

COMPUTING COMPETENCIES FOR SCHOOL TEACHERS
A PRELIMINARY PROJECTION FOR THE TEACHER OF COMPUTING

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Introduction

This paper is one of several dealing with the development of curricular and teacher training guidelines for the intergration of computing into the elementary and secondary schools of the country. It represnets part of the continuing work of the Elementary and Secondary Schools Subcommittee (ES³) of the ACM Curriculum Committee. This particular paper deals only with matters related to preparation of the teacher of computing science as a separate subject in the school. The computing education of all other teachers is treated in "Computing Competencies for School Teachers -- A Preliminary Projection for all but the Teacher of Computing" by the same authors (Taylor, et al 1979), a paper which also contains a more complete introduction then this one.

Numerous papers have been written on the general problem of computing education for school teachers, and those papers and the ACM "Curriculum '78" guidelines have been freely drawn upon in drafting this paper. While many of them suggest specific courses and programs, this paper focuses upon competencies.

Rather than approaching the problem of "how" to educate teachers of computer science, it attempts to specify the competencies needed by such a teacher. Once such competencies are defined, training programs with a variety of approaches should be definable.

The Teacher of Computing in the Schools -- General

The teacher of computer science at the pre-college level should not only be able to teach courses in computer literacy, computer programming and computer applications, he/she should also be able to serve as a resource to the gifted child pursuing advanced projects, to fellow teachers wishing to use the computer as a tool, and more than likely, to the principal of the school needing help in administrative applications. Competency in computer programming alone then is not sufficient for the teacher of computing.

Since much of the knowledge required for such a teacher is similar to that required of anyone desiring to be a computer professional, many of the computer competencies defined in the recent ACM Curriculum Committee report "Curriculum '78" apply to the teacher as well. This report was therefore used extensively in arriving at the recommended teacher competencies. Another very important assumption that we make, is that the teacher of computer science is exactly that, a teacher. Thus the competencies we list are primarily

related to the area of computer science and computer education.

The task force realizes that the vast majority of educational programs have been implemented by dedicated teachers in the field who have had little opportunity to obtain formal computer science education. We wish to stress that by listing desired competencies, we are not implying that these competencies must be gained by formal coursework. Many teachers already have acquired these skills by self study and on-the-job training. However, it is hoped that this work clarifies and guides those individuals and institutions attempting to implement teacher education programs in computer science.

Teacher Competencies

The core material recommended for teachers of computer science represents essential elementary material, as well as material especially designed for educators. Computer science teachers should:

1. be able to write programs in a reasonable amount of time that work correctly, are well documented and are readable;
2. be able to determine whether or not they have written a reasonably efficient and well organized program;

3. know what general types of problems are amenable to computer solution, and the various tools necessary for solving such problems;
4. understand basic computer architectures;
5. know adequate motivational arguments for teaching computer science topics at the pre-college level and know objectives to be reached when teaching these topics;
6. know what educational tools can be uniquely employed in computer science education;
7. develop the ability to assist in the selection, acquisition, and use of computers, interactive terminals, and computer services which are suitable to the enhancement of instruction.
8. be able to assist teachers in evaluation, selection, and/or development of appropriate instructional materials which utilize computing facilities.

The first four competencies are of the sort commonly needed by all computing professionals and are listed in Curriculum '78 as among those to be covered by the undergraduate computer science degree program. The last

four competencies are not commonly needed by all computing professionals. They are essential only in the preparation of computer science teachers.

Topics of Study to Attain Competencies

It should be stressed once again that the problem of competency attainment is not being addressed in this paper. Thus we do not list specific courses or programs of study. However, to further clarify the level of expertise to be expected of a computer science teacher, the following topics should be common to all teacher preparation programs:

Programming Topics: Includes algorithms, programming languages, programming style, debugging and verification, applications.

Software Organization: Includes computer structure and machine language, data representation, symbolic coding and assembly systems, addressing techniques, macros, program segmentation and linkage, linkers and loaders, systems and utility programs.

Hardware Organization: Includes computer systems organization, logic design, data representation and transfer, digital arithmetic, digital storage and accessing control, I/O, reliability.

Data Structures and File Processing: Includes data structures, sorting and searching, trees, file terminology, sequential access, random access, file I/O.

Teaching Computer Science: Includes techniques of teaching, motivational "whys" of teaching and objectives to be reached when teaching computer topics, utilization of computer tools such as games and simulations.

Computers in Education: Includes computer assisted instruction, computer managed instruction, social implications of computers in education, administrative applications.

Once again we rely on Curriculum '78, along with a vast amount of research in computer education, to support the inclusion of Programming Topics, Software Organization, Hardware Organization, and Data Structures and File Processing.

We feel the topics of Teaching Computer Science and Computers in Education are essential to any program of teacher preparation. Materials on "why" and "how" of teaching computer science are invaluable to a teacher. Most research conducted on "First Courses In Computing" have arrived at the conclusion that computer programming alone is not sufficient. Thus motivation for covering

other computer related material in a beginning course should be included within a teacher preparation program.

Including study of Computers in Education, will increase the teacher's ability to assume a role of leadership in providing direction to school systems in integrating computing into its curriculum. This additional computer background should allow the computing teacher to act as a resource person to assist in fostering development and implementation of computing throughout the school, even when the other teachers know nothing of computing.

Future Steps

Having guidelines for teacher competencies only allows us to now define a much greater (and more pressing) problem: development of adequate teacher education programs. This problem may be broken into two parts, preservice and inservice teacher education.

Preservice programs involve the education of future teachers within standard type teacher educational programs. Certification programs for the computing teacher [11], as well as graduate level programs [7], have already been implemented in several states, but much work still remains. For example, a survey conducted during the 1975-76 school year and results published in Computers in Education by

Justine Baker, showed that only 6.8% of the 1975 major universities surveyed offered complete computer curriculum for teachers. The competencies finally worked out for the computing teacher should be translated into training for this teacher of a new subject, in teacher training institutions across the country.

Inservice teacher education is required for teachers already in the field. The need for well-defined programs in this area is urgent, since for economic and other reasons, many individual teachers across the country are being pressed into teaching computing science even though they have no formal training in the area. The competencies worked out for the computing teacher must be translated into other programs for these people, programs which are scheduled so that working teachers can take them.

Clearly, much remains to be done. It will require computer scientists to work closely with education faculties, to design programs that will guarantee that the teacher of computing will emerge from his or her training with the required competencies in both computing and education. The task force will continue to work on this problem of defining competencies and in identifying broad program outlines, but we will welcome help from any colleagues in a position to give it, either to our subtask or to other aspects of the work of ES³ as a whole. We believe the need demands the effort.

Bibliography

- [1] Atchinson, William F. "Computer science preparation for secondary school teachers". SIGCSE Bulletin, 5, 1:45-47 (1973).
- [2] Conference On Basic Mathematical Skills and Learning, U. S. Department of Health, Education and Welfare. Euclid, Ohio, 1975.
- [3] Curriculum '78: Recommendations for the Undergraduate Program in Computer Science, A Report of the ACM Curriculum Committee on Computer Science, December, 1978.
- [4] Danver, Jean H. "Suggestions for programs". Hanover, N. H.: Keiwi Computational Center, Dartmouth College, 1970.
- [5] Dennis, J. Richard, Dillhung, C. and Muiznieks, J. "Computer Activities in Secondary Schools in Illinois", Illinois Series on Educational Applications of Computers, No. 24, Univ. of Illinois, 1977.
- [6] Esterson, D.M. "Problems of Implementation: Courses for Pre- and In-Service Education". Information and Mathematics In Secondary Schools. North-Holland Publishing Co., 1978.
- [7] Moulton, Peter and Moursund, David. "A summer Master's degree program in computer science". Topics in Instructional Computing SIGCSE. Vol. 1, 31-36, January, 1975.

- [8] Poirot, James L. "A course description for teacher education in computer science". SIGCSE Bulletin, Vol. 8, 39-48, February, 1976.
- [9] Poirot, J.L. and Groves, D.N. Beginning Computer Science. Sterling Swift Publishing, Manchaca, Texas, 1978.
- [10] Poirot, J.L. and Groves, D.N. Computer Science for the Teacher. Sterling Swift Publishing, Manchaca, Texas, 1976.
- [11] Poirot, J.L. and Early, G.G. "Teacher certification -- a computer science necessity". Topics in Instructional Computing SIGCSE, Vol. 1, 15-18, January, 1975.
- [12] Recommendations Regarding Computers in High School Education, Conference Board of the Mathematical Sciences, Washington, D.C., April 1972.
- [13] Spencer, Donald. "Curriculum and Teacher Training for Secondary Schools", Interface, Vol. 5, No. 2, April, 1971.
- [14] Statz, Joyce. "Training secondary school computer science educators". Topics in Instructional Computing SIGCSE, Vol. 1, 4-9, January, 1975.
- [15] Taylor, Robert P. "Graduate Remedial Training in Computing for Educators", SIGCSE Technical Symposium Proceedings, Dayton, February, 1979.