching Advanced Placement Computer Science, rating of question d and years of business experience. This factor accounts for 12.9% of the variance.

Factor 2: rating of questions a, b and d, years teaching Advanced Placement Computer Science. This factor accounts for 11.7% of the variance.

Factor 3: student scores, prerequisites, rating of questions e and f, and rating of helpfulness of business experience. This factor accounts for 10.7% of the variance.

Factor 4: comfort level, years since last computer course, number of languages teacher understands and proficiency on 14 selected topics. This factor accounts for 8.9% of the variance.

Factor 5: number of students taking the Advanced Placement Examination, number of students taking the Advanced Placement course and teacher's college major. This factor accounts for 7.1% of the variance.

Factor 6: rating of question c, number of computer courses taken by the teacher and the number of hours of teacher preparation time. This factor accounts for 5.9% of the variance.

Factor 7: years at present school, use of Karel the Robot, student access to computers, years of business experience and years teaching Advanced Placement Computer Science. This factor accounts for 5.4% of the variance.

Factor 8: computer type and rating of helpfulness of business experience. This factor accounts for 4.9% of the variance.

Factor 9: years teaching and number of computer courses taken by the teacher. This factor accounts for 4.5% of the variance.

Factor 10: rating of question a and years teaching computing. This factor accounts for 3.5% of the variance.

Factor 11: type of school and student access to computers. This factor accounts for 3.2% of the variance.

Factor 12: highest degree held by teacher. This factor accounts for 3.1% of the variance.

Factor 13: prerequisites. This factor accounts for

2.7% of the variance.

Based on the results from the factor analysis several variables were grouped and a multivariate analysis of variance was performed comparing each cluster with student scores. Four such clusters were used and in no instance were the results of the analyses significant.

One cluster grouped the teacher rating of the level of difficulty of questions a, b and d. The analysis showed no significant relation between this cluster and student scores, ($F(89,1,24) = 1.3504$, $p = .157$). Another cluster grouped teacher proficiency on 14 topics selected from the syllabus, years teaching computing and years teaching the Advanced Placement Computer Science course. No significant relation was found between this cluster and student scores, ($F(75,1,31) = 0.7974$, $p = .755$).

Another cluster included teacher proficiency on 14 topics selected from the syllabus, years teaching and years teaching Advanced Placement Computer Science. No significant relation was found between this cluster and student performance, ($F(59,1,49) = 1.2681$, $p = .191$). A final cluster included teacher comfort level teaching the course, years since the last computer course and the number of languages understood by the teacher. Some interaction of these variables was evident though the relation was not significant, ($F(64,1,47) = 1.5514$, $p = .051$.

Interpretation of results

What is the relationship between the number of years experience a) teaching, b) teaching mathematics and c) teaching programming or computer science and student success on the Advanced Placement Computer Science Examination?

Based upon the data of this study the kind of academic preparation that the teacher brings to the Advanced Placement Computer Science course does not have a significant bearing on student performance. No significant relation exists between the teacher's area of specialization (major in college or specialization at the masters level) and student performance on the examination.

Years teaching and years teaching the Advanced Placement course also exhibited no relation to student performance. The majority of those teaching the Advanced Placement course and responding to the questionnaire were very experienced teachers and were very experienced in teaching computing. The students of the less experienced teachers did not score lower than the students of the more experienced teachers. One reason could be because the younger teachers, more recently graduated from college, have more recently taken computer science courses than their more experienced colleagues. This exposure to computer science courses could balance the greater experience. Also the more experienced teachers have used their years of experience teaching computing as a way of learning the material.

The amount of time teachers prepare each week for the

Advanced Placement course has no relation to student scores. One teacher commented that he put in more time the first time he taught the course than he does now. This is typical of most teachers. No relation exists between the amount of preparation time and any of the other indicators of teacher experience (years teaching, number of graduate credits, etc.). Business related experience in the computer field has no relation to student scores nor does the perception by the teacher as to whether the experience was helpful in teaching the Advanced Placement course. A delineation of the type of business experience might provide a relation to student success.

What does relate to student scores is the highest degree the teacher achieved, though the area of specilization is not important, and how comfortable the teacher feels teaching the course. The higher the degree, or the greater the number of graduate credits, and the more comfortable the teacher felt with the material, the higher the scores. An assumption could be made that teachers who attend graduate school are more committed to the profession and to keeping current in discipline and pedogogy. Those who feel comfortable with the subject convey that feeling to the students and give them a feeling of self confidence. These factors are thus more important than total years of teaching experience or the teacher's area of specialization.

The teacher's level of comfort stems from his/her preparation in computer science. Total years of teaching experience are not important but years teaching the Advanced

Placement course are. The teacher's perception of his/her ability in programming and in the topics in the course helps in making the teacher feel more assured. Perhaps this sense of confidence is conveyed to the students and influences their performance on the Advanced Placement test.

What is the relationship between teachers who do and teachers who do not attend Advanced Placement Computer Science workshops and student success on the Advanced Placement Computer Science Examination? Whether the teacher attends summer workshops or not has no relation to student performance. This is, at first, curious because one would expect any exposure to the material covered in the Advanced Placement syllabus to be better than none at all. It should also be noted that less than 50% (42%) of the teachers surveyed attended one or more workshops.

Why do the students of those attending workshops not outperform those whose teachers did attend workshops? Do these workshops do no good? It is possible that the students of teachers attending workshops were less able to begin with than those whose teachers did attend. A more likely explanation is that those who have not taken a summer workshop received the information needed to effectively teach the Advanced Placement course in other ways. At least one teacher noted that his district ran a series of year-long workshops to prepare the teachers for the Advanced Placement course. Others noted that they had taken graduate courses during the school year. It would seem that teachers need to be trained until they judge themselves ready to teach the material. Thus the amount of exposure to the Advanced Placement material will vary, possibly substantially, from teacher to teacher.

Those with a minor or a degree in computer science would probably not find a summer workshop necessary. Jones (1975) asks from where the teachers of Advanced Placement courses will come. He maintains that level of competence in high school teaching is not enough to prepare the teacher to deal with college level materials. He feels that some teachers are equal to the task and that perhaps a "summer's recharging" at a university would be wise. This advice does not appear to be necessary in the case of Advanced Placement Computer Science course. The teachers are seeking and receiving the information needed to teach the Advanced Placement course. Some have the necessary background from undergraduate and graduate schools and those without degrees in computer science attend more workshops.

What is the relationship between the textbooks used in the course and student success on the Advanced Placement Computer Science Examination? The type of textbook used had no relation to student scores. This is not unexpected; the College Board has developed a syllabus and an examination that is textbook independent. The College Board, in fact, makes no textbook recommendation to the teacher in any Advanced Placement syllabi.

A surprising result is the sheer number, and number of combinations, of textbooks used-40 different books. Even more surprising is the fact that almost 10% of the schools did not use a commercial text. The diversity of textbooks, and the fact that some teachers used personal notes, would indicate that what textbook(s) the teacher uses is far less important than how the teacher uses it (them). The teacher is the determining factor in student success. This could mean that though there are a large number of books in use they basically offer the same content or do not differ enough in their presentation of the material to make a difference in student scores.

What is the relationship between teacher training in a) Pascal syntax, b) data structures and c) algorithms and student success on the Advanced Placement Computer Science Examination? It is difficult to assess the level of mastery teachers had in Pascal, data structures and algorithms without testing these areas. In this research this was impractical. It was felt that by asking the teachers to rate the level of difficulty of questions from the three main topic areas an indication of their level of competence could be obtained. This is not a definitive indicator of teacher ability. The teacher's estimate of their own expertise is a better indicator.

Based on the results teachers appear to have a good understanding of how their students will perform on data structures type questions but not on Pascal or algorithms type questions. It is possible that the courses that the teachers have taken stressed data structures more than the other areas. It is also possible that teachers find data structures more difficult and stress that area more in their teaching. A teacher's rating of the difficulty of a question may not, however, show any relation to the teachers knowledge of that topic.

Though not directly related to this proposal question, teacher mastery of other computer languages does relate to student performance. Mastery of other languages implies a careful analysis and reinforcement of data structures and algorithm questions and solutions. Approaching these questions from the perspective of different languages forces the teacher to be more flexible in thinking. This flexibility, although not measurable, significantly affects student performance.

The teachers consider the time teaching the Advanced Placement course important in their own learning of Pascal. This result points to teacher motivation and interest as important factors in student performance. Those who have learned more programming languages clearly have more than a passing interest in computers. This enthusiasm and interset is likely passed on to the students, if only unconsciously, resulting in more student interest and involvement.

What is the relationship between a teacher's perception of his/her proficiency in syntax, data structures and algorithms and his/her actual training? Teacher perception of proficiency in Pascal and on the 14 selected topics from the syllabus was an important determiner of student performance. It is to be stressed that these proficiency ratings were not evaluated by an objective observer nor were they set to objective criteria. Even with much subjectivity the teachers who thought themselves most knowledgable produced students with the best scores, and those who perceived themselves least knowledgable had the students with the lowest scores. Either the teachers are very good judges of their own ability or those who think they are good convey that confidence to their students. It is likely that a combination of these factors is in effect.

Are there other factors that relate to student success on the Advanced Placement Computer Science Examination? Several were found that related to student success on the Advanced Placement Examination. The type of computer system showed a small effect on student performance. Those using Apples had significantly lower scores than those using a combination of computers or less common systems (mainframes, mini computers, etc.). It could be that those using several types of computers for the course have developed a flexibility in moving from one system to another that those using one computer do not. This flexibility could enhance student problem solving ability, thus leading to higher scores on the examination. This supports the position of the College Board that the purpose of the course is not to train students in a particular computer system (Garland, 1983).

It is also important that each student have access to his/her own computer, or terminal, during the class and have as much access as possible to computer time outside of class time. This would suggest that schools seeking to implement an Advanced Placement Computer Science program make the necessary financial committment to fully fund the course. This includes hardware and software in sufficient number and variety to provide each student sufficient access. This is unlike most other Advanced Placement programs where the expenditures are primarily for teacher training and textbooks.

It is also essential that the teacher follow the syllabus set by the College Board. While to some this may smack of "teaching to the test" it indicates a more focused approach to the material. The material covered by the course is highly concentrated and specialized. This focusing is important for student success. Establishing appropriate prerequisites is somewhat important, though specific mathematics prerequisites seem to be less important than several years of mathematics in conjunction with some background in programming. From the results we can conclude that the Advanced Placement course should not be the first formal exposure to computer science or programming. Some prior exposure to computers benefits the student.

The factor analysis points to several important, overall factors. One of these could best be labeled "experience and language proficiency." This includes total years teaching experience and teaching computing as well as self-rated proficiency in Pascal and BASIC. Another factor can be labeled "test question difficulty." This includes an estimate of the difficulty of both data structures questions and one algorithms question. A third important factor can be labeled "teacher comfort." This includes teacher comfort level, the time since taking the last computer course, number of languages understood and the teacher's self-rating of 14 selected Advanced Placement topics. A fourth factor can be labeled "number of students." This includes the number of students taking the examination and the number of students enrolled in the Advanced Placement course.

Chapter V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this study was to investigate the relation between student success on the Advanced Placement Computer Science Examination and

- teacher experience,
- teacher attendance at summer summer workshops,
- textbooks,
- the teacher's perception of his/her ability in computing.

A questionnaire was constructed covering teacher-related, student-related and course-related areas. A pilot study was conducted using three members of the Advanced Placement Computer Science Committee and fourteen readers of the Advanced Placement Computer Science Examination. Based on the results of the pilot study several modifications were made to the questionnaire. The final questionnaire was mailed to 203 schools that administered the Advanced Placement Computer Science Examination in 1986. Usable responses were received from 120 of these schools. The sample was randomly selected to give a stratified sample of the schools that administered the examination. Because schools where fewer than four students took the examination were not likely to have a formal course, these schools were eliminated from the population and were not sampled. The mean score for each school was obtained from the College Board and was used as the measure of student success.

Pearson correlation coefficients were calculated comparing the mean scores of the students with the other variables. One-way analyses of variance, using the Tukey-b multiple comparison test, were also performed. A factor analysis was performed using the varimax rotation and Kaiser normalization methods. A multivariate analysis of variance was porformed using several clusters obtained form the factor analysis.

Conclusions

Thirteen factors proved to be related to student performance on the Advanced Placement Computer Science Examination. These fall into two categories: teacher preparation factors and student factors. There were significant relations between student performance and teacher's evaluations of four of the six examination questions. It appears that teachers need to have a good sense of their students' capabilities and that they be good judges of question construction and level of difficulty. This undoubtedly comes about through experience.

Teachers must possess some minimum amount of knowledge to teach the Advanced Placement Computer Science course. Precisely what this minimum preparation is or how it is acquired is not at all clear. Those teaching Advanced Placement Computer Science are learning the needed material from many sources. Though no one mode of teacher preparation is significant, it is likely that the varied ways the teacher has learned makes the teacher more flexible and open in his/her approach to the material. This flexibility may make the teacher a better problem solver and may serve as a model of flexibility for the students. The ways the teachers have learned the material include college courses, self instruction, workshops and on the job training, that is, teaching the Advanced Placement course.

Students need access to computers to succeed in the Advanced Placement Course. Ideally the students should have unlimited access and should not have to share computer time with a partner. The College Board recognizes that for some students the Advanced Placement Computer Science Course is the students' first exposure to computer science (Braswell, 1984). This study shows those students who have had at least one course in computer programming have an advantage.

What textbook(s), if any, were used proved unrelated to student success. It is likely that several factors are at work. Because of the highly specific syllabus and the relative newness of the course it is possible that no one book encompasses the course to the level or depth required by the syllabus. This could explain the large number of combinations of books used. It is also likely that because of the newness of the course teachers are willing to extend themselves to make up for the lack of standardized textbooks. It is likely that books for the Advanced Placement Computer Science Course will proliferate as they have for calculus. These books will be single volumes incorporating the complete content of the Advanced Placement Computer Science Course. If the standardization in computer science, at least at the beginning college level, occurs it will facilitate development of these all in one books, just as has occurred in calculus.

Several findings proved to be surprising. Whether teachers attended summer workshops showed no relation to student success on the Advanced Placement Examination. Students whose teachers attended summer workshops did not enjoy an advantage on the examination over those whose teachers did not attend these workshops. One would expect that exposure to material specifically involved in the Advanced Placement course would enhance teacher effectiveness. Also surprising was the lack of a relation between the teacher's area of specialization and student performance. One might expect mathematics and science majors to produce the best students. This is not the case.

The literature is inconsistent in answering the question of whether teachers make a difference in student outcomes. The research specific to this study examines a much more sharply delineated area of student performance than previous studies. The Advanced Placement Computer Science course is highly specific in its content. The

College Board maintains that this can be the first course in computer science. Thus for many students this is the first exposure to programming and computer science. Unlike other advanced placement courses they may take this course without any prior experience in its content. This is analogous to taking Advanced Placement Mathematics without a previous mathematics course or Advanced Placement French without a previous French course. Thus the results of this study are specific to the Advanced Placement Computer Science course and may not transfer to other specific courses or to learning in general.

Does this mean that those with no background in computer science can teach the Advanced Placement course? Certainly not. The whole area of personal computers is relatively new, and the proliferation of the technology has been very rapid. Those who do not have computer science degrees have probably been drawn to this field because of an intense interest in computers regardless of their formal training. They probably found they had an ability working with computers. This interest has perhaps motivated them to seek the information needed to teach this course.

Paramount in producing successful computer science students is the teacher. What is also important is the teacher's perception of his or her abilities in computer science.

Why is teacher background not a better indicator of student performance on the Advanced Placement Computer Science examinaton? One possibility is that schools where three or fewer students took the examination were excluded from the study. The reason for this was that few of these schools conducted a formal class for Advanced Placement Computer Science. If these students had formal classroom instruction student performance might be more closely related to teacher background. In a small group the teacher influence could possibly have greater impact on student performance than in a larger group.

Another reason the relation between teacher background and student performance is not stronger could be due to "computer hackers" in the class. These individuals acquire vast amounts of computer knowledge on their own, usually spending long hours working on the computer. Because they tend to work on their own when it comes to computers, they might have been influenced very little by the teacher in the Advanced Placement Computer Science course. Their scores, included with the other student's scores, may have altered the significance of the statistics. Thus, a teacher effect might be present but is masked by the "hackers".

Recommendations

The four most important recommendations to improve examination scores would be to cover precisely the Advanced Placement Computer Science syllabus, to provide enough computers so that all students could have as much access outside the course time as they wished, to make some programming a prerequisite for the Advanced Placement course and to have teachers who feel comfortable teaching the course. The second set of recommendations would be to have teachers who are proficient in Pascal and in the fourteen topics selected from the Advanced Placement syllabus and teachers who know at least four computer languages. The teachers should also be experienced in teaching computing. Each student should have sole use of a computer during classroom instruction. Lastly, schools should equip the computer lab with a variety of hardware and software options for students. This fosters flexibility and may enhance problem solving.

There are a number of studies that can be done in light of this research. A more detailed study of the differences between summer workshops should be undertaken. Exactly what material they cover, the sequencing of topics, how well the teachers attending these workshops perform and the type of computers used could be compared with how the students of these teachers perform on the Advanced Placement Examination. This might be best accomplished as a small scale clinical study.

A detailed examination of teacher proficiency in computer science could be carried out. This could be done as a clinical study or large scale testing of the Advanced Placement Computer Science teachers. These results would be interesting in themselves, but could be compared with student performance on the examination. One would assume that all the teachers have at least some minimum level of knowledge in the subject but do those who are more knowledgeable produce students who score better?

A more thorough study of prerequisites for the Advanced Placement course could be completed. This would involve examining not just what courses are required as prerequisites but also the sequencing of the courses at each school. The content of these courses could be examined by reviewing the syllabi for the prerequisites.

This study indicates that teachers with more experience teaching the Advanced Placement course produce better student scores. Overall teaching experience does not show the same relation to student scores. Over time will those teaching the Advanced Placement course plateau as the newness of the course wears off?

Another question involves funding for the Advanced Placement Computer Science Course. Do those schools spending more on hardware and software produce students with better scores? What correlation exists between student scores and low versus high socio-economic districts?

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Appendix A

COMPARISON OF SCHOOLS AND STUDENTS IN THE STUDY WITH ALL SCHOOLS IN THE POPULATION

A	B	C	D	E
45-40	1	0.49	0.26	0.13
39-35	1	0.49	0.39	0.19
34-30	1	0.49	0.39	0.19
29-25	1	0.49	0.64	0.32
24-21	2	0.99	1.02	0.52
20	2	0.99	1.02	0.52
19	2	0.99	1.16	0.58
18	1	0.49	0.64	0.32
17	3	1.48	1.54	0.78
16	2	0.49	1.28	0.65
15	3	1.48	1.67	0.84
14	5	2.46	2.57	1.30
13	7	3.45	3.59	1.81
12	9	4.43	4.75	2.40
11	8	3.94	4.24	2.14
10	13	6.40	7.06	3.57
9	15	7.39	7.83	3.96
8	17	8.37	8.09	4.09
7	22	10.84	10.78	5.46
6	24	11.82	11.30	5.71
5	30	14.79	14.12	7.14
4	34	16.75	15.66	7.92

A students per school
B number of schools in study
C % of schools in study 203
D % of schools with >=4 students 779
E % of all US schools 1541

A	B	C	D	E	F
45-40	45	88	2.58	1.30	1.09
39-35	35	108	2.00	1.59	1.34
34-30	32	93	1.83	1.37	1.56
29-25	26	130	1.49	1.92	1.62
24-21	46	179	2.63	2.64	2.22
20	40	160	2.29	2.36	1.99
19	38	171	2.17	2.52	2.13
18	18	90	1.03	1.33	1.12
17	51	204	2.91	3.01	2.54
16	32	160	1.83	2.36	1.99
15	45	195	2.57	2.87	2.42
14	70	280	4.00	4.13	3.48
13	91	364	5.20	5.36	4.52
12	108	444	6.17	6.54	5.52
11	88	363	5.03	5.35	4.51
10	130	550	7.43	8.18	6.83
9	135	549	7.71	8.09	6.82
8	136	504	7.77	7.43	6.26
7	154	588	8.80	8.66	7.31
6	144	528	8.23	7.78	6.56
5	150	550	8.57	8.18	6.83
4	136	488	7.77	7.19	6.06

A students per school
B number of students in study
C total students in US schools 8047
D % of students in study 1750
E % of students in schools >=4 students 6786
F % of students in all US schools 8047

APPENDIX B

INITIAL QUESTIONNAIRE

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1. What computer(s) do you use to teach Advanced Placement Computer Science (if micros, how many)?

2. In what type of school are you teaching: 1-urban, 2-suburban or 3-rural?

3. During your Advanced Placement Computer Science class how many of your students are there per computer?

4. Do your students have access to computers outside of class time? If yes, how much time?

5. How many years have you been in the school where you are teaching the Advanced Placement Computer Science course?

6. How much preparation time (including correcting programs, but not on the computer) do you spend on the Advanced Placement Computer Science course?

7. On a scale from 1 to 5 (1-not at all, 5-exactly) how closely do you follow the Advanced Placement Computer Science syllabus?

8. In semesters (2 per year). how long is your Advanced Placement Computer Science course?

9. What was your class size in Advanced Placement Computer Science during 1985-86?

10. What are your prerequisites (if any) for the students entering your Advanced Placement Computer Science course?

11. What percent of the year do you spend on:
    - The Pascal language _____
    - Data structures _____
    - Algorithms _____

12. Do you use the 'Karel the Robot' program in your course? If so, when during the year and for how long (in weeks)?

13. Which text(s) do you use?

    ____
    ____
    ____
    ____
    ____
    ____

14. How many summer workshops dealing with the Advanced Placement Computer Science course have you attended? List where you attended.

15. What percent of the workshop was spent on (if more than one workshop give percents for each workshop seperately):

the Pascal language	_____	_____	_____
data structures	_____	_____	_____
algorithms	_____	_____	_____

16. Listed are some of the topics from the Advanced Placement Computer Science Course Description. Indicate how much time you spend (in weeks) on each topic.

Local/global identifiers	_____
Parameters	_____
Recursion	_____
Linear structures	_____
Tree structures	_____
Searching	_____
Sorting	_____
Numerical algorithms	_____
Computer systems	_____
Social implications	_____

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These consist of pages:

94-95, Initial Questionnaire

U·M·I

19. On a scale from 1 to 5 (1-not at all, 5-very) how comfortable are you teaching the Advanced Placement Computer Science course?

20. Highest degree you attained:

BA or BS	_____
BA or BS + 15 graduate credits	_____
BA or BS + 30 graduate credits	_____
Masters degree	_____
Masters degree + 15 additional credits	_____
Masters degree + 30 additional credits	_____
Doctorate	_____

21. What was your major field in college (if 'education', list the area of education in which you specialized, if any)?

22. What was your minor field in college (if 'education', list the area of education in which you specialized, if any)?

23. If you have a masters degree (or higher) what was your major field (if 'education', list the area in which you specialized, if any)?

24. How long ago was the last computer programming or computer science course? 1/2. 1, 1 1/2, 2 or more than 2 years.

25. Have you had any business related computer experience (programmer, systems analyst, etc.)? For what period of time?

26. On a scale from 1 to 5 (1-not at all, 5 very much) how much has this helped you in teaching the Advanced Placement Computer Science course?

27. How much leisure time do you spend using the computer?

28, Did you teach the Advanced Placement Computer Science course at your present school in the 1985-86 year?

29. How many years have you been teaching (not including this year)?

30. How many years have you been teaching programming (not including this year)?

31. How many years have you been teaching computer science, including the Advanced Placement Computer Science course (not including this year)?

32. How many computer programming or computer science courses have you taken? List them.

33. How many years have you been teaching the Advanced Placement Computer Science course?

APPENDIX C

FINAL QUESTIONNAIRE AND COVER LETTER

---

173 Larch Ave.
Teaneck, NJ 07666
March 15, 1987

Dear Colleague,

I need your help in completing a research project conducted in conjunction with Teachers College, Columbia University and The College Board. I am gathering data concerning Advanced Placement Computer Science teachers and their students. Your school is one of 203 selected for this national study, and I would greatly appreciate your time and effort in completing the enclosed questionnaire. It will take approximately twenty minutes to complete.

If you did not teach the Advanced Placement Computer Science course at your present school during the 1985-86 school year, please pass this on to the person who did. If the person who taught the AP Computer Science course during 1985-86 is no longer at the school, do not fill in the questionnaire. Simply return it.

In filling out the questionnaire, please keep in mind that all questions pertain to 1985-86, so you may need to jog your memory.

Please return the completed questionnaire by March 25.

Thank you very much for your valuable help. If you have any questions, my phone number is 201-692-9059.

Sincerely,

Andrew J. Guzo

1. Did anyone, besides yourself, teach the Advanced Placement Computer Science course at your school in 1985-86?
   [ ] YES
   [ ] NO

2. What computer(s) do you use to teach Advanced Placement Computer Science?
   [ ] Apple II
   [ ] MacIntosh
   [ ] IBM PC
   [ ] TRS-80
   [ ] Commodore
   [ ] Other ______________

3. During your Advanced Placement Computer Science class how many of your students are there per computer?
   [ ] 1 per computer or terminal
   [ ] 2 per computer or terminal
   [ ] other, specify______________

4. In what type of school are you teaching?
   [ ] Urban [ ] Private
   [ ] Suburban [ ] Public
   [ ] Rural

5. What fraction of the advanced placement class had access to computers outside your class time?
   [ ] less than 10%
   [ ] 10%-25%
   [ ] 26%-50%
   [ ] 51%-75%
   [ ] more than 75%

6. How many years have you been in the school where you are teaching the Advanced Placement Computer Science course?
   [ ] less than 2 years
   [ ] 2-3 years
   [ ] 4-5 years
   [ ] 6-10 years
   [ ] more than 10 years

7. How much preperation time did you spend (per week) during 1985-86 on the Advanced Placement Computer Science course?
   [ ] less than 5 hours
   [ ] 6-10 hours
   [ ] 11-15 hours
   [ ] more than 15 hours

8. How closely do you cover the Advanced Placement Computer Science syllabus?
   [ ] not at all
   [ ] somewhat
   [ ] very closely
   [ ] exactly

9. How long is your Advanced Placement Computer Science course?
   [ ] 1 semester
   [ ] 2 semesters
   [ ] 3 semesters

10. What was your total number of students in Advanced Placement Computer Science during 1985-86?

    _____

11. What are your math prerequisites for students entering your Advanced Placement Computer Science course? (Check all that apply)
    [ ] none
    [ ] Algebra I
    [ ] Algebra II
    [ ] Geometry
    [ ] pre-Calculus
    [ ] Calculus
    [ ] other (specify)

    ____

12. Do you use the "Karel the Robot" program in your course?
    [ ] yes, for about _____periods
    [ ] no

13. What are your primary textbooks?

Title	Author
________________	________________
________________	________________
________________	________________
________________	________________
________________	________________
________________	________________

14. How many summer workshops dealing with the Advanced Placement Computer Science course have you attended? List where and when you attended.

    ____
    ____
    ____
    ____
    ____

PLEASE NOTE:

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These consist of pages:

99, question 16 A and B on the right side of the page

100, test questions

U·M·I

15. Rate your proficiency in the following languages and topics
    1-none
    2-fair
    3-good
    4-excellent
  and indicate how you learned each
    1-college computer course
    2-summer Advanced Placement Computer Science workshop
    3-self taught
    4-own Advanced Placement Computer Science teaching

	PROFICIENCY	HOW LEARNED
Pascal	_____	_____
BASIC	_____	_____
FORTRAN	_____	_____
COBOL	_____	_____
Machine language (specify system)	_____	_____
C	_____	_____
APL	_____	_____
Other (specify)		
_______________	_____	_____
_______________	_____	_____
_______________	_____	_____
_______________	_____	_____
Local/global identifiers	_____	_____
Parameters	_____	_____
Parameter passing	_____	_____
Recursion	_____	_____
Linear structures	_____	_____
Tree structures	_____	_____
Linked structures	_____	_____
Searching	_____	_____
Sorting	_____	_____
Numerical algorithms	_____	_____
Computer systems	_____	_____
Social implications	_____	_____
Records	_____	_____
Program verification	_____	_____

Computer Science test questions from the entire 1984 Advanced Placement Computer Science Examination and Key copyright © 1986 by College Entrance Examination Board. All rights reserved. Reprinted by permission of Educational Testing Service, the copyright holder of the sample questions.

c) Consider the following poorly formatted Pascal program fragment.

```
if A=7 then if C=6 then begin C:=9;
D:=9 end else begin T:=10; if C=6
then C:=5 end else P:=9
```

If A=7 and C=6 before the fragment is executed, which of the following indicates the values of A,C,D,P, and T after the fragment is executed? (An undetermined value is indicated by a questions mark.)

A) A=7, C=9, D=9, P=?, T=?
B) A=7, C=5, D=?, P=?, T=10
C) A=7, C=6, D=?, P=?, T=?
D) A=7, C=5, D=9, P=?, T=10
E) A=7, C=6, D=?, P=9, T=?

Rating 1 2 3 4

d) Suppose List1 and List2 are pointers to the first nodes in each of two linked lists, and q points to some node in the first list. The initial segment of the first list, that is, all nodes up to and including the one pointed to by q, is to be removed and this segment put onto the beginning of the second list while the order of the nodes in the initial segment is maintained. If neither q nor List1 is nil, then this task is correctly performed by which of the following program segments, where p is the pointer?

I.
```
q↑.Link:=List2;
List2:=List1;
List1:=q↑.Link
```

II.
```
while List1<>q↑.Link do
  begin
   p:=List1;
   List1:=List1^.Link;
   p↑.Link:=List2;
   List2:=p
  end
```

17. How comfortable are you teaching the Advanced Placement Computer Science course?
    [ ] not at all
    [ ] only a little comfortable
    [ ] only a little uncomfortable
    [ ] very comfortable

18. Highest degree you attained:
    [ ] BA or BS
    [ ] BA or BS + 15 grad. credits
    [ ] BA or BS + 30 grad. credits
    [ ] Masters degree
    [ ] Masters + 15 add. credits
    [ ] Masters + 30 add. credits
    [ ] Doctorate

19. What was your major field in college (if 'education', list the area of education in which you specialized, if any)?

    ____

20. What was your minor field in college (if 'education', list the area of education in which you specialized, if any)?

    ____

21. If you have a masters degree (or higher) what was your major field (if 'education', list the area in which you specialized, if any)?

    Masters____________________
    Doctorate__________________

22. How long ago was the last computer programming or computer science course?
    [ ] I have taken none
    [ ] 1/2 year
    [ ] 1 year
    [ ] 1 1/2 years
    [ ] 2 years
    [ ] more than 2 years

23. Have you had any business related computer experience (programmer, systems analyst, etc.)?
    [ ] yes, for__________years
    [ ] no

24. If you answered yes to question 23, ho much has this helped you in teaching t Advanced Placement Computer Science course?
    [ ] not at all
    [ ] minimally helpful
    [ ] somewhat helpful
    [ ] very helpful

25. How many years have you been teaching (not including 1986-87)?

    ____

26. How many years have you been teaching computing (not including 1986-87)?

    ____

27. If you do not have a degree in computer science, how many computer programming computer science courses have you taken List them.

    ____
    ____
    ____
    ____
    ____
    ____
    ____

28. How many years have you taught the Advanced Placement Computer Science course (not including 1986-87)?
    [ ] 1 year
    [ ] 2 years
    [ ] 3 years

29. Do you own your own computer?
    [ ] yes
    [ ] no

APPENDIX D

FOLLOW-UP COVER LETTER

---

173 Larch Ave.
Teaneck, NJ 07666
April 11, 1987

Dear Colleague,

I have not yet received the questionnaire I sent to you.

I still need your help in completing this research project. I realize that the questionnaire may have been lost in the mail or in the shuffle of all the paperwork required by schools these days. Because of the carefully selected sample it is imperative that I get all of the questionnaires back. I know your time is very valuable, but please take the twenty minutes to complete the questionnaire. If you have already mailed yours, thank you very much.

If you did not teach the Advanced Placement Computer Science course at your present school during the 1985-86 school year, please pass this on to the person who did. If the person who taught the AP Computer Science course during 1985-86 is no longer at the school, do not fill in the questionnaire. Simply return it because it is important that I account for all the questionnaires.

In filling out the questionnaire, please keep in mind that all questions pertain to 1985-86, so you may need to jog your memory.

Please return the completed questionnaire by April 21.

Thank you very much for your valuable help. If you have any questions, my phone number is 201-692-9059.

Sincerely,

Andrew J. Guzo

APPENDIX E

LETTER FOR INCOMPLETE TEXTBOOK INFORMATION

---

173 Larch Ave.
Teaneck, NJ 07666
February 8, 1988

Dear Colleague,

Last March or April you assisted me in a research project by filling out a questionnaire. Thank you again for your help. One of the questions involved the textbook(s) you used in the Advanced Placement Computer Science course in the 1985-86 school year. You listed as a textbook:

Computer Programming A First Course
by Miller & Miller

Unfortunately I cannot find this book listed in Books In Print, and I need a complete citation for this book. I would greatly appreciate your help in filling out and returning the enclosed postcard.

Thank you very much for your valuable help. If you have any questions, my phone number is 201-692-9059.

Sincerely,

Andrew J. Guzo

Complete title......................................

....

Author(s)..

....

Copyright............

Publisher..

APPENDIX F

SUMMER WORKSHOPS ATTENDED BY TEACHERS

Workshop	# times indicated	Location
Arizona State University	2	Tempe, AZ
The Bishop's School	1	La Jolla, CA
BOCES	2	Nassau County, NY
Boston University	2	Boston, MA
Boulder Colorado	1	
Brigham Young University	2	Provo, UT
Caldwell College	1	Caldwell, NJ
Carleton College	1	Northfield, MN
Carnegie Mellon University	2	Pittsburgh, PA
Colgate University	1	Hamilton, NY
Earlham College	4	Richmond, IN
Eau Gallie High School	1	Melbourne, FL
Fresno State College	1	Fresno, CA
Friends of 2?	1	Boston, MA
Gonzaga University	2	Spokane, WA
Woods Cross High School	1	Woods Cross, UT
Hamline University	1	St. Paul, MN
Harvard	1	Cambridge, MA
Kent State University	1	Kent, OH
Lake Forest College	1	Lake Forest, IL
Manhatten College	5	Bronx, NY
Phillips Academy	1	Andover, MA
Rensselaer Polytechnic Institute	2	Troy, NY
Rutgers University	1	New Brunswick, NJ
Salem College	1	
Southern Methodist Univ.	2	Dallas, TX
The Taft School	5	Watertown, CT
Teachers College, Columbia University	6	New York, NY
The Citadel	1	Charleston, SC
UCLA	2	Los Angeles, CA
University of Alabama	1	Tuscaloosa, AL
University of Maryland	1	College Park, MD
University of Massachusetts	2	Amherst, MA
University South Carolina	1	Columbia, SC
Utah State University	1	Logan, UT
Western Carolina University	2	Cullowhee, NC
Winthrop College	2	Rock Hill, SC

APPENDIX G

TEXTBOOKS USED BY THE SCHOOLS IN THE STUDY

The number in parenthesis following each citation indicates the number of schools using the text.

Aho, A., Hopcroft and Ullman., (1982) Data Structures and Algorithms. Reading, MA: Addison-Wesley. (1)

Austing, R.H., (1985) Advanced Placement Test in Computer Science. New York: Arco. (2)

Bowles, K.L., et al., (1984) Problem Solving Using UCSD Pascal. New York: Springer-Verlag. (1)

Cooper, D. and Clancy, M., (1985) Oh! Pascal. New York: Norton. (18)

Dale, N.B. and Lilly, S.C, (1985) Pascal Plus Data Structures, Algorithms and Advanced Programming. Lexington, MA :Heath. (53)

Dale, N.B. and Orshalick, D.W., (1983) Introduction to Pascal and Structured Design. Lexington, MA :Heath. (52)

Dennis, T.L., (1985) Apple Pascal: A Problem-Solving Approach. St. Paul, MN:West Publishing. (1)

Downing, D., (1984) Computer Programming in Pascal the Easy Way. Hauppauge, NY: Barrons. (1)

Dromey, R., (1983) How to Solve It by Computers. New York: Prentice Hall. (1)

Gilbert, H.M. and Larkey, A.I., (9184) Practical Pascal. Cincinnati: South-Western. (1)

Graham, N., (1982) Introduction to Computer Science: A Structured Approach. St. Paul, MN:West Publishing. (5)

Grant, C.W. and Butah, J., (1982) Introductiob to the UCSD p-System. Alameda, CA: SYBEX. (1)

Grogono, P., (1984) Progamming in Pascal. Reading, MA: Addison-Wesley. (1)

Jensen, K. and Wirth, N.E., (1978) Pascal Users Manual and Report. New York: Springer-Verlag. (1)

Jones, W.B., (1982) Programming Concepts: A Second Course. New York: Prentice Hall. (2)

Koffman, E.B., (1982) Pascal: A Problem Solving Approach. Reading, MA: Addison-Wesley. (3)

Koffman, E.B., (1985) Problem Solving and Structured Programming in Pascal. Reading, MA: Addison-Wesley. (4)

Kruse, R.L., (1984) Data Structures and Program Design. New York: Prentice Hall. (2)

Mandell, S. and Mandell, C. (1985) Computer Science with Pascal for Advanced Placement Students. St. Paul, MN: West Publishing. (10)

Mazlack, L.J., (1983) Structured Problem Solving with Pascal. Boston: Holt. (1)

Miller, P. and Miller, L., (1986) Programming by Design- A First course in Structured Programming. Pittsburgh: Carnegie Publishing. (1)
Miller, P. and Miller, L., (1986) Computer Programming: The First Course. Pittsburgh: Carnegie Publishing. (2)
Moll, R. and Folsom, R., (1985) Apple II Instant Pascal: An Introduction to Programming. Boston: Houghton Mifflin. (1)
Naps, T.L. and Singh, B., (1986) Introduction to Data Structure with Pascal. St. Paul, MN: West Publishing. (1)
O'Brien, S., (1987) Turbo Pascal: The Complete Reference. New York: Osborne-McGraw. (2)
Peterson, J.L and Silberschatz, A., (1983) Operating Systems Concepts. Reading, MA: Addison-Wesley. (1)
Pattis, R., (1981) Karel the Robot: A Gentle Introduction to the Art of Programming. New York: Wiley. (8)
Presley, B. and Corica, (1986) Guide to Programming in Apple Pascal. Lawrenceville, NJ: Lawrenceville Press. (1)
Savitch, W.J., (1984) Pascal: An Introduction to the Art and Science of Programming. Menlo Park, CA: Benjamin-Cummings. (3)
Schneider, G.M. and Bruell, S.C., (1981) Advanced Programming and Problem Solving with Pascal. New York: Wiley. (2)
Schulman, et al., A.P. Review. (2)
Sedgewick, R., (1983) Algorithms. Reading, MA: Addison-Wesley. (2)
Standish, T.A., (1979) Data Structure Techniques. Reading, MA: Addison-Wesley. (1)
Tenenbaum, A. and Augenstein, M.J., (1986) Data Structures Using Pascal. New York: Prentice Hall. (6)
Trembley, J.P. and Bunt, R.B., (1980) An Introduction to Computer Science: An Algorithmic Approach. New York, McGraw. (2)
Tucker, A.B.,Jr, (1982) Apple Pascal: A Programming Guide. Boston: Holt. (1)
Walker, H., (1986) Introduction to Computing and Computer Science. Boston: Little. (1)
Welsh and Elder, (1982) Introduction to Pascal, 2nd Edition. New York: Prentice Hall. (1)
Wirth, N., (1976) Algorithms + Data Structures = Programs. New York: Prentice Hall. (1)
Zaks, R., (1981) Introduction to Pascal (Using UCSD Pascal). Alameda, CA: SYBEX. (2)

APPENDIX H

BREAKDOWN OF BACHELORS AND ADVANCED DEGREES

Bachelor Degrees	#	% of respondents (124)
Accounting	1	0.81
Architecture	1	0.81
Biology	6	4.84
Business	1	0.81
Business Administration	1	0.81
Chemistry	5	4.03
Education	2	1.61
Electrical Eng.	2	1.61
Engineering	1	0.81
English	4	3.23
German	1	0.81
Health	1	0.81
Mathematics	71	57.26
Math Education	9	7.26
Applied Mathematics	1	0.81
Music	1	0.81
Philosophy	3	2.42
Physical Education	2	1.61
Physics	7	5.65
Political Science	1	0.81
Psychology	1	0.81
Science	1	0.81
Speech	1	0.81

Masters Degrees	#	% of respondents (99)
Administration	3	3.03
Biology	2	2.02
Business	1	1.01
Business Administration	1	1.01
Chemistry	1	1.01
Computer Education	1	1.01
Computer Science	10	10.10
Education	9	9.09
Engineering	1	1.01
English	2	2.02
Library Science	1	1.01
Mathematics	33	33.33
Mathematics Education	22	22.22
Applied Mathematics	2	2.02
Music	1	1.01
Physical Science	1	1.01
Physics	2	2.02
Political Science	1	1.01
Science	4	4.04
Special Education	1	1.01