THE NEW ADVANCED PLACEMENT COMPUTER SCIENCE COURSE: AN ANALYSIS

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Introduction

Why would a computer science instructor and a mathematics education faculty member team up in 1983 to review the 1977 IEEE's "A Curriculum in Computer Science and Engineering: Committee Report" [1] and to re-examine the ACM's "Curriculum '78 Recommendations for the Undergraduate Program in Computer Science" [2] publication?

Educational Testing Service (ETS) has been offering for many years Advanced Placement (AP) tests in twenty four introductory college course subjects such as calculus, physics, and history to name a few. ETS will be offering a new Advanced Placement exam in Computer Science (AP CS) and the first test is scheduled for May, 1984. Selected high school mathematics teachers will be expected to meet this new challenge and to offer a brand new course to selected high school seniors hoping to score sufficiently high enough on the exam so as to have the college they attend waive the entry computer science course or courses.

The AP test will be based on a curriculum encompassing "Fundamental of Computing" and "Data Structures" described in the IEEE Curriculum Guidelines for Computer Science and Engineering and CS1- Computer Programming I and CS2- Computer Programming II as described in the ACM Curriculum '78.

The authors teamed up in the spring of 1983 to analyze the AP test in Computer Science and to offer a course to high school and other interested teachers on the subject of the Computer Science AP test. The course (summary outline of course available upon request) entitled PASCAL Summer Institute was offered in the summer, 1983 at the State University of New York at Binghamton.

The following is our observations and conclusions concerning the AP Computer Science test.

Course Content As Applicable to AP CS

As discussed previously, the entire AP CS course is designed on the subject matter of the first two courses of a college level Computer Science curriculum. However, no distinction is made in the ETS AP CS curriculum concerning the break point between Course I and Course II. The following is a summary of the course content with a distinction between Course I and Course II. This summary is based on the curriculum guidelines as they relate to the AP CS curriculum.

Course I Outline:

1. Need for computers in society
2. History and terminology
3. Hardware components of a computer
4. System software components of a computer
5. Writing programs
   a. Representation of Real, Integer, Character, and Boolean types of data
   b. Constants, Variables
   c. Arithmetic expressions
   d. Top Down problem analysis and solutions with concern for requirements, design, coding, and testing
   e. Documentation
   f. PASCAL language syntax including Do-While, Repeat, Count Controlled repetition, If-Then-Else
   g. Sequential Computational process
   h. Definition and uses of data structures such as arrays, strings, records, files, pointers, and linked lists
   i. Procedures
   j. Parameter passing
   k. Searching and sorting techniques
   l. Local and global variables)
6. Use of a computer system and editor

Course II Outline:

1. Larger and more sophisticated programs and projects in PASCAL
2. Additional Algorithm designs, development, and testing
3. Additional structured programming concepts
4. Analysis of algorithms
5. Specific Data Structures such as string, arrays, lists, stacks, queues, linked lists, trees, tables, graphs, records, files, pointers
6. Recursion
7. Operations on Data Structures
8. Testing and debugging techniques

Prerequisites

Due to the demanding and intense structure of the AP Computer Science course, prerequisites are necessary. ETS recommends [3] a second course in algebra, problem solving experience, logic and competency in written expression before taking the AP Computer Science course. No mention is made of any prior computer experience or familiarity with any programming languages. The authors feel that an introductory high school computer course and some familiarity with programming combined with ETS' recommendations seem more appropriate.

Language

The language chosen for the first AP CS test is PASCAL. The concept behind the test is NOT merely to teach the PASCAL programming language, but to use PASCAL as a vehicle for learning programming concepts, techniques, algorithms, data structures, etc. Therefore, theoretically, the test should concentrate on those concepts and not the specifics of PASCAL. The authors feel that overall the sample test questions were extremely difficult, but fairly accurate in their ability to test the concepts mentioned. However, several of the question types seemed inappropriate because they dealt with the trivialities of PASCAL, rather than programming concepts.

An example of this is question #7 from the sample test provided.

"Question #7 and #8 are based on the following declarations:

```
TYPE  AgeType    = 0..125;
      SexType    = (M,F);
      PartyType  = (Republican,
                    Democrat,
                    Independent,
                    Other);

   CitizenType   = RECORD
                     age   = AgeType
                     sex   = SexType
                     party = PartyType
                   END;

VAR
      citizen    : CitizenType;
      longevity  : AgeType;
```

7. Which of the following is a valid PASCAL statement?
   (A) writein(citizen.age)
   (B) writein(citizen.sex)
   (C) writein(citizen)
   (D) writein(age)
   (E) writein(sex)" [4]

The answer is A, because in Standard PASCAL enumerated types, and entire records cannot be printed. Subrange types, however, can be printed and CITIZEN.AGE is of this type. This is definitely a triviality of PASCAL and not necessarily a test of a general programming concept.

The authors thought that sample question #10 was especially good.

"Consider the following sequence of procedure calls.

```
Push(x);
Push(y);
Add;
Push(z);
Push(w);
Mult;
Add;
```

Invoking PUSH causes its argument to be pushed onto a Stack. Invoking the procedures Add or Mult causes (1) The stack to be popped twice, (2) the two popped items to be added or multiplied, and (3) the result to be pushed onto the stack. If x = 10, y = 20, z = 30, and w = 40, then at the end of the sequence of procedure calls above, the stack contains

(A) nothing (B) 0 (C) 940 (D) 1230 (E) 1410 [5]

This is a good question because it deals with programming concepts rather than language specifics. The question deals with data structures, procedure calls, parameter passing, algorithm analysis, etc.

Why Not BASIC

Many teachers who have recently become proficient at teaching BASIC are probably disappointed to learn that the AP CS test is initially using PASCAL. And many may be waiting until a version of the test will come along which will use BASIC. The wait will probably be forever. We cannot anticipate the test as ever allowing BASIC. PASCAL is structured and modular, easy to code in blocks, procedure oriented, has parameter passing, permits logically structured "GO TO -less" programs, has the If-Then-Else, Do While constructs and has supporting AP oriented

texts available, to mention a few of the advantages of PASCAL. BASIC, while easy to learn, has restricting limitations in these areas.

Equipment

Adequate equipment for the students is an imperative element to the course. Computer programming and related concepts can NOT be learned without extensive actual hands-on experiences on proper equipment. And adequate equipment must consist of computer(s) with PASCAL capability. Other necessities consist of a means of permanent/secure data files for EACH student. This should consist of diskettes in the case of microcomputers or secure storage on a time sharing mainframe. Printing capability is also needed. Each student having his or her own computer, or unlimited access to a time sharing system is highly unlikely, therefore ETS has made a recommendation [6] that each student be allowed a minimum of 30 minutes per day, five days per week, throughout the academic year. The authors feel that this is insufficient time. Because of the intensity of the AP CS test and because most learning in these types of courses occurs through hands-on experience on equipment, we feel that at least double the time recommended by ETS is essential as a minimum requirement.

Teacher Training Needs

High school teachers, secondary mathematics departments and/or school districts need to prepare for this new course. Inservice courses, credit or non-credit higher institution courses, summer institutes or on-going workshops offer opportunities for this needed preparation. The authors feel that self preparation will not be enough. While the language of PASCAL can be self taught, good programming procedures and the nuances of data structures are better understood when presented in a formal education setting.

College Credit? How Much? Implications for College

Are Computer Science faculties deciding policies on credit granting for incoming students? Or will they be taken by surprise when students ask for advanced credit next fall? Scores on AP tests range from 1 to 5 with a 5 rated as "extremely qualified." [7] ETS indicates a score of 3 ("qualified") is possible by "... performing acceptably in the free-response section..." and "... need answer about 60% of the multiple choice questions correctly..." Would this be a minimum passing grade for one of your college introductory computer science courses is a question that needs to be answered. In some institutions the answer will be yes and in others it will be no. The implication is that decisions need to be made before students arrive with their AP scores. And the first group of students could arrive in September 1984.

Usually AP credit will be granted in terms of entire courses. The AP test represents two entire courses, so credit would be granted in terms of no course, one course or two courses. The Computer Science Information Science Program at The State University of New York at Binghamton plans to allow no AP credit for a score of below 3, one course credit for a score of 3 or 4, and two course credits for scores of 5. This policy will be evaluated yearly.

Summary

Recently, there has been much criticism concerning the quality of high school teachers and students. After having taught the AP CS course to teachers who will be teaching this course in high schools, we are extremely impressed. The AP CS course and the available sample questions are extremely intense and difficult, and the teachers who will be teaching this will have to devote an extreme amount of time for preparation, teaching, and grading of programs; along with their other job requirements.

The students who take and do well on the AP CS exam will be of the highest caliber. It is the concensus of the authors and the participants of the PASCAL summer Institute held at SUNY-Binghamton that the test is exacting and difficult, and those students who do well will be extremely capable in concepts of programming, data structures, algorithms, etc.

In the June, 1983 issue of Computer, Taylor Booth, [8] Vice President for Educational Activities of the IEEE Computer Society, wrote of "one of the most important areas of education today" -- the need to disseminate information about computer technology to the pre-college sector of the curriculum. With the new AP exam, this goal will become even more crucial.

References

1. IEEE Computer Society Education Committee, "A Curriculum in Computer Science and Engineering: Committee Report," IEEE Publication EH0119-8, January 1977.

2. ACM Committee on Computer Sciences, "Curriculum '78 Recommendations for the Undergraduate Program in Computer Science," Communications of the ACM, Vol. 22, No. 3, March 1979, pp. 151-153.

3. "Advanced Placement Course Description, Computer Science," College Entrance Examination Board, Princeton, New Jersey, 1982, pp. 8-9.

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PROGRAM SPECIFICATIONS

A company has a file of potential customers accumulated over several years. It is realized that there are several customers duplicated in the file and management would like to know how serious the number of duplications is.

You have been asked to write a program that will read the customer file that has already been sorted by customer name and produce a report giving the names of any duplicated customers together with the number of times the name appears.

Customers that have not been duplicated should not appear on the report.

The report should also print the total number of different customers, at the end.

Since your program need only reference the customer's name, the input file can be defined simply as:

```
01  I-CUST-REC.
    03  I-CUST-NAME      PIC X(20).
    03  FILLER           PIC X(40).
```

APPENDIX B
'ALTERNATIVE METHODS'

Objectives

a. to revise and put to use REDEFINES, table processing and GO TO DEPENDING ON
b. to enable you to see that there is often more than one way of programming a particular problem.
c. to develop criteria with which to judge the alternative methods.

1. Working in pairs, revise REDEFINES, table defintions and processing and GO TO DEPENDING ON

   HINT:
   One useful way of doing this is to try and explain the concept to each other IN YOUR OWN WORDS WITH YOUR BOOKS CLOSED. Try to make up examples to help your explanations.

2. A program is needed that will display on the VDU, the number of widgets manufactured a day in a particular factory. The particular factory number will be typed in at the terminal by the user.

   The production of widgets is as follows:

factory no.2	20,000 widgets
factory no.3	25,000 widgets
factory no.4	20,000 widgets
factory no.5	29,000 widgets
factory no.6	30,000 widgets

   There are at least two different ways of writing this program. Consider with your partner what these methods are broadly speaking. Choose one method each and so between you write the two versions of the program. Desk check your own version with the test data. When you have finished swap your versions and desk check each other's version. Help each other arrive at correct programs.

3. Together make a list of criteria by which you should judge the merits and demerits of a program. List them in order of importance. Now judge the two programs that have been written according to these criteria and arrive at conclusions ready for class discussion.

4. We will spend the last 15 minutes discussing together the merits of the various methods according to your criteria.

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4. Ibid., p. 21.

5. Ibid., p. 22.

6. Ibid., pp. 9-10.

7. Ibid., p. 5.

8. Booth, Taylor L. "Special Message," Computer, Vol. 16, No. 6, June 1983, IEEE Computer Society, p. 5.

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Sutton, J. and R. Sprague, "A Study of Display Generator and Management in Interactive Business Applications", IBM Research Report RJ23992, November 1973

Tharp, Alan L. "Interactive Computing in a Project-oriented File Organization Course", Proceedings of the Tenth Annual ACM SIGCSE Conference, February 1979, pp. 82-86.

Wasserman, A. I. and Steven Gutz, "The Future of Programming", CACM, March 1982, pp. 196-206.